Nutrition and Health
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Diet Quality

An Evidence-Based Approach

Volume 2

Humana Press

Nutrition and Health Series

Adrianne Bendich, PhD, FACN, FASN, Series Editor

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An Evidence-Based Approach, Volume 2

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ISBN 978-1-4614-7314-5 ISBN 978-1-4614-7315-2 (eBook)
DOI 10.1007/978-1-4614-7315-2
Springer New York Heidelberg Dordrecht London

Library of Congress Control Number: 2013937590

Printed on acid-free paper

Humana Press is a brand of Springer
Springer is part of Springer Science+Business Media (www.springer.com)

Preface

It is well known that nutritional well-being relates to the ingestion of specific micro- and macronutrients. The optimum intakes of these nutrients are subjected to national or international guidelines such as the Dietary Reference Values or the Recommended Daily Allowances. However there is an increasing awareness that well-being is also associated with the qualitative nature of diets.

Diet quality is a broad term that encapsulates both perceived and actual practices, personal preferences, and cultural diversity. Its imprecision contrasts sharply with information derived from quantitative measures of micro- and macronutrients intakes or status. For quantitative measures, the analytical tools range from dietary recall studies and weighed intakes to laboratory measures of circulating nutrients in blood or clinical signs of disease. Measuring dietary quality is more problematic and includes investigating food types, the number or size of portions or their frequency. Diet quality may also be related to the type of food being ingested, snacking, and other eating habits. The inclusions of manufactured beverages (carbonated drinks) or take-away meals may also be included within the measures of diet quality, albeit as a negative measure. It may also include microbiological quality and detailed composition of single food items such as meats, pulses, or vegetables. However, hitherto finding out information on food quality and diet has been fragmentary.

In this book *Diet Quality*: *An Evidence-Based Approach* we cover all of the major facets of diet quality. The book adopts a holistic approach to diet quality and imparts information on the major areas of concern or knowledge. Chapters link in measurable indices of health such as obesity, cardiovascular disease, pregnancy outcomes, mortality, diseases of organs, and cancer.

Contributors are authors of international and national standing, leaders in the field and trendsetters. Emerging fields of science and important discoveries are also incorporated in *Diet Quality*: *An Evidence-Based Approach*.

This book is designed for nutritionists and dietitians, public health scientists, doctors, epidemiologists, healthcare professionals of various disciplines, policy makers, and marketing and economic strategists. It is suitable for teachers and lecturers, undergraduates and graduates, researchers and professors.

London, UK — Victor R. Preedy
Maidenhead, UK — Lan-Anh Hunter
London, UK — Vinood B. Patel

Series Editor Page

The great success of the Nutrition and Health Series is the result of the consistent overriding mission of providing health professionals with texts that are essential because each includes (1) a synthesis of the state of the science, (2) timely, in-depth reviews by the leading researchers in their respective fields, (3) extensive, up-to-date fully annotated reference lists, (4) a detailed index, (5) relevant tables and figures, (6) identification of paradigm shifts and the consequences, (7) virtually no overlap of information between chapters, but targeted, inter-chapter referrals, (8) suggestions of areas for future research, and (9) balanced, data-driven answers to patient as well as health professionals questions which are based upon the totality of evidence rather than the findings of any single study.

The Series volumes are not the outcome of a symposium. Rather, each editor has the potential to examine a chosen area with a broad perspective, both in subject matter as well as in the choice of chapter authors. The editor(s), whose trainings are both research and practice oriented, have the opportunity to develop a primary objective for their book, define the scope and focus, and then invite the leading authorities to be part of their initiative. The authors are encouraged to provide an overview of the field, discuss their own research, and relate the research findings to potential human health consequences. Because each book is developed de novo, the chapters are coordinated so that the resulting volume imparts greater knowledge than the sum of the information contained in the individual chapters.

"Diet Quality: An Evidence-Based Approach," edited by Professor Victor R. Preedy, PhD, DSc, FRSPH, FRSC, FSB, FRCPath, Dr. Lan-Anh Hunter, BSc, MBBS, MRCGP, and Vinood B. Patel, PhD clearly exemplifies the goals of the Nutrition and Health Series. The major objective of this comprehensive two volume text is to review the body of research on the growing importance of the role of diet quality in assuring adequate intake of the essential nutrients, sufficient calories to maintain normal weight, and improve indices of good health. The book includes 50 up-to-date informative reviews of the current thinking about the role of diet quality in the health of individuals during different stages of life, determinants of diet quality around the world and examines the consequences of diet quality on diseases, public health, and international nutrition program development. Practicing health professionals, researchers, and academicians can rely on the chapters in this volume for objective data-driven sources about essential vitamins and minerals, proteins and fats as well as other dietary components that have been determined to be required in healthy diets. This new comprehensive review of the science behind the assessment of diet quality is of great importance to the nutrition community as well as for health professionals who have to answer patient, client, or graduate student questions about the newest clinical research on the nutritional interactions of foods and the health consequences.

"Diet Quality: An Evidence-Based Approach" represents the most comprehensive compilation of the recent data on the critical drivers of food consumption independent of the nutrient density of the foods being consumed. It is to the credit of Drs. Preedy, Hunter, and Patel that they have organized this volume so that it provides an in-depth overview of the critical issues involved in the determination of the best nutritional strategies for infants, toddlers, school-age children, and adult populations whether they were born in developing nations or in developed nations. The volumes' editors provide their in-depth knowledge and expertise to help the reader to understand the value of diet quality in the development of national dietary recommendations. Professor Preedy is a senior member of King's College London where he is a Professor of Nutritional Biochemistry and is also a Professor of Clinical Biochemistry at King's College Hospital. He is also Director of the Genomics Centre and a member of the School of Medicine. He is a member of The Royal College of Pathologists, a Fellow of the Society of Biology, The Royal College of Pathologists, The Royal Society for the Promotion of Health, The Royal Institute of Public Health, The Royal Society for Public Health and in 2012 a Fellow of the Royal Society of Chemistry. Dr. Hunter received her medical degree from Guys, King's & St Thomas' Medical School, London. Her research focuses on the psychological and cultural aspects of diet, nutrition, and anorexia. She also has a background in diabetes research. Dr. Patel is a Senior Lecturer in Clinical Biochemistry at the University of Westminster and honorary fellow at King's College London. Dr. Patel obtained his degree in Pharmacology from the University of Portsmouth, his PhD in protein metabolism from King's College London and completed postdoctoral research at Wake Forest University School of Medicine.

Each of the two volumes contains about 25 comprehensive chapters. The first volume contains four related parts. The first part provides an overview and perspective on national and international diet quality scoring systems and the potential nutritional and health benefits of adopting high quality diets. The quality of diets consumed at home, in the military, hospitals, or other institutions can be dependent upon the costs associated with diets of different levels of quality. Health economics can help to determine the cost-effectiveness of dietary choices. The four chapters in the first part examine the complexities of developing standards and scoring systems, initiatives to determine the science behind food preferences, and use examples of successful and not so successful dietary programs which focus on health as well as cost-effectiveness. The first chapter presents a comprehensive review and tabulation of the current diet quality indexes including, but not limited to the Healthy Eating Index (HEI), Diet Quality Index (DQI), Healthy Diet Indicator (HDI),the Mediterranean Diet Score (MDS), the Diet Quality Index-International (DQI-I), and the Food-Based Quality Index (FBQI). The second chapter examines the biological drive to eat and the complex neural and hormonal systems that control food consumption. The factors affecting the selection of one food over another, including food availability, social and cultural norms, economic, biologic, and cognitive elements, are reviewed. Food preferences are examined including both the learned and innate and those stemming from environmental, psychosocial, biologic, and genetic influences. The environmental and psychosocial elements influencing food choice and preference includes food's perceived value, culture, religion, cost, access, and exposure to food advertisements are discussed. Several of the assessment tools to quantify food intake and preference including food frequency questionnaires, hedonic food scales, feeding studies, food records, and open-ended questionnaires are also reviewed.

The next unique chapter examines the interaction between emotional attachments between parents and children and the quality of foods consumed in the home compared to meals eaten outside the home. The authors take an evidence-based approach to examine the underlying mechanisms contributing to the protective effects of the home on healthy eating. It is widely observed that the nutritional quality of home consumed meals is healthier than in away-from-home settings. The authors present the results of their recent studies that found that the more anxious the children and parents, the poorer the diet quality. The last chapter in this part reviews the literature that examines the cost-effectiveness of healthy eating and describes the association seen between lowered healthcare costs and improved diet quality using data from studies in Australia.

The second part looks at the importance of diet quality for men and women of reproductive age, during pregnancy and in the growth of children. The first two chapters clearly indicate that the effects of maternal diet, as a composite measure of total diet quality on pregnancy outcomes have only recently been studied. There is an overall review of the nutritional requirements of pregnancy that includes a discussion of recent data on dietary fatty acid and folate requirements using the Mediterranean diet as an example. There are important tables and figures that summarize the evidence showing that dietary intake (and diet quality as determined using any of the three quality indexes that have a pregnancy component), influences pregnancy outcomes such as fetal growth, preterm delivery, or neural tube defects. However, the totality of epidemiological evidence regarding the association of diet quality and pregnancy outcomes is weak overall; nonetheless it is suggestive of a beneficial effect of a high quality diet on pregnancy outcomes even in populations that are assumed to be well nourished. Of importance, a study in the USA found that a maternal diet of high quality as measured by the DQI and the MDS during the preconceptional period was associated with a reduced risk of neural tube birth defects.

The importance of maternal choices of foods for their offspring is reviewed in the next chapter. There is evidence that the foods consumed in the first 2 years of life can determine a child's food preferences until adulthood. Poor dietary quality during childhood has been associated with micronutrient deficiencies, overweight, and cardiovascular disease risk factors. The chapter discusses the formation of feeding habits in early childhood, the importance and influence of nutritional programs and guidance for mothers and the impact of diet quality on children's health. Several studies on educational interventions with mothers are reviewed and provide evidence about the positive effects of such interventions on children's diet quality and nutritional conditions. The final chapter in this part examines the diet quality of women from Africa, Asia, and Latin America and concludes that from a biological standpoint as well as a cultural one, women are at greater risk for micronutrient deficiencies than men and that this equates into a number of adverse health outcomes for women and their offspring.

The third part of this volume contains eight chapters that describe the diet quality of children and seniors. Currently, there are no studies that are specifically designed to look at diet quality in children and/or adolescents. The intervention studies that have been done are reviewed and suggest modest improvements in fruit intakes from school-based intervention programs. Two studies from Norway are described that provided a free fruit to school-age children in controlled settings. Free fruit provided over a year resulted in increased fruit intake after the program concluded and reduced consumption of unhealthy snacks. In the next chapter, studies of dietary patterns and their associations with growth and weight parameters in children and adolescents are examined. Using the Youth HEI scores of over 16,000 children and teens, it was reported that children with higher diet quality had lower body mass indexes. Other studies reviewed showed that lower percent body/abdominal fat in children was associated with higher diet quality and conversely, childhood obesity prevalence decreased significantly with increasing diet quality. Diet quality can be significantly influenced by nonfood components.

The next chapter summarizes the data linking TV viewing in children and video game playing in adolescents with lowered diet quality. There is even a large, WHO collaborative cross-national study that was conducted in a number of European countries and regions, and also in the USA, Canada, and Israel. A common identical questionnaire was used. Increased TV viewing time was statistically significantly associated with higher rates of daily consumption of sugared drinks and sweets and was significantly negatively associated with the consumption of vegetables and fruit indicating a common non-healthy diet quality pattern related to TV viewing. The next chapter examines the complex role of parents in the diet quality of their children. As an example, diet quality is negatively associated with not eating regular family meals and the frequent consumption of fast food and meals in front of the television. Unfortunately, there is limited research on parental perceptions of their children's eating behaviors and diet quality, with only one study of the direct comparison between maternal perceptions of the child's diet quality with the actual quality of the child's diet.

Many parents rely on convenience foods, defined in this chapter as foods where preparation has occurred outside the home and the foods are consumed in the home, to complement their children's meal. Use of convenience foods is growing and is often initiated in the second half of infancy and continues through adolescence. Recent research suggests that there is an inverse relationship between convenience food consumption and diet quality; however, producers are reducing salt and fat content to improve the convenience food's quality profile. Changing dietary habits is challenging, as documented in the next chapter that describes an intervention study in high school students in Spain. There were significant, but small, increases in fruit consumption and reductions in body weight in this intensive educational program. Recommendations for follow-up studies include initiation in elementary grades and a more prolonged program of at least 1 year to better reinforce new dietary habits. The last chapter in this part reviews the rationales behind the development of dietary recommended intakes for individuals 70 years old and older in the USA and Canada. The recommendations include an increase in the nutrient density of foods consumed as caloric intake decreases with aging, yet essential nutrient requirements either stay the same or increase. Additionally, there are decreased levels of physical activity, decreased metabolic rates, and increased proportions of fat to lean muscle mass, as well as a greater risk of chronic degenerative diseases and use of many drugs that can affect energy requirements and appetite.

The fourth part, entitled “Foods and Dietary Components” contains five chapters that examine key nutrients such as salt, sweet potatoes, meats, orange juice, and whole grains and how these individual dietary components can alter the quality of diets consumed in different parts of the world. The chapter that describes the beneficial effects of the Mediterranean diet on blood pressure examines current data on the higher than expected salt intake of children and adolescents who are consuming this diet by including a number of processed foods, such as bread, pizza, and cheeses that are high in salt. The authors warn that the beneficial effects on blood pressure may be lost for the next generation if salt concentrations in processed foods are not reduced. The next four chapters describe nutrient sources that can enhance the overall diet quality for populations that may be at risk for nutrient deficiencies. The sweet potato is not one plant, but many different varieties that provide valuable nutrients shown to have health benefits. Sweet potatoes are the seventh most commonly consumed carbohydrate-rich food source in the world. Varieties have been bred that contain higher concentrations of phenolic compounds, β-carotene, anthocyanins, and proteins called sporamins. Health benefits associated with sweet potato consumption include reductions in risk of diabetes, cancer and hypertension, reduction in vitamin A deficiency, improving hepatic functions, and enhanced memory.

Meat, discussed in the next chapter, is an important source of high quality protein, providing all the essential amino acids needed for growth and development. Meat is also an excellent source of essential micronutrients (vitamins, minerals, and trace elements), which are often limited in the diet, including vitamin A, iron, and zinc. Cooking methods and their effects on the nutritional quality of meats are reviewed in this detailed, well-referenced chapter. Another important food that is consumed globally and has high nutrient density is orange juice. Brazil is South America’s largest producer of orange juice and orange derivatives. The second largest producer is the USA, followed by China, Costa Rica, Mexico, and the Mediterranean region. Orange juice is a major contributor to vitamin C intake for children and also contains high quantities of flavonoids and carotenoids. Whole grains are also important contributors to diet quality. In addition to fiber and protein, whole grains are rich sources of B vitamins and vitamin E, minerals including iron, magnesium, potassium, zinc and selenium, beta-glucan, inulin, numerous phytochemicals, phytosterols, phytin, and sphingolipids. Of importance, as described in the final chapter in this part, these compounds exert an additive and/or synergistic effect on health when consumed together. Individuals who consume diets containing higher than average intakes of whole grains have significantly reduced risk of cardiovascular disease and diabetes. Dietary guidelines from nations around the world are tabulated and consistently recommend the daily consumption of whole grains.

The second volume of "Diet Quality: An Evidence-Based Approach" also contains four related parts. The first part examines the data linking diseases and health conditions that are associated with aspects of diet quality. The six chapters in this part review the associations between diet quality and body weight, strokes, menstrual irregularities and pain, breast cancer and nonalcoholic fatty liver disease (NAFLD). Obesity is a major global problem and there are a number of studies that have examined the association between diet quality and body mass index (BMI). Overall, as reviewed in the first chapter in this part, there is a consistent inverse association between the healthiness of dietary intake and prospective weight gain. Poor diet quality is also strongly associated with increased cardiovascular and cerebrovascular diseases. The next chapter describes the detailed data that corroborates the association of low diet quality with significant increased risk of stroke in the male Korean population. C-reactive protein is an accepted biomarker of inflammation associated with increased cardiovascular risk. Preliminary data, summarized in a unique chapter, indicates that C-reactive protein can also serve as an indicator of a poorer diet in children. One nutrient that has been linked to cardiovascular health is calcium. Low calcium intakes, often seen in children and young women, have been associated with increased blood pressure and newer research has also linked low calcium intakes with menstrual pain that may be linked to blood vessel and/or muscle contractions. This chapter examines the potential for numerous nutrients to reduce prostaglandin secretions from uterine tissue that is considered the major source of menstrual pain. Diets that are rich in antioxidants and anti-inflammatory nutrients have been associated with reduced pain during menstruation.

Breast cancer is the leading cancer to affect women and is related to genetic as well as environmental components including dietary factors. Several of the diet quality indexes have been used to determine if dietary factors are predictive of breast cancer incidence, progression, or mortality. The data, tabulated and reviewed, point out the lack of consistent findings between studies that may be in part due to the strong genetic component of this disease. The next chapter describes a relatively new liver disease, NAFLD. The majority of NAFLD patients have metabolic risk factors such as visceral obesity, type II diabetes, and dyslipidemia. As the prevalence of metabolic syndrome, obesity and diabetes continue to increase globally, the prevalence of NAFLD has increased. This very serious disease is mainly treated with weight loss diets and/or surgery. Diet quality, including the composition of the macronutrients in the diet of NAFLD patients may help to reduce the adverse effects of hepatic fat and inflammation. A diet that is low in carbohydrates and saturated fat and high in fiber and omega-3 fatty acids may be beneficial.

As indicated earlier, there are many critical factors that determine an individual's diet quality. The five chapters in the next part examine the roles of eating behavior and psychology on food choices. Survey data suggest that certain behavioral factors can improve diet quality. As an example, the next chapter reviews the association between consuming meals in a family setting vs. eating alone. Family meal frequency is associated with more healthy food intake and behaviors, including more fruits and vegetables, whole grains, calcium rich foods, and protein; less-fried food and sugar-sweetened beverages and more micronutrients from food. The next chapter discusses the motivations for eating. Motivations to eat are related to weight status and predict food intake. Environmental motivations to eat include eating in response to the environment, food availability, and social influences; biological cues including taste and hunger, and psychological factors such as emotional eating and dietary restraint. Obese individuals have less availability of healthy foods, eat in response to environmental cues, and are more comfortable with their weight when surrounded by obese peers. Perceptions of taste and hunger are associated with weight status. Greater self-efficacy and dietary restraint, and reduced vulnerability to eating in response to emotional states are linked to a healthier weight status. Another chapter examines the importance of breakfast to diet quality. A nutrient dense breakfast influences the composition of subsequent meals, regulates energy intake, boosts physical activity levels, and provides a crucial source of dietary micronutrients. The benefits are consistently observed in the USA and around the world when the breakfast includes fortified ready-to-eat cereals. Consistent cereal consumption has been shown to predict improvements in body composition, including BMI in children, adolescents, and adults.

Most animals have biological controls that determine their normal food intake and obesity is not an issue. In contrast, in humans, non-homeostatic or psychological factors may play a more important role in food selection and energy intake than do homeostatic or biological factors. Foods that are high in energy density are often preferred and more reinforcing, but these foods are typically lower in nutrient density. Finding ways to reduce motivation to eat unhealthier food while increasing motivation to eat healthier food to improve diet quality and reduce obesity is the major focus of the next chapter. The final chapter in this part confirms the association between fast food consumption and reduced diet quality. Studies in the USA showed that fast food consumers have a lower overall dietary intake quality score, higher intake of energy, fat, saturated fat, sodium and soft drinks, and lower intake of vitamins A and C, milk, fruits and vegetables than those who did not reported eating fast foods. In addition, a growing number of studies showed an association between fast food consumption and obesity in children and adults.

The third part of this volume examines, from and international perspective, the public health initiatives that have been undertaken by governments to improve the diet quality of their citizens. The ten chapters review recommendations from Germany, Norway, the USA and Puerto Rico, Arabs in Israel, developing countries, sub-Saharan Africa and South Africa specifically.

In the first chapter, we learn that in Germany, the German Nutrition Society establishes the nation's dietary recommendations. Two graphical representations are used. The Nutrition Circle as a concrete representation of quantitative food-based dietary guidelines for adults representing the quantity relationships of different food groups in a balanced diet. The 3D Food Guide Pyramid with four triangle sides is used to illustrate qualitative recommendations for adequate food choices within four major food groups: plant foods, animal foods, fat and oil as well as beverages. There is an interesting chapter that compares the dietary components of the Nordic vs. Mediterranean diets. The Nordic climate does not support the growth of a great variety of fresh vegetables, olives and citrus fruits, but does include plant-derived foods including root vegetables, berries, cabbages, plums, apples, and pears. Rye, oats, barley, and rapeseed oil are also readily available and the Nordic waters contain fish that are rich in long-chain omega-3 fatty acids. These foods are regarded as traditional Nordic foods with favorable health effects.

For over a century, the US Department of Agriculture has issued dietary recommendations for its population. The history of these recommendations and the rationale for the foods that are recommended are reviewed in several chapters. Awareness of these guidelines is also examined in a separate chapter. Awareness of US dietary guidelines has varied by sex, age, race-ethnicity, income, and education. Over 80 % of adults have heard of at least one of the three sets of federal dietary guidance with the greatest awareness of the Food Guide Pyramid. Only about half had heard of the Dietary Guidelines for Americans or the 5 A Day program. There was a significant linear trend of increasing awareness with increasing education, and a similar significant trend of increasing awareness with increasing income level. The Hispanic population of the USA is growing rapidly and represents the largest minority population in the USA. The next chapter describes the process of dietary acculturation which is defined as a minority group adopting the eating patterns or food choices of the host country. Traditional Hispanic foods are fresh and rich in complex carbohydrates, micronutrients, fiber, and phytochemicals. These foods are being replaced by highly processed foods with higher amounts of salt, sugar, and fat. Thus, food acculturation may not change the percentage of the contribution that a specific food group has on total calorie intake, but it can have an impact on the kind of foods that are selected. A unique chapter describes in detail, using nine tables and figures, the melding of the US dietary guidelines with the foods usually consumed in Puerto Rico, a commonwealth and territory of the USA.

Dietary acculturation of nomadic Arabs into Israeli society has been associated with significant changes in all aspects of daily life including diet quality and increased prevalence of chronic diseases. Among traditionally seminomadic Bedouin Arabs, the transition away from whole wheat bread to white bread as the main dietary staple was associated with reductions in diet quality. This chapter confirms that dietary acculturation, in addition to many other changes in lifestyle among Arabs in Israel often negatively affects their diet quality, and may increase the risk for the development of chronic diseases. Determination of diet quality in developing countries and/or developing populations, such as discussed above, can be improved with the use of tools that capture the diversity of the foods consumed. Dietary diversity is defined as the number of foods or food groups consumed, and it is considered as a key dimension of dietary quality. Diverse diets increase the likelihood of adequate intake of essential nutrients. The chapter on diet diversity summarizes new evidence regarding their potential use as a proxy for dietary quality in developing countries. The new studies confirm a positive association between dietary diversity indicators and anthropometric measures in both children and women. As evidence of the importance of diet diversity for measuring diet quality, the next chapter endorses this tool for use in sub-Saharan Africa. Currently, data-driven dietary patterns and dietary diversity may be more appropriate to assess dietary quality in Africa. The dietary transition seen in sub-Saharan Africa reflects globalization of food culture. The chapter describes diet quality of South Africans who have recently moved to cities and uses diet diversity as a tool to determine overall diet quality. In South Africa, the characteristics of malnutrition are changing together with the nutrition transition. In 2007 a health survey found that underweight was uncommon, with less than 5 % of women and 8 % of men with a BMI of <18.5. The survey also found that 50 % of young women and 30 % of young men were either overweight or obese. Research has shown that both hunger and obesity are often present within the same household, especially in low-income households. Higher obesity rates are, furthermore, associated with low-income and education levels and low diet diversity mainly among women.

The final part in the volume includes seven chapters dealing with methods, indexes, and scoring systems and their applications and analysis. The first chapter describes the development of the DQI. The original DQI was developed in the early 1990s for the US population and included food and nutrient-based recommendations. A number of revisions and additions for subpopulations have been developed over time. An adapted version is described that was exclusively based on Food Based Dietary Guidelines (FBDG) and was designed for use in Flemish preschoolers. Although the FBDG-based DQI was designed to compare and monitor dietary changes in populations rather than individuals, it has also served as an effective evaluation tool for intervention studies and clinical trials.

The next chapter describes the development of diet quality indices that reflected the nutritional status of participants in the Framingham Heart Study (FHS) cohorts. The FHS has investigated cardiovascular disease and other health outcomes among Framingham residents in Massachusetts since 1948. A second-generation cohort of 5,124 FHS offspring and their spouses was enrolled in 1971 and comprise the Framingham Offspring/Spouse Study (FOS). Members of the FOS cohort participate in standardized clinical assessments approximately every 4 years. The Framingham Nutrition Studies were initiated in 1984–1988. All men and women completed the Framingham Food Frequency Questionnaire, a single 24-h recall, and a nutrition behavior questionnaire; two-thirds of these participants also completed 3-day dietary records. The Framingham Nutritional Risk Score (FNRS) is a validated 19-nutrient index for evaluating diet quality. The index was developed specifically to assess cardiovascular disease, which is a focus of the FHS. The FNRS has been shown to predict weight change, overweight and obesity, abdominal obesity, and metabolic syndrome. The FNRS is the only index that has shown long-term stability, further validating the utility of diet quality indices. In addition to the FNRS, there are more than 40 published papers that have examined the diet quality in seniors, mainly in developed nations. The systematic review by Freisling et al. evaluates the major criteria for determining factors that affect the diet quality of the elderly. The chapter reminds us that the elderly population is more heterogeneous in terms of functional capacity, physical conditions, social, economic, and lifestyle situations than any other age group, and individual diversity tends to increase with age. This diversity adds an additional dimension in identifying factors that are associated with diet in older adults.

Consistent findings among studies indicate that more efforts are needed to improve diet among elderly, particularly men, overweight and obese individuals, and those with lower educational levels. Health conditions may directly affect food selection, including impaired oral health and/or gastrointestinal problems. Poor diets tend to be clustered with other unhealthy behaviors such as smoking or being physically inactive.

The Overall Nutritional Quality Index (ONQI™) is another index, designed in 2005, to quantify the nutritional and health consequences of certain diet patterns. The objectives of the index are (1) to develop a (the) definitive algorithm to stratify food items within any category, and across food categories, based on overall nutrition quality; (2) to develop a novel metric for the nutritional quality of individual foods based on the relationship among nutrients in foods, the overall quality of the diet, and associations with health outcomes; (3) to place the ability of top nutrition experts to discriminate among food choices on the basis of nutrition into the hands of every consumer; (4) to provide the public a powerful and empowering means to improve dietary intake patterns, and thereby health, one food choice at a time. The authors indicate that the ONQI™ is the only system with published data demonstrating a direct correlation between score variation, and variation in health outcomes including all-cause mortality. Another important component of diet quality is the actual data capture from individuals. There is a unique chapter that describes the use of newly developed electronic data capture tools especially to affect weight loss. Self-monitoring is a behavior change strategy that is central in behavioral weight loss interventions. The process of self-regulation involves self-monitoring, self-evaluation, and self-reinforcement, where self-monitoring occurs first followed by self-evaluation of progress made toward one's goal and self-reinforcement for the progress made. From a practical perspective, self-monitoring consists of identifying a behavior and recording details about its occurrence. It helps individuals learn when and how often a behavior occurs and the circumstances that surround that behavior and the necessary actions to be taken to change desired behaviors.

Another index has been developed to capture food purchasing and its impact on diet quality. The chapter reviews a system of indicators for the nutritional quality of the marketing and food environments in terms of product quality, availability, affordability, and promotion. Indicators in the system were constructed by observing marketing activities at the stock keeping unit

(SKU) level and by geo-coding the stores and media through which the marketing activities occurred. The diagnostic tool assessed the nutritional quality of the food environment created by marketing activities at community, city, provincial/state, national, and global levels. This index has the potential to provide an understanding of how food marketing and nutrition influences individual food choices. Continuous monitoring of manufacturers' and retailers' marketing activities over time can provide vital information to decision-makers regarding whether there is an opportunity to improve the food environment and hence achieve food supply chain transformations toward healthy eating.

The Mediterranean Diet Pattern (MDP) has been shown in numerous studies to be consistently associated with a lower prevalence of ischemic heart disease and lower overall mortality and morbidity. The pattern is characterized by a diet rich in fruit, vegetables, legumes, whole grains, fish, and low-fat dairy products. The next chapter reviews the data and also comments on the changes seen recently in the diets of populations living in the Mediterranean regions. New indexes have been developed to help capture these changes. The Mediterranean Diet Quality Index (KIDMED) was developed to assess the adherence to MDP in school children and adolescents. Based on a new study using the KIDMED score of students, only 6 % were classified as high adherers to a Mediterranean diet and about 42 % were classified as having very low diet quality that correlated with clinically relevant levels of urinary albumin.

The logical sequence of the parts in each volume as well as the chapters within each part enhances the understanding of the latest information on the current standards of practice in diet quality assessment in different countries around the world. This comprehensive two volume resource has great value for academicians involved in the education of graduate students and postdoctoral fellows, medical students, allied health professionals, and public health nutritionists who plan to improve diet quality especially for populations at risk for macro and/or micronutrient deficiencies. Moreover, the final chapter in the volume provides a comprehensive resource to websites, professional organizations, books, journals, and other resources that are of value to any health professional interested in diet quality.

The two volumes contain over 250 detailed tables and figures that assist the reader in comprehending the complexities of food choices, quantification of intake and availability of essential nutrients, composition of diet indexes across the world, comparisons of the nutritional needs of infants and children, pregnant women, other healthy adults and seniors. There are in-depth discussions of the behavioral aspects of eating as well as cultural, genetic, and emotional health inputs into food choices. The overriding goal of this volume is to provide the health professional with balanced documentation and awareness of the newest research and technical approaches including an appreciation of the complexity of the interactions between genetics, health and disease, nutrient deficiencies, and new issues of psychological aspects to food choice in this relatively new field of investigation of diet quality. Hallmarks of the 50 chapters include key words and bulleted key points at the beginning of each chapter, complete definitions of terms with the abbreviations fully defined for the reader, and consistent use of terms between chapters. There are over 2,300 up-to-date references; all chapters include a conclusion to highlight major findings. The volume also contains a highly annotated index.

This unique text provides practical, data-driven resources based upon the totality of the evidence to help the reader understand the basics of determining diet quality, historic perspectives, and descriptions of the most widely used indexes as well as updates that are specialized to capture the diet quality of children, seniors, and other population groups. New research using novel sources of data such as information concerning food purchase choices and uses of electronic personal data collection are described as these are being implemented in the most at risk populations in developed as well as developing nations across the world. Of equal importance, critical issues that involve food preferences, food choice interactions that affect nutrient absorption, and regulatory and public health perspectives in developing national dietary recommendations based upon diet quality data are included in well-referenced, informative chapters. The overarching goal of the editors is to provide fully referenced information to health professionals so they may have a balanced perspective on the value of measuring diet quality to assure governments that their food fortification options improve the nutrient density of consumed diets, as one example.

In conclusion, "Diet Quality: An Evidence-Based Approach," edited by Professor Victor R. Preedy, PhD, DSc, FRSPH, FRSC, FSB, FRCPath, Dr. Lan-Anh Hunter, BSc, MBBS, MRCGP, and Vinood B. Patel, PhD provides health professionals in many areas of research and practice with the most up-to-date, well-referenced, and comprehensive volumes on the current state of the science and medical practice guidelines with regard to the value of dietary quality assessment programs. The two volumes will serve the reader as the most authoritative resource in the field to date and are very welcome additions to the Nutrition and Health Series.

Morristown, NJ, USA

Adrianne Bendich, PhD, FACN, FASN
Series Editor

About Series Editor

Dr. Adrianne Bendich, PhD, FACN, FASN has recently retired as Director of Medical Affairs at GlaxoSmithKline (GSK) Consumer Healthcare where she was responsible for leading the innovation and medical programs in support of many well-known brands including TUMS and Os-Cal. Dr. Bendich had primary responsibility for GSK's support for the Women's Health Initiative (WHI) intervention study. Prior to joining GSK, Dr. Bendich was at Roche Vitamins Inc. and was involved with the groundbreaking clinical studies showing that folic acid-containing multivitamins significantly reduced major classes of birth defects. Dr. Bendich has coauthored over 100 major clinical research studies in the area of preventive nutrition. Dr. Bendich is recognized as a leading authority on antioxidants, nutrition and immunity and pregnancy outcomes, vitamin safety and the cost-effectiveness of vitamin/mineral supplementation.

Dr. Bendich, who is now President of Consultants in Consumer Healthcare LLC, is the editor of ten books including "Preventive Nutrition: The Comprehensive Guide for Health Professionals, Fourth Edition" coedited with Dr. Richard Deckelbaum, and is *Series Editor of* "Nutrition and Health" for Springer/Humana Press (http://www.springer.com/series/7659). The Series contains over 50 published volumes—major new editions include *Vitamin D, Second Edition* edited by Dr. Michael Holick; "Dietary Components and Immune Function" edited by Dr. Ronald Ross Watson, Dr. Sherma Zibadi, and Dr. Victor R. Preedy; "Bioactive Compounds and Cancer" edited by Dr. John A. Milner and Dr. Donato F. Romagnolo; "Modern Dietary Fat Intakes in Disease Promotion" edited by Dr. Fabien DeMeester, Dr. Sherma Zibadi, and Dr. Ronald Ross Watson; "Iron Deficiency and Overload" edited by Dr. Shlomo Yehuda and Dr. David Mostofsky; "Nutrition Guide for Physicians" edited by Dr. Edward Wilson, Dr. George A. Bray, Dr. Norman Temple, and Dr. Mary Struble; "Nutrition and Metabolism" edited by Dr. Christos Mantzoros and "Fluid and Electrolytes in Pediatrics" edited by Leonard Feld and Dr. Frederick Kaskel. Recent volumes include "Handbook of Drug-Nutrient Interactions" edited by Dr. Joseph Boullata and Dr. Vincent Armenti; "Probiotics in Pediatric Medicine" edited by Dr. Sonia Michail and Dr. Philip Sherman; "Handbook of Nutrition and Pregnancy" edited by Dr. Carol Lammi-Keefe, Dr. Sarah Couch, and Dr. Elliot Philipson; "Nutrition and Rheumatic Disease" edited by Dr. Laura Coleman; "Nutrition and Kidney Disease" edited by Dr. Laura Byham-Grey, Dr. Jerrilynn Burrowes, and Dr. Glenn Chertow; "Nutrition and Health in Developing Countries" edited by Dr. Richard Semba and Dr. Martin Bloem; "Calcium in Human Health" edited by Dr. Robert Heaney and Dr. Connie Weaver and "Nutrition and Bone Health" edited by Dr. Michael Holick and Dr. Bess Dawson-Hughes.

Dr. Bendich served as Associate Editor for "Nutrition" the International Journal; served on the Editorial Board of the Journal of Women's Health and Gender-based Medicine, and was a member of the Board of Directors of the American College of Nutrition.

Dr. Bendich was the recipient of the Roche Research Award, is a *Tribute to Women and Industry* Awardee and was a recipient of the Burroughs Wellcome Visiting Professorship in Basic Medical Sciences, 2000–2001. In 2008, Dr. Bendich was given the Council for Responsible Nutrition (CRN) Apple Award in recognition of her many contributions to the scientific understanding of dietary supplements. Dr. Bendich holds academic appointments as Adjunct Professor in the Department of Preventive Medicine and Community Health at UMDNJ and has an adjunct appointment at the Institute of Nutrition, Columbia University P&S, and is an Adjunct Research Professor, Rutgers University, Newark Campus. She is listed in Who's Who in American Women.

About Volume Editors

Victor R. Preedy, BSc, **PhD**, **DSc**, **FSB**, **FRCPath**, **FRSPH**, **FRSC** is a senior member of King's College London (Professor of Nutritional Biochemistry) and King's College Hospital (Professor of Clinical Biochemistry). He is attached to both the Diabetes and Nutritional Sciences Division and the Department of Nutrition and Dietetics. He is also Director of the Genomics Centre and a member of the School of Medicine. Professor Preedy graduated in 1974 with an Honors Degree in Biology and Physiology with Pharmacology. He gained his University of London PhD in 1981. In 1992, he received his Membership of the Royal College of Pathologists and in 1993 he gained his second doctoral degree, for his outstanding contribution to protein metabolism in health and disease. Professor Preedy was elected as a Fellow to the Institute of Biology in 1995 and to the Royal College of Pathologists in 2000. Since then he has been elected as a Fellow to the Royal Society for the Promotion of Health (2004) and The Royal Institute of Public Health (2004). In 2009, Professor Preedy became a Fellow of the Royal Society for Public Health and in 2012 a Fellow of the Royal Society of Chemistry. In his career Professor Preedy has carried out research at the National Heart Hospital (part of Imperial College London) and the MRC Centre at Northwick Park Hospital. He has collaborated with research groups in Finland, Japan, Australia, USA, and Germany. He is a leading expert on the science of health. He has lectured nationally and internationally. To his credit, Professor Preedy has published over 570 articles, which includes 165 peer-reviewed manuscripts based on original research, 100 reviews, and over 50 books and volumes.

Dr. Lan-Anh Hunter, **BSc**, **MBBS**, **MRCGP** qualified from Guys, King's & St Thomas' Medical School, London in 2001. This is part of King's College London, currently ranked 21st in the QS World University Rankings. Her undergraduate degree was a BSc in Medical Anthropology from University College, London in 1998 (currently ranked fourth in the QS World University Rankings). Her thesis focused on the psychological and cultural aspects of diet, nutrition, and anorexia. She has a background in diabetes research, often with an emphasis on the role of nutrition in diabetes. She worked in Australia in both urban and rural contexts and has won awards for her contributions to the study of nutritional education and diabetes care in the Aboriginal population. Prior to becoming a principal General Practitioner in the UK, she undertook a period of specialist training in diabetes. Her current practice is the diabetes lead in the primary care locality, advising practice and policy for the region. She is dedicated to teaching having taught medical students, lectured regularly at Charing Cross Hospital, London and is a General Practitioner trainer, training the General Practitioners of the future. In addition to her academic, teaching, and advisory roles she remains a General Practitioner with special interests in nutrition and diabetes, and more broadly the role of diet in health and disease.

Dr. Vinood B. Patel, **PhD** is currently a Senior Lecturer in Clinical Biochemistry at the University of Westminster and honorary fellow at King's College London. Dr. Patel obtained his degree in Pharmacology from the University of Portsmouth, his PhD in protein metabolism from King's College London in 1997 and carried out postdoctoral research at Wake Forest University School of Medicine, USA where he developed novel biophysical techniques to characterize mitochondrial ribosomes. He presently directs studies on metabolic pathways involved in fatty liver disease, focusing on mitochondrial energy regulation and cell death. Dr. Patel has published over 150 articles, including books in the area of nutrition and health prevention.

Acknowledgments

The development of this book is built upon the foundation of the excellent work provided by the staff of Humana and we are very thankful to them. In particular we wish to acknowledge the outstanding support, advice, and patience of the Series Editor, Dr. Adrianne Bendich, Developmental Editor, Michael Griffin, and Editor, Amanda Quinn.

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Part I

Diseases and Conditions

1 The Association Between Diet Quality and Weight Change in Adults Over Time: A Systematic Review of Prospective Cohort Studies

Haya Aljadani, Amanda Patterson, David Sibbritt, and Clare Collins

Key Points

- In general women with unhealthy dietary intakes, as assessed by diet quality scoring tools, gain more weight over time compared to men with unhealthy dietary intake patterns.
- Women with the poorest diet quality gain approximately an additional 300 g/year compared to those assessed as having the highest diet quality.
- Assessing diet quality using differing diet scores or diet indexes can be used to evaluate the variation in annual weight gain. The strength of the relationship between diet quality and weight gain over time does vary depending on the tool used to assess the relationship.
- However there are not enough studies using similar methods to allow a thorough examination of this, and further research is required using different diet quality assessment tools and approaches to determine how reliably they are able to predict for future weight gain in adults.
- Although the current evidence base is not extensive and there is some inconsistency across the findings there is an inverse association between the healthiness of dietary intake and prospective weight gain.
- More research of high methodological quality is needed to examine other lifestyle behaviours of participants with the poorest diet quality in order to try and identify other factors associated with consumption of

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V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health, DOI 10.1007/978-1-4614-7315-2_1,

unhealthy foods as well as opportunities to tailor interventions to prevent weight gain in adults.
- Future research studies should consider confounders and interactions between variables when examining the relationship between diet quality and weight gain.

Keywords

Diet index • Diet Quality • Diet score • Weight Change • Weight Gain • Obesity • Longitudinal • Cohort

Abbreviations

BMI	Body mass index
DQI	Diet Quality Index
EI	Energy intake
FFQ	Food Frequency Questionnaire
FNRS	Framingham Nutritional Risk Score
MDP	Mediterranean dietary patterns
MDS	Mediterranean Diet Score
rMDS	Revised Mediterranean Dietary Score
TEI	Total energy intake
WC	Waist circumference

Introduction

Obesity is defined as an excess of body fat. Different methods can be used to determine the degree of adiposity, with body mass index (BMI) being a commonly used indirect method [1]. BMI is defined as weight in kilograms divided by the square of height, in metres. According to the WHO BMI classifications, obesity is defined as BMI ≥30 kg/m^2, while overweight is defined as $25 \leq \text{BMI} < 30$ kg/m^2 [2].

Obesity is associated with a decreased quality of life, increased morbidity and reduced life expectancy [3, 4]. Obesity increases the risk of many chronic diseases, including cardiovascular disease (CVD), diabetes, hypertension, metabolic syndrome and dyslipidaemia [5, 6]. It can also increase the risk of some cancers such as cancer of the breast, oesophagus, pancreas, colon and rectum, endometrium, kidney and potentially the gallbladder [7–9]. Studies show that obese people have lower levels of high-density lipoprotein (HDL) with higher levels of total cholesterol, triglycerides and apolipoprotein than nonobese people [10]. A relationship between body weight, body fat and bone mineral density (BMD) has also been suggested with some studies finding increased body fat and waist circumference with decreased BMD [11]. One such study examined 398 subjects aged 44.1 ± 14.2 years with a BMI 35.8 ± 5.8 kg/m^2 and found a significant inverse correlation between BMI and BMD [12].

Obese women are more likely than nonobese women to experience morbidity and to die prematurely due to the adverse effects of overweight and obesity [7]. The same is true of men, especially men with excess abdominal adiposity, which is associated with premature mortality due to CVD [13], along with an increased prevalence of mental health conditions, such as depression [8].

The costs of the adverse effects of obesity on individuals, the health system and to society are enormous. A 2009 US report has predicted that from 2020 to 2025 about $208 billion will be attributed to the costs of lost worker productivity, morbidity and premature death [14]. Furthermore, 1.5 million life-years will be lost, with the total cost of medical care estimated at $46 billion for this same period [14]. In Australia, a recent report estimated that the annual (2004–2005) total direct cost in health care and non-health care per person increased from $1,472 per year (95 % CI, $1,204, 1,740) for those of normal weight to

$2,788 per year (95 % CI, $2,542, 3,035) for those who were obese [15].

The prevalence of obesity has grown rapidly all over the world [16]. A 2006 estimate suggests that obesity affects at least 400 million adults worldwide with an additional 1.6 billion adults (age ≥15 years old) defined as overweight [2]. In Australia, more than half (54 %) of the adults were reported as overweight or obese in the 2004–2005 Australian National Health Survey [17] and this percentage increased to 61.4 % in the 2007–2008 Australian National Health Survey [18].

Today adults are more likely to gain weight at an earlier age than adults in the past [19]. Further, adults currently of an ideal body weight have a 50 % chance of becoming overweight and a 25 % chance of becoming obese over a period of 30 years [20]. Adults gain weight throughout life, especially at specific life stages. For example, men are more likely to gain weight after marriage, whereas women tend to gain weight during pregnancy and during the menopausal transition [21]. Also after giving up smoking and/or changing one's place of residence, weight gain can occur and has been reported for both genders [21]. The specific causes of weight gain are complex and are due to more than one single factor. Epidemiological and experimental studies demonstrate that nutrition behavioural factors such as diet composition, portion size, types of food and eating patterns, as well as snacking lead to weight gain [19].

Diet is a major modifiable factor. Dietary manipulation assists people to successfully lose weight whereas unhealthy dietary patterns or poor dietary quality can contribute to weight gain [22–24]. An excessive calorie intake, above total energy requirements, contributes to obesity and overweight [2]. Some studies have reported that excessive dietary fat and protein intakes are associated with higher BMI. One such study followed a cohort of 31,940 healthy women aged 30–55 years for 8 years and found that prior weight loss and younger age were stronger predictors of subsequent weight gain than dietary intake and that calorie intake was significantly related to past weight gain but did not relate to future weight gain [25]. Other studies suggest that higher intakes of dietary fibre, carbohydrate, vegetables, fruits, vitamin C, carotene and caffeine can be inversely related to BMI, but the studies' findings are mixed [25, 26].

Although major research efforts have been made, the contributions of dietary factors and eating behaviour to the development of excessive body weight have been particularly difficult to identify [27], partly due to the challenges in measuring dietary intake. Further, the contribution of dietary quality has not been studied extensively. Links between dietary intake and weight change are complex because of the multifactorial nature of obesity and overweight, including eating in excess of requirements, together with a poor lifestyle, including lack of physical activity [25, 28]. Further, the environment can affect eating behaviour. For example, people who live near fast-food restaurants have been shown to consume more fast food [29]. On the other hand, people who live near a supermarket tend to eat more healthful foods, especially fruit and vegetables [29]. There are also additional factors that contribute to obesity and overweight such as genetics, ethnicity and age [30, 31].

Little is known about the association between overall or total diet patterns, especially in terms of diet quality, and weight change over time. Diet quality is a measure of the quality of the whole diet and is a concept that aims to assess the quality of an individual's overall eating patterns using various scores or indexes to assess how closely the individual's usual diet is aligned with national dietary guidelines [32]. Therefore, the aim of this review is to identify the best available evidence on the association between diet quality and weight change over time, both short and long term, in cohort or case–control studies, and to summarise what is currently known in this area.

To obtain relevant published studies, a search was performed in two stages: the first stage was a search of four databases: MEDLINE, CINAHL, EMBASE and Scopus. This search was conducted to find cohort or case–control studies, published between 1970 and February 2011 in the English language. The second stage involved manual searches to find additional studies by means of the reference lists of all identified reports and articles.

Keywords included those relating to diet in the adult population (e.g. food patterns, eating behaviours, diet quality, diet index, diet variety, diet patterns) and weight status (e.g. weight gain, BMI, weight change, waist circumference).

The studies selected here include studies with a follow-up period in a longitudinal or case–control study and which assessed dietary intake and weight status in adults aged ≥18 years at baseline.

Dietary intake was the exposure variable with a range of methods used to measure dietary intake, including but not limited to 24-h recalls, multiple day dietary records, food frequency questionnaires (FFQ) or diet histories.

Weight status was the primary outcome and was measured by any of the following methods: weight (kg), BMI, waist circumference (WC) or % body fat.

Participants were all healthy adult males and females aged ≥18 years at baseline.

All longitudinal studies were included where the participants were followed up to determine the association between the overall dietary intake and weight change. A number of methods, including scoring techniques or indexes, were used to evaluate diet quality.

The selection of the included studies was carried out in two stages. The first stage was to retrieve all studies which met the previous criteria based on reading the title and abstract. The second stage was to thoroughly examine all of the retrieved papers. Seven studies were identified and assessed by two independent reviewers in the two stages. In the case of a disagreement about study selection in the first stage, that paper was retrieved. If any disagreement occurred in the second stage, a third independent reviewer was consulted to decide whether the paper should be included or not (Fig. 1.1).

Study quality was assessed using standardised critical appraisal instruments from the Joanna Briggs Institute Meta Analysis of Statistics Assessment and Review Instrument (JBI-MAStARI).

Figure 1.1 describes the flow of studies meeting the inclusion criteria for this systematic review. Table 1.1 summarises each study's details (i.e. sample size, country and length of follow-up) and participant baseline characteristics. Table 1.2 reports the data extraction for dietary intake within the included studies and how the diet quality score is derived, including how each component or subscale is scored. Table 1.3 summarises the main outcome data related to absolute change in body weight or BMI during follow-up, the statistical analysis and any confounders for which results were adjusted. Table 1.4 reports the significance of the included studies and Table 1.5 the quality of the included studies.

Of 2,304 studies originally identified, seven met all inclusion criteria. These examined the association between overall diet quality and weight change, BMI or obesity incidence and used different methodologies to evaluate dietary patterns. One study [24] used the diet quality index (DQI), two studies [1] used the Framingham Nutritional Risk Score (FNRS) and four studies used different scoring methods to assess adherence to the Mediterranean dietary patterns (MDP).

The total number of participants across the two studies which used FNRS was 2,105 adults (≈67 % female) [1, 33]. Both of these studies were derived from the Framingham Offspring and Spouse Study (FOSS) in the USA, with 16 years of follow-up. The only study that used DQI was also derived from FOSS with 60 % of the participants being female [24]. Two studies were derived from the Seguimiento Universidad de Navarra (SUN) cohort, and different scoring methods were used to evaluate a number of Mediterranean Diet Scoring (MDS) approaches in these studies [34, 35]. Three studies were carried out in Spain [34–36]. Romaguera et al.'s [37] analysing data from the European Prospective Investigation into Cancer—Physical Activity, Nutrition, Alcohol consumption, Cessation of smoking, Eating out of home And obesity (EPIC-PANACEA) Project derived from six cohorts that were established in ten European countries to study the association between adherence to MDP

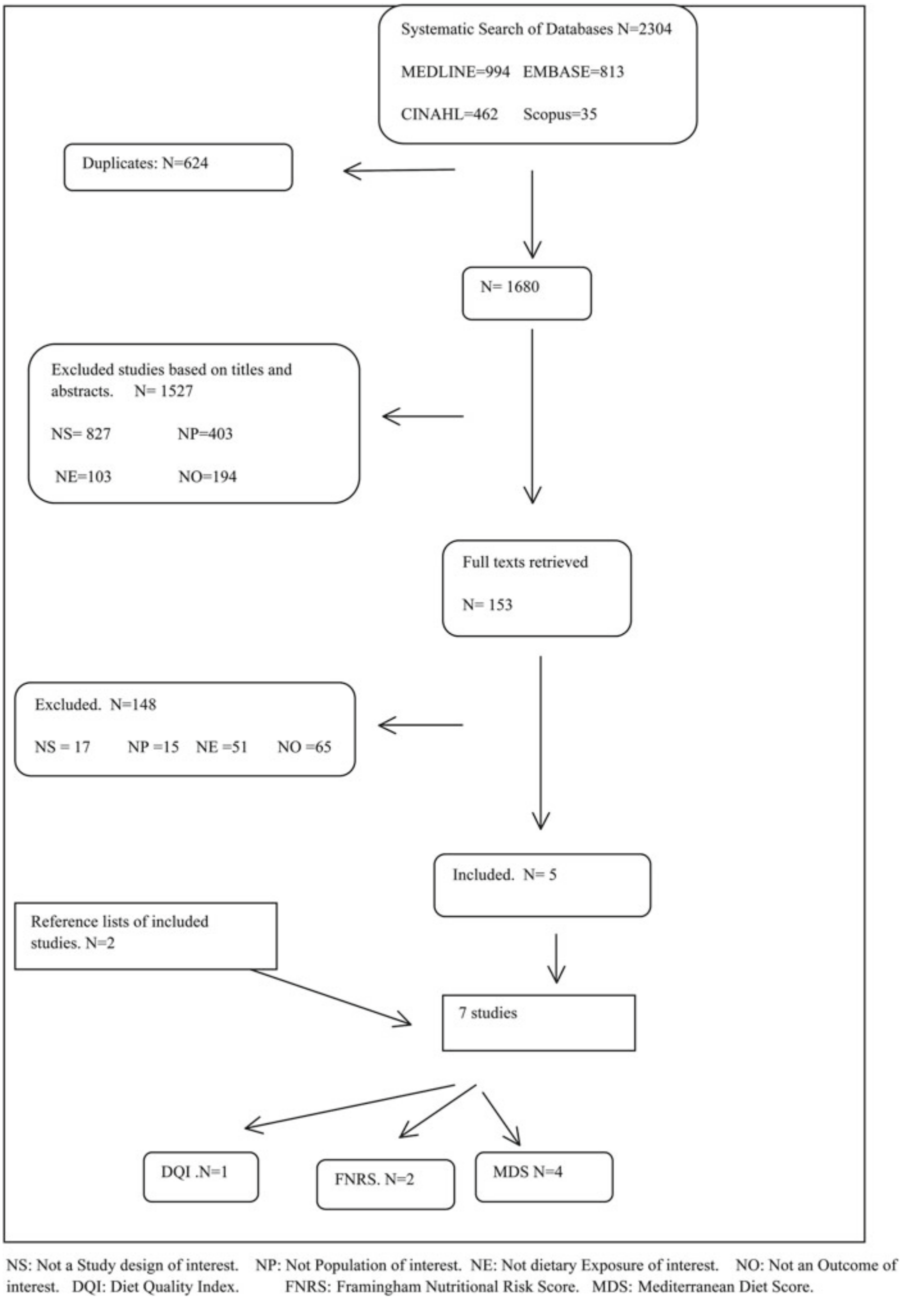

Fig. 1.1 Flowchart of studies identified for inclusion in a systematic review of the relationship between diet quality and weight change in adults over time

and weight change, and incidence of overweight or obesity. Mean participant age across all included studies was ≥25 years and retention rates varied from 58 to 100 % (Table 1.1).

Dietary intake methods used in the seven included studies were 3-day estimated dietary records [21, 32, 33], FFQ [34, 35] and diet history [37] (Table 1.2).

Table 1.1 Characteristics of the studies that examined diet quality

	References	Study design and cohort's name	Population at baseline, *N*, age and gender	BMI at baseline	Country	F/U	Retention	Purpose
1	Quatromoni et al. [24]	Framingham Offspring and Spouse (FOSS) Study	M∞, F¨ = 2,245 M = 990 F = 1,255, aged 49–56 years	BMI for M in lowest and highest scores of DQI were 27.4 ± 3.7 and 26.9 ± 3 (kg/m^2), respectively; *P* for trend 0.4 And for F were 25.8 ± 5.8 and 25.7 ± 4.3, respectively; *p* for trend 0.0042	USA	8 years	58 %	To assess the relationship between 8-year weight change among Framingham study participants and adherence to the fourth edition of the Dietary Guidelines measured using DQI
2	Kimokoti et al. [1]	Framingham Offspring and Spouse (FOSS) Study	M∞, F¨ = 1,515 M = 690 F = 825, aged ≥30 years	Mean BMI = 24.7 ± 4.3; 26.8 ± 3.4 kg/m^2 in F and M, respectively	USA	16 years	67 %	(1) Examined patterns of long-term weight change among Framingham men and women over 16 years. (2) Evaluate how diet quality compares with demographic, anthropometric, biological, clinical and other lifestyle factors in predicting weight change in our participants; and (3) impact of these factors, including smoking status, on the association between diet quality and weight change
3	Wolongevicz et al. [33]	The Framingham Offspring and Spouse (FOSS) Study	F = 590 normal weight (BMI < 25 kg/m^2), aged 25–71	Mean BMI across the FNRS tertiles were 22.3, 21.9 and 22 from the lowest to highest tertiles	USA	16 years	100 %	The relationship between diet quality and the development of overweight or obesity in women

4	Beunza et al. [34]	The Seguimiento Universidad de Navarra (SUN) cohort	F, M = 10,376 Mean age 38 years	Mean BMIs were 23.4 ± 3.4, 23.4 ± 3.4, 23.4 ± 3.4 and 23.3 ± 3.4 across baseline MDS from the lowest to highest quartile of MDS	Spain	Mean F/U 5.7 ± 2.2 years	>90 % (for the first 24 months)	The correlation between MDSs and weight gain
5	Sanchez-Villegas et al. [35]	The Seguimiento Universidad de Navarra (SUN) cohort	F, M = 6,319	Mean BMIs were 23.4 ± 3.4, 23.4 ± 3.4, 23.6 ± 3.4 and 23.4 ± 3.4 across baseline MDS from the lowest to highest quartile of MDS	Spain	28 months	90 %	The association between each component at baseline (score_1) and weight or BMI change as outcome. Also overall adherence to the MDP (quartiles of score_1 and outcome)
6	Mendez et al. [36]	The European Prospective Investigation into Cancer and Nutrition (EPIC)—Spain	F = 17,238 M = 10,589 Aged 29–65 years	BMI of participants was >18 and <30 kg/m^2	Spain	Mean of F/U 3.3 years	95 %	To examine whether adherence with MD patterns is associated with obesity incidence for 3 years of follow-up
7	Romaguera et al. [37]	The European Prospective Investigation into Cancer and Nutrition—Physical Activity, Nutrition, Alcohol consumption, Cessation of cmoking, Eating cut of come And obesity (EPIC-PANACEA) project	F, M = 373,803 F = 270,348 M = 103,455 Aged 25–70 years	No data given—all categories of BMI included	Denmark, France, Germany, Greece, Italy, Netherlands, Norway, Spain, Sweden and UK	Median F/U 5 years	Unclear	The association between adherence to MDP and weight change and incidence of overweight or obesity

M male, *F* female, *F/U* follow-up

Table 1.2 Description of dietary intake methods used in included studies

	References	Dietary intake method	Diet quality tool	How the score is derived using the diet quality tool	How the diet quality scores are calculated
1	Quatromoni et al. [24]	3 day estimated food records	Diet quality index (DQI)	5-point DQI to assess adherence to key US dietary recommendations One DQI point was contributed for each of five nutrients if (1) Total fat (<30%kcal) (2) Saturated fat (<10 % kcal) (3) Carbohydrate (>50 % kcal) (4) Cholesterol (<300 mg/day) (5)Sodium (<2,400 mg/day) DQI scores ranged from 0 to 5	Participants classified at baseline within gender across the five points of DQI scores
2	Kimokoti et al. [1]	3 day estimated food records	Framingham Nutritional Risk Score (FNRS)	19 nutrients (1) Total energy (kJ) (2) Protein (% energy) (3) Total fat (% energy) (4) Monounsaturated fat (% energy) (5) Saturated fat (% energy) (6) Alcohol (% energy) (7) Cholesterol (mg/4,184 kJ) (8) Sodium (mg/4,184 kJ) (9) Carbohydrate (%energy) (10) Polyunsaturated fat (% energy) (11) Fibre (g/4,184 kJ) (12) Calcium (mg/4,184 kJ) (13) Selenium (μg/4,184 kJ) (14) Vitamin C (g/4,184 kJ) (15) Vitamin B-6 (g/4,184 kJ) (16) Vitamin B-12 (μg/4,184 kJ) (17) Vitamin E (g/4,184 kJ) (18) Folate (μg/4,184 kJ) (19) Beta-carotene (μg/4,184 kJ)	FNRS had an overall score computed from the mean score of 19 nutrients for each subjects within each gender

3	Wolongevicz et al. [33]	3 day dietary record	Framingham Nutritional Risk Score (FNRS)	19 nutrients (1) Total energy (kJ) (2) Protein (% energy) (3) Total fat (% energy) (4) Monounsaturated fat (% energy) (5) Saturated fat (% energy) (6) Alcohol (% energy) (7) Cholesterol (mg/4,184 kJ) (8) Sodium (mg/4,184 kJ) (9) Carbohydrate (%energy) (10) Polyunsaturated fat (% energy) (11) Fibre (g/4,184 kJ) (12) Calcium (mg/4,184 kJ) (13) Selenium (μg/4,184 kJ) (14) Vitamin C (g/4,184 kJ) (15) Vitamin B-6 (g/4,184 kJ) (16) Vitamin B-12 (μg/4,184 kJ) (17) Vitamin E (g/4,184 kJ) (18) Folate (μg/4,184 kJ) (19) Beta-carotene (μg/4,184 kJ)	Participants were categorised across tertiles of FNRS
4	Beunza et al. [34]	FFQ with 136 food item	MDS-Trichopoulou	There are nine food items—the amount of intake of these food are for M and F, respectively (1) Vegetables 550 and 500 (g/day) (2) Fruit and nuts 360 and 360 (g/day) (3) Legumes 9 and 7 (g/day) (4) Cereals, bread and potatoes 180 and 140 (g/day) (5) Ratio of monounsaturated fatty acids to saturated fatty acids 1.7 and 1.7 (g/day) (6) Moderate alcohol (10–15 g/day) for M and (50–25 g/day) for F (7) Fish 24 and 19 (g/day)	MDS: low score range, 0–3; moderate score, 4–6; high score, 7–9. Participants were categorised into tertile

(continued)

Table 1.2 (continued)

	References	Dietary intake method	Diet quality tool	How the score is derived using the diet quality tool	How the diet quality scores are calculated
				(8) Meat and poultry 120 and 90 (g/day) (9) Dairy products 200 and 190 (g/m) A maximum of 9 points total from the last components	
4	Beunza et al. [34]	FFQ with 136 food item	The Mediterranean Adequacy Index (MAI) proposed by Alberti-Fidanza et al. (2004)	Sum of percentage total energy from the following typical Mediterranean foods (1) Bread (2) Cereal (3) Legumes (4) Potatoes (5) Vegetables (6) Fruit (7) Fish (8) Red wine (9) Vegetable oils	MAI-Alberti-Fidanza Scores: ≤0.95 (lowest); >0.95 to ≤1.31 (moderate); >1.31 to ≤1.84 (high); >1.84 (highest)
				Divided by sum of the percentage total energy from the following nontypical Mediterranean foods (1) Milk (2) Cheese (3) Meat (4) Eggs (5) Animal fat and margarines (6) Sweet beverages (7) Pastries (8) Cookies (9) Sugar	The researchers examined the relationship between these indexes and yearly weight change according to categorical (tertiles or quintiles) of indexes scores
			Mediterranean Diet Quality Index (MDQI) proposed by Scali et al. (2001)	Each of the following items categorised into tertiles and scored from 1 to 3: *Positive* (higher consumption scored 1, medium consumption scored 2, low consumption scored 3)	MDQI-Scali Scores: ≥11 (lowest); 8–10 (moderate); 5–7 (high); ≤4 (highest)

		(1) Vegetables and fruit (g/day) (2) Cereals (bread, pasta, rice and breakfast cereals) (g) (3) Olive oil (mL) (4) Fish (g) *Negative* (higher consumption scored 3, medium consumption scored 2, low consumption scored 1) (1) Meat (g) (2) Saturated fatty acids (% total energy) (3) Cholesterol (mg); the 7 scores were summed (range 0–14): lower score = higher adherence to Mediterranean diet	
	Mediterranean dietary pattern (MDP) proposed by Sánchez-Villegas et al. (2002)	Energy-adjusted intakes of the following items: *Positive* (1) Vegetables (g/day) (2) Fruit (g/day) (3) Legumes (g/day) (4) Cereals incl. bread and potato (g/day) (5) Ratio of monounsaturated fatty acids to saturated fatty acids (6) Moderate alcohol (g/day)—30 for men, 20 for women (not energy adjusted) *Negative* (1) Meat and meat products (g/day) (2) Milk and dairy products (g/day) (3) Trans-fatty acids (g/day) All items standardised as *z*-scores then summed (subtracting negative items) and transformed into % of adherence Score range: 0–100 %	MDP-Sánchez-Villegas Scores: ≤44.23 (lowest); >44.23 to ≤49.47 (moderate); >49.47 to ≤54.97 (high); >54.97 (highest)
	Diet score (DS) proposed by Panagiotakos et al. (2006)	Food items rated 0–5 (reverse for negative items) according to position in Mediterranean diet pyramid:	MDS-Panagiotakos Scores: ≤29 (lowest); 30–33 (moderate); ≥34 (highest)

(continued)

Table 1.2 (continued)

References	Dietary intake method	Diet quality tool	How the score is derived using the diet quality tool	How the diet quality scores are calculated
			Positive (1) Vegetables (times/day or month) (2) Potatoes (times/day or month) (3) Fruit (times/day or month) (4) Legumes (times/day or month) (5) Non-refined cereals (times/day or month) (6) Olive oil (times/day or month) (7) Alcohol (times/day or month) (0 for >700 mL/day, 5 for <300 mL/day) (8) Fish (times/day or month) (9) Poultry (times/day or month) *Negative* (1) Meat and meat products (times/day or month) (2) Full-fat dairy (times/day or month) Score range: 0–55	
		Mediterranean-Style Dietary Pattern Score (MSDPS) recently proposed by Rumawas et al. (2009)	0–10 rating for each item according to its closeness to the goals of the Mediterranean pyramid:	MSDPS-Rumawas Scores: ≤20 (lowest); >20 to 35 (moderate), >35 (highest)
			(1) Vegetables (6 servings/day) (2) Potatoes and other starchy roots (3 servings/week) (3) Fruit (3 servings/day) (4) Legumes, olives and nuts (4 servings/week) (5) Wholegrains (8 servings/day) (6) Sweets (3 servings/week) (7) Dairy products (2 servings/day) (8) Eggs (3 servings/week) (9) Olive oil (as the only fat) (10) Wine (3 glasses/day for M, 1.5 glasses/day for F)	

				(11) Fish (6 servings/week) (12) Poultry (4 servings/week) (13) Meat (1 serving/week) Further adjustment made according to proportion of total energy intake (TEI) provided by consumption of Mediterranean foods Score range: 0–100	
5	Sánchez-Villegas et al. [35]	FFQ with 136 food item	MDS	A maximum of 30 points total from the components (1) Cereals (g/day) (2) Vegetables (g/day) (3) Fruits (g/day) (4) Legumes (g/day) (5) Fish (g/day) (6) Nuts (g/day) (7) Olive oil (g/day) (8) Moderate red wine consumption (g/day) (9) Meat and meat products (g/day) (10) Whole-fat dairy products (g/day)	MDS categorised into quartiles: l ower (<18); moderate (18–19); high (20–21); highest (≥22)
6	Mendez et al. [36]	Diet history with >600 items	MDS	A maximum of 8 points derived from the following components (1) Fish (g/MJ) (2) Vegetables (g/MJ) (3) Fruits and nuts (g/MJ) (4) Legumes (g/MJ) (5) Cereals (g/MJ) (6) Ratio of monounsaturated fat to saturated fat (g/MJ) (7) Moderate ethanol intakes (defined as 5–25 g/day for women, 10–50 g/day for men) (8) Meat (g/MJ)	MDS were categorised in three parts: low (0–3), medium (4–5) and high (6–8)

(continued)

Table 1.2 (continued)

	References	Dietary intake method	Diet quality tool	How the score is derived using the diet quality tool	How the diet quality scores are calculated
7	Romaguera et al. [37]	FFQ	A revised MDS	There are nine components of this score as follows (1) Vegetables (2) Legumes (3) Fruit and nuts (4) Cereals (5) Fish and seafood (6) Olive oil (7) Moderate alcohol consumption (8) Meat and meat products (9) Dairy products Each component was measured in g/1,000 kcal to express ED	The rMED was classified into categories to reflect low (0–6 points), medium (7–10 points) or high (11–18 points) adherence to the MDP

[AU4] **Table 1.3** Description of the outcome measures for the included studies

	References	The outcome	Statistical analysis	Result	Key finding	Confounders
1	Quatromoni et al. [24]	8-year wt gain in lb	Multivariate generalised estimating equations within gender using the mean of DQI score for all participants as the predictor	Participants in the highest DQI quintile gain less wt over 8 years (*P* for trend <0.01). The mean ± SD of wt gain in F in the highest DQI quintile was 3.3 ± 17.4 lb compared with 8.0 ± 13.0 lb gained in those within the lowest DQI quintile. The mean ± SD of wt gain in M in the highest DQI quintile was 2.7 ± 10.1 lb compared with 5.1 ± 13.3 lb those in the lowest DQI quintile	There is significant inverse association between the mean of DQI score for all participant and weight change in both adults; $p = 0.026$ and $p = 0.008$, respectively, for M and F	Age, BMI, physical activity, alcohol intake, smoking cessation, intentional change in diet, postmenopausal, energy intake Note: Smoking cessation was an important predictor of weight gain, accounting for about a 5- to 9-pound difference in weight gain
2	Kimokoti et al. [1]	Wt change in kg	Multivariable linear regression analysis within gender Baseline used FRNS as predictors for weight change during a 16-year follow-up	FNRS was not associated with weight gain in both M and F; $p = 0.16$ and $p = 0.61$, respectively F who were former smokers and who were in the lowest tertile of FRNS gained an additional 5.2 kg compared with former smokers who were in the highest tertile of FNRS; *P* for trend = 0.03	FNRS was not a predictor for wt gain in either M or F	In F: age, wt, physical activity index, FNRS, former smoker and FNRS across smoking category In M: age, wt, wt fluctuation and former smoking and nonsmokers
3	Wolongevicz et al. [33]	Incidence of overweight or obesity; BMI ≥25 kg/m^2	Logistic regression model to estimate odds ratio of being overweight or obese	FNRS was associated with incidence of overweight or obesity (*p* for trend = 0.009). Women with lower diet quality were significantly more likely to become overweight or obese; OR, 1.76; CI, 95 %(1.16–2.69) times compared with those with highest diet quality	Higher FNRS was associated with a reduced chance of being overweight or obese	Age, physical activity and smoking status

(continued)

Table 1.3 (continued)

	References	The outcome	Statistical analysis	Result	Key finding	Confounders
4	Beunza et al. [34]	(1) Annual wt gain in kg (2) Incidence of wt gain (≥3 kg/year or ≥5 kg/year) during the first 2 or 4 years of follow-up	(1) Multiple linear regressions were used to estimate the annual means change in body weight across categories of adherence the MD (2) Logistic regression analysis for the first index only and to estimate OR for incidence of weight gain (≥3 or ≥5 kg) during the first 2 or 4 years of follow-up	(1) Participants in the highest tertile of MDS had the lowest average yearly wt gain relative to lowest tertile of MDS −059 kg/year; 95 % CI (−0.111, −0.008 kg/year) (2) OR for incident of wt gain for highest tertile relative to lowest tertile OR: CI 95 % (2 years) for ≥3 kg, 0.8 (070, 0.92) OR: CI 95 % (2 years) for ≥5 kg, 0.76 (0.62, 0.92) OR: CI 95 % (4 years) for ≥3 kg, 0.80 (0.71, 0.91) OR: CI 95 % (4 years) for ≥5 kg, 0.76 (0.64, 0.90)	(1) There was a significant inverse association between all MDS and wt change (2) Those in the highest tertile of MDS were less likely to have absolute wt gain relative to those in the lowest tertile	Age and sex, BMI, physical activity, sedentary behaviour, smoking, snacking and TEI
4	Beunza et al. [34]	(1) Annual wt gain in kg	(1) Multiple linear regressions were used to estimate the annual means change in body weight across categories of adherence the MD	MAI-Alberti-Fidanza Scores >1.84 (highest) had the highest mean wt gain −0.077 (−0.131, −0.022) compared with the lowest ≤0.95	There was a significant inverse association between all MDS and wt change except MDS-Panagiotakos and MSDPS-Rumawas with *p* for trend 0.30, 0.41, respectively while all other MDS had *p* for trend <0.05	Age and sex, BMI, physical activity, sedentary behaviour, smoking, snacking and TEI

					MDQI-Scali Scores ≤4 (highest) had the highest mean wt gain −0.102 (−0.194, −0.009) compared with ≥11 (lowest) MDP-Sánchez-Villegas Scores >54.97 (highest) gained −0.061 (−0.116, −0.006) compared with ≤44.23 (lowest)		
					MDS-Panagiotakos ≥34 (highest) gained −0.029 (−0.079, 0.021) compared with ≤29 (lowest) MSDPS-Rumawas Scores >35 (highest) gained −0.028 (−0.094, 0.038) compared with ≤20 (lowest)		
5	Sánchez-Villegas et al. [35]	Wt in kg		(1) Linear regression models were used to assess the association between MD scores at baseline and wt change and BMI change during F/U time (2) Logistic regression to examine the association between baseline of MDS and incidence of overweight or obesity during the F/U time	(1) Participants in the highest quartile of MDS gained less weight (+0.65 kg) (+0.59 to +0.80) compared with those in the lowest quartile (*p* for trend 0.291) (2) Participant in the highest quartile of MDS had smaller increase in BMI +0.23 (+0.12 to +0.33) compared with those in the lowest quartile of MDS (*p* for trend 0.279)	There was not a significant association between MDS and weight gain	Age, gender, BMI, smoking, physical activity, alcohol, EI, change in dietary habits (fruit, vegetables, meat, meat product, fish, olive oil and alcohol) and change in physical activity during F/U time

(continued)

Table 1.3 (continued)

	References	The outcome	Statistical analysis	Result	Key finding	Confounders
6	Mendez et al. [36]	(1) Incidence of obesity (BMI ≥30 kg/m²)	Logistic regression models were used to estimate odds of becoming overweight or obese	(1) Overweight participants in the highest MDS were less likely to become obese OR (95 % CI) of becoming obese for F and M, respectively +0.69, (0.54–0.89) +0.68, (0.53–0.89)	(1) There was inverse significant association between MDS and becoming obese	Underreporting of dietary data, age, physical activity, education, centre, height, smoking status, season, follow-up time, changes in employment status during follow-up, use of special diets, parity and menopause in women and history of chronic diseases (cancer, diabetes or heart diseases) at baseline or follow-up
		(2) Incidence of overweight (BMI ≥25 to <30 kg/m²)		(2) High MD adherence was not associated with overweight incidence in women and men OR (95 % CI) of becoming overweight for F and M, respectively +0.99 (0.78, 1.25) +1.11 (0.81–1.52)	(2) There was no significant association between MDS and incidence of overweight	
7	Romaguera et al. [37]	(1) Wt gain in 5-year F/U	(1) Multiple linear regression between rMED and 5-year wt gain	(1) Those in the highest tertile of rMED had less wt gain −0.16 kg (CI 95 %: −0.24, −0.07) and −0.04 kg (−0.07, −0.02) for the combined results	There is a significant inverse association between MDP and becoming overweight or obese	Sex, age, baseline BMI, follow-up time, educational, physical activity, smoking, TEI and misreporting of EI
		(2) Overweight or obesity incidence in 5-years of F/U (BMI ≥25 kg/m²)	(2) Logistic regression to examine the association between a 2-point increase in rMED and becoming overweight	(2) Overall results showed that a 2-point increase in the rMED was associated with becoming overweight after compounding the result from all the cohorts OR (CI 95 %): 0.97 (0.95, 0.99)		

WT weight, *EI* energy intake

Table 1.4 Conclusions and significance of included studies

	References	Was there an inverse relationship between diet quality and body weight change?	Were the results significant?
1	Quatromoni et al. [24]	Y	Y
2	Kimokoti et al. [1]	N However, there was inverse correlation between women who quit smoking in the lowest FNRS and higher weight gain in women only	N Y in former smokers in the lowest FNRS tertile gain more weight than other in highest tertile
3	Wolongevicz et al. [33]	Y	Y
4	Beunza et al. [34]	Y in 6 diet quality indexes	Y in 4 indexes N in two indexes
5	Sanchez-Villegas et al. [35]	Y	N
6	Mendez et al. [36]	Y of becoming obese N of becoming overweight	Y of becoming obese among the overweight only N of becoming overweight
7	Romaguera et al. [37]	Y	Y

Methods Used to Measure Diet Quality

To evaluate diet quality, the studies examined used a number of different indexes and scores which are described in detail in Table 1.2 and summarised below.

Quatromoni et al. [24] used the DQI to judge the quality of overall dietary intake, with a higher DQI representing greater adherence to the US national dietary guidelines. The DQI score ranges from zero to five, and the five points constitute adherence to percentage energy intake from total fat, saturated fat and carbohydrate (3 points), and the total intakes of cholesterol and sodium (2 points) [24]. The intake levels were set according to the US dietary guidelines [24] and are given in Table 1.2. Each DQI component is awarded a score of either zero or one. If consumption of the nutrient is optimal and within the recommended limits, then a score of one is awarded, otherwise it is scored as zero [38]. Therefore, higher DQI scores are associated with lower total fat, saturated fat, cholesterol and sodium intakes and higher intakes of carbohydrate, representing greater adherence to the Dietary Guidelines for Americans. Thus, it reflects a dietary pattern that contains food rich in carbohydrate and fibre such as fruits and vegetables and lower intakes of foods that are high in sodium and fat [21].

Two [32, 33] studies used the FNRS, which is based on intakes of 19 nutrient components (Table 1.2). These nutrients are classified into three groups according to their relationship with CVD risk as follows: (1) optimal intake profile of selected macronutrients including energy, protein, monounsaturated fat and polyunsaturated fat; (2) increased risk-related nutrients including total fat, saturated fat, cholesterol, alcohol and sodium; (3) protective nutrients including carbohydrate, dietary fibre, calcium, selenium, vitamin C, vitamin B-6, vitamin B-12, vitamin E, folate and beta-carotene [39]. The nutrients included in FNRS are scored in such a way that a person with a more desirable nutrient profile is awarded a lower score. For example, a lower fat or higher vitamin and mineral intake will attract a lower score. Similarly a less desirable nutrient profile is given a higher score, e.g. higher total fat or lower micronutrient intake. Higher monounsaturated fat intake was given a higher score, because the source of these fats was mostly animal products (e.g. beef fat) for participants in the Framingham study [1, 33]. The rank given to individual nutrients was aggregated to give an overall composite risk rank [1].

The Mediterranean Diet Score (MDS) was compiled by Trichopoulou et al. [40]. All four studies included in this review that used the MDS [34–37] used different scoring methods to calculate

Table 1.5 Quality assessment for included studies

	References	(1) Is the sample representative of patients in the population as a whole?	Was everyone assessed at the same follow-up time?	Are the confounding factors identified and strategies to deal with them stated?	Are outcome assessed using objective criteria?	Was follow-up carried out over a sufficient time period?	Were the people who withdrew described and included in the analysis?	Were the outcome measured in reliable way?	Was appropri-ate statistical analysis used?	The total
1	Quatromoni et al. [24]	U	Y	Y	Y	Y	U	Y	Y	2U 6Y
2	Kimokoti et al. [1]	U	Y	Y	Y	Y	U	Y	Y	2U, 6Y
3	Wolongevicz et al. [33]	U	Y	Y	Y	Y	U	Y	Y	2U, 6Y
4	Beunza et al. [34]	N	N	Y	N	Y	U	Y	Y	1U, 3N, 4Y
5	Sanchez-Villegas et al. [35]	N	Y	Y	N	Y	U	Y	Y	1U, 2N, 5Y
6	Mendez et al. [36]	Y	Y	Y	N	Y	U	Y	Y	1U, 1N, 6Y
7	Romaguera et al. [37]	N	N	Y	N	Y	U	N	Y	1U, 4N, 2Y
	The total	3U, 1Y, 3N	1N, 6Y	7Y	3Y 4N	7Y	7U	1N, 6Y	7Y	

U unclear, *N* no, *Y* yes

adherence to the Mediterranean Diet Pattern (MDP). Each one referenced the MDS, even though they varied in the actual method. In general, the Mediterranean Diet Pattern includes regular consumption of vegetables, fruit, legumes, cereals, nuts, fish and foods rich in olive oil, as well as a low in intake of foods high in saturated fat, dairy products, meat and poultry [40].

The MDS as used in the paper by Beunza et al. [34] considered the intake of nine food items (Table 1.2), which were classified into (1) positive components (vegetables, fruit, nuts, legumes, cereals, moderate alcohol and fish) and (2) negative components (meat and poultry, dairy products) [34]. The score assigned to each component was based on both the nature of the food component and the quantity of that food consumed in relation to the median value for all subjects under consideration [41]. A score of zero was assigned to a positive component if the individual's consumption was less than the gender-specific median consumption [42]. A score of one was awarded if the food item was positive and consumption was greater than the gender-specific median. The opposite procedure was followed in case of negative components. A score of zero was awarded if the consumption was greater than the gender-specific median and one if consumption of the negative component was less than the relevant median [34, 42].

The MDS as used by Sanchez-Villegas et al. [35] was defined a priori and considered the intake of ten food item components. These foods were classified into two groups: (1) beneficial food items which included cereals, vegetables, fruits, legumes, fish, nuts, olive oil and moderate red wine and (2) detrimental food items which included meat, meat products and whole-fat dairy products [35]. The total score range was 10–30 points. To compute the score for each participant, a rank system was applied to each component. First, each item was classified into tertiles and scored from 1 to 3 from the lowest to the highest tertile for beneficial food items and then 1–3 from the highest to lowest tertile for detrimental food components. The ten components scores were summed for each participant. Thus, a maximum of 30 points reflects the highest MDS and the greatest adherence to MDP, while a score of 10 points reflects the lowest adherence [35].

The MDS used by Mendez et al. [36] collected the dietary intake data from a diet history, which generated a list of approximately 600 food items. This MDS score is similar to a previous one [34] and classified food items into (1) beneficial foods including fish, vegetables, fruits, legumes, cereals and the ratio of monounsaturated saturated fat and (2) detrimental food items, including moderate alcohol intake and meat. Milk and dairy products were not considered in this index. A score of zero was assigned to a component if it was beneficial and if the individual's consumption was less than the gender-specific median consumption of that particular food for all individuals in the study. The opposite procedure was followed in the case of detrimental foods, with a score of zero awarded if consumption was more than the gender-specific median and a score of one given if consumption was less than the relevant median [36].

Researchers for the Romaguera et al. [37] paper used a revised Mediterranean Diet Pattern [43] evaluated using a Relative Mediterranean Diet Score (rMed). This rMed differs from the original MDS and comprises nine nutritional components which characterise MDP. Components like vegetables, legumes, fruit, nuts, cereals, seafood and fish, moderate alcohol consumption and olive oil are rated as beneficial foods, while meat and meat products and dairy products are rated as detrimental. All food items in this score are expressed in units as grams/1,000 kcal. Each component in this index is scored as tertiles, except for alcohol and olive oil. Scores of 0, 1 and 2 were given from the lowest to the highest tertile for the beneficial food items. The detrimental components of meat/meat products and dairy were given 0, 1 or 2 from the highest to the lowest tertile. Thus, higher intakes of beneficial foods and lower intakes of detrimental foods contributed more to the score, reflecting greater adherence to Mediterranean patterns. For olive oil, a zero score was given to nonconsumers, 1 to those with consumption below the median level and 2 to those with consumption greater than or equal to the median. Regarding alcohol, a score of 2 was given to those with a moderate alcohol consumption, ranging from 10 to <50 g/day for men and 5 to <25 g/day for women. Consumption outside of this range for alcohol scored zero. The rMed score ranged from 0 (lowest adherence to MDP) to 18 (highest adherence to MDP). Further evaluation classified the score 0–6 as low adherence, 7–10 as medium and 11–18 as high adherence to MDP [43].

The Implications of Diet Quality on Weight Change

This systematic review aimed to synthesise the best evidence available on the relationship between diet quality and weight change in adults within cohort studies. There were only seven studies included that assessed dietary quality using a dietary quality score or index from an initial search generating 2,304 citations from a comprehensive search of the four most relevant databases, specific for the research question. This review indicates that the relationship between diet quality and weight gain is important. Using the DQI tool, the mean diet quality score at baseline was shown to be a strong predictor of prospective weight gain [24]. Another study [34] found that the risk of having a specific amount of weight gain (≥3 or ≥5 kg) during follow-up periods of 2 and 4 years was higher among those in the lowest tertile of MDS compared to those in the highest tertile. Moreover, there were significant associations between annual weight gain in adults using all four indexes of MDP [34]. However, in the same study, the authors also evaluated another two indexes to generate MDPs and found that there were no relationships between these two indexes and annual weight gain [34]. In addition, two other diet quality indexes [1, 35] found no relationship between diet quality and weight gain over time. More specifically, evaluation of FNRS at baseline with prospective weight gain within gender demonstrated a strong interaction with smoking status in both genders [1]. In this study women who quit smoking and also had the poorest diet quality, as evaluated by FNRS, had higher weight gain than those in the highest FRNS tertile. A significant association was found between having lower diet quality, as determined by FNRS or rMDS, and a higher risk of becoming overweight or obese [33, 37] Moreover, a significant risk of becoming obese was demonstrated among those who were overweight and in the lowest tertile of diet quality score, but there was no greater risk of becoming overweight among those with the poorest diet quality [36].

Quality of the Studies

From Table 1.5 it was identified that most studies have confounders and although this is a potential risk of bias, the majority adjusted for at least the major confounders in the statistical analysis. It was unclear from the population descriptions whether some of the researchers used a representative sample or not, but at least three studies used non-representative population samples. Three studies reported analyses were conducted in the USA [21, 32, 33] from the same cohort and three studies were carried out in Spain [34–36], so although they may each be representative within countries, internationally they are not.

Limitations of the Studies

Within the included studies, the reporting of confounders and statistical adjustment for them is the most common weakness. The most commonly reported confounders were similar and included age, BMI, physical activity, education and income (Table 1.3).

One of the most important confounders that is rarely addressed is changes in dietary intake during the follow-up period, especially when follow-up times are extensive, as there is no guarantee of stability of dietary intake and behaviours over time. This means that weight gain could also have been influenced by other factors apart from baseline diet. There are other important confounders, such as misreporting of energy intake, and the only study to adjust for underreporting was Mendez et al. [36].

Further, use of a 3-day food record has been identified as commonly associated with underreporting of dietary intake [24].

The finding of this systematic review demonstrates that within cohort studies examining weight change over time, dietary intake has not commonly been categorised using a diet quality score or dietary index in adults. Due to the small number of studies in this area, further research is needed. Moreover, this is an important field warranting more research because diet is an important determinant of weight change. In addition, there is limited research identifying which are the most useful tools to assess diet quality as a predictor of weight change in adults within longitudinal studies.

The results from the studies in Table 1.1 are heterogeneous and use different methodologies to evaluate both dietary intake and the outcome of body weight. In general, four studies out of the total of seven found an inverse association between diet quality and weight change, both as absolute weight gain or as a change in weight status category. This means that consuming a higher quality diet, or one which is consistent with healthier eating habits and dietary intakes, that aligns more closely with national dietary guidelines does lead to smaller amounts of weight gain. However, two studies found this association in multivariate models only among specific groups of participants who were overweight at baseline or women who were former smokers and also had the poorest dietary intake as scored by FNRS or MDS [1, 36] (Table 1.4).

The first three studies in Table 1.1 [1, 24, 33] were evaluations using differing methodologies but performed on the same FOSS cohort. Each used different criteria for including participants; different methods to assess diet quality (DQI or FNRS), varied in how the weight change was defined; different methods to report the weight change outcomes; and differing approaches to the statistical analysis. However, across the studies, women with the poorest diet quality gained an additional 1,040 g compared to men with the poorest dietary intake over time [24].

On average, adults in the lowest diet quality category gain additional weight (59–1,090 g) compared to those who had eating patterns consistent with higher diet quality over follow-up periods of 1–8 years duration.

Conclusions

In conclusion, the current evidence is insufficient to set benchmarks for optimal diet quality in order to prevent weight gain. However, aspiring to diet quality scores that reflect adherence to national dietary guidelines appears prudent. Although we cannot determine whether lower diet quality, as assessed by scores or indexes, could definitely lead to higher weight gain due to the limitations of the evidence in this area currently, it is clear from the available evidence that there is a strong association between higher weight gain and poor diet quality. Further, smoking status, especially in women, and baseline BMI in adults were important confounders that should be considered in future studies, along with any interactions between them and dietary intake.

Recommendations for Researchers

Further studies are required that use a number of different methods within the one cohort to measure diet quality as predictors of weight gain in adults. This approach would ideally be repeated across a number of nationally representative population cohorts to examine how robust any relationships are internationally or whether any of the approaches is more applicable.

Although there have been a considerable number of studies that have examined the relationship between macronutrient or energy intakes and weight change over time, it is clear from this systematic review that there is a lack of studies examining overall diet quality or total dietary patterns. Such an approach would better characterise the relationship between weight change and diet quality in adults over time and facilitate development of food-based guidelines targeting the prevention of weight gain.

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2 Diet Quality and Cerebral Infarction: South Korean Aspects

Hyunjung Lim and Ryowon Choue

Key Points

- Stroke is one of the major causes of death among adults over the age of 50 in Korea.
- Malnutrition is common in Korean CI patients based on the PG-SGAs and concise MNAs score, which are thought to be suitable for evaluating the nutritional status of Korean CI patients with stable vital signs, especially elderly CI patients.
- Korean CI patients tend to prefer saltier and spicier foods, to exhibit more irregular eating patterns, and to have fewer beneficial foods (e.g., dairy products and fruits), which results in a diet low in nutritional density and a poor overall dietary quality, than subjects without CI.
- Korean CI patients consumed less diverse food groups and less variability of foods within each food group. A large proportion of the CI patients consumed diets lacking foods from one or more food groups. The most frequently omitted food groups were the dairy group, both the dairy and fruit group, and the fruit group.
- The overall measure of dietary quality, the DQI-I, in the Korean CI patients was significantly lower than in the non-CI subjects. The scores for each of the four subcategories (variety, adequacy, moderation, and overall balance) in the CI patients were significantly lower than those in the non-CI subjects.
- Active and customized medical nutrition therapy or management programs to improve the quality of diet are needed. Clinical dieticians should consider the individual patient's medical history and comorbidities, as well as health-related behaviors.

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V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health,
DOI 10.1007/978-1-4614-7315-2_2, © Springer Science+Business Media New York 2013

Keywords
Diet quality • Nutritional status • Dietary pattern • Cerebral infarction • Stroke • South Korea

Abbreviations

CI	Cerebral infarction
DDS	Dietary Diversity Score
DMGFV	Dairy, meat, grain, fruit, and vegetable
DQI-I	Diet Quality Index-International
DVS	Dietary Variety Score
HDL-C	High-density lipoprotein (HDL)-cholesterol
KDRI	Dietary reference intakes for Koreans
MAR	Mean adequacy ratio
MNA	Mini nutritional assessment
NAR	Nutrient adequacy ratio
PG-SGA	Patient-generated subjective global assessment
SGA	Subjective global assessment
WHO	World Health Organization

Introduction

Cerebral infarction (CI)is caused by an obstruction and/or a fatty deposit lining the walls within a blood vessel that supplies blood to the brain. When either of these events occurs, the likely outcome is brain damage [1].

The World Health Organization (WHO) estimated that stroke accounted for 5.7 million deaths worldwide, equivalent to 9.9 % of all deaths in 2005 [2]. Over 85 % of these deaths occurred in people living in low and middle-income countries, and one-third in people under the age of 70 [3] As a disease of the elderly, the prevalence of stroke is expected to increase significantly throughout the world [4].

In South Korea, CI is responsible for 12.0 % of mortality [5]. According to the Korea National Statistical Office, stroke was the second most common cause of death in 2007 [6]. In addition, stroke is a leading cause of death and disability among individuals older than 65. The annual medical costs associated with stroke accounted for more than 10 % of total medical expenditures in South Korea [6].

There are many risk factors associated with CI occurrence, including hypertension, age, sedentary occupation, high-density lipoprotein (HDL)-cholesterol reduction, hyperglycemia, family history of stroke, nutritional status [7, 8], depression [9–12], and diet-related behaviors [10, 13–17]. Among these risk factors, dietary patterns and certain foods or nutrient consumption, such as insufficient consumption of fruits [18], vegetables [18], whole grains [19], dietary fiber [20], dairy products [21], long-chain polyunsaturated fatty acids and potassium [22], and a high intake of sodium [23], are well-known risk factors for CI. In particular, the typical Korean diet has been shown to be related to a high incidence of CI. Therefore, controlling the nutritional status, dietary pattern, and the quality of diet in Korean CI patients may be of extreme importance.

This chapter described the prevalence, nutritional status, and dietary quality of CI patients in South Korea. In addition, using previous studies, eating behaviors, dietary patterns, and nutrient intakes of CI patients were reviewed. We especially focused on the quality of diet in Korean CI patients using various dietary assessment tools. Such information may be useful in managing CI patients, as well as for preventing the reoccurrence of CI in South Korean patients, and more generally, for CI patients in other countries experiencing a high prevalence of CI.

Cerebral Infarction in Korea: Prevalence and Nutritional Status

Prevalence of CI in Korea

Stroke is one of the most prevalent geriatric diseases and is the second leading cause of death in South Korea, affecting approximately 780,000

Table 2.1 Prevalence of stroke in South Korea: Korean National Health and Nutrition Examination Survey (1998–2009)

	KNHANES I	KNHANES II	KNHANES III	KNHANES IV		
	1998	2001	2005	2007	2008	2009
Men and women						
Age						
<50 y	2.8	3.4	4.5	4.7	4.3	3.3
≥ 65 y	4.6	5.3	6.8	7.6	7.6	5.1
Residence region						
Urban	3.0	3.3	4.5	4.6	4.2	3.3
Rural	2.7	3.5	4.6	6.0	4.6	3.7
Household income[a]						
Low	3.1	3.7	5.0	5.1	4.9	5.0
Middle–low	3.0	3.8	4.8	6.3	5.0	3.7
Middle–high	3.1	3.1	3.9	3.0	3.7	3.0
High	2.3	2.8	4.1	4.5	3.4	1.9
Men						
Age						
<50 y	2.7	4.1	5.0	4.1	5.0	3.8
≥ 65 y	4.9	6.6	7.7	5.5	9.3	6.3
Residence region						
Urban	3.3	4.6	5.4	3.6	4.9	3.7
Rural	2.8	4.0	5.0	6.8	6.2	5.0
Household income[a]						
Low	3.8	4.4	6.1	5.0	6.6	6.3
Middle–low	3.0	4.7	5.1	7.0	6.2	4.4
Middle–high	2.9	4.5	5.3	4.2	5.0	3.2
High	2.5	3.6	4.2	0.5	4.1	2.4
Women						
Age						
<50 y	2.8	2.8	4.1	5.3	3.8	2.8
≥ 65 y	4.4	4.4	6.1	9.1	6.4	4.2
Residence region						
Urban	2.8	2.4	3.9	5.3	3.7	2.9
Rural	2.6	3.2	4.2	5.1	3.6	2.8
Household income[a]						
Low	2.5	3.1	3.9	4.9	3.8	3.7
Middle–low	3.1	3.2	4.6	5.5	4.0	3.4
Middle–high	3.3	2.1	3.2	2.0	2.8	2.9
High	2.3	2.4	4.2	7.6	2.9	1.4

Data source: Korean Centers for Disease Control and Prevention. The Fourth Korean National Health and Nutrition Examination Survey (KNHANES IV). Seoul, Republic of Korea 2010

KNHANES Korean National Health and Nutrition Examination Survey

[a]The quartiles of average monthly household income (monthly household incomes/number of family members)

adults each year [6]. In the previous decade, the population older than 65 years has increased in Korea [24]. This trend implies that the elderly population with health problems, such as cardiovascular disease, hypertension, and diabetes mellitus, will also increase [25]. Stroke is an independent disease and is the number one cause of death in both men and women older than 50 years in Korea [26] (Table 2.1). It also causes permanent physical disability and can affect not only the patient but also his or her family members, damaging their quality of life [27].

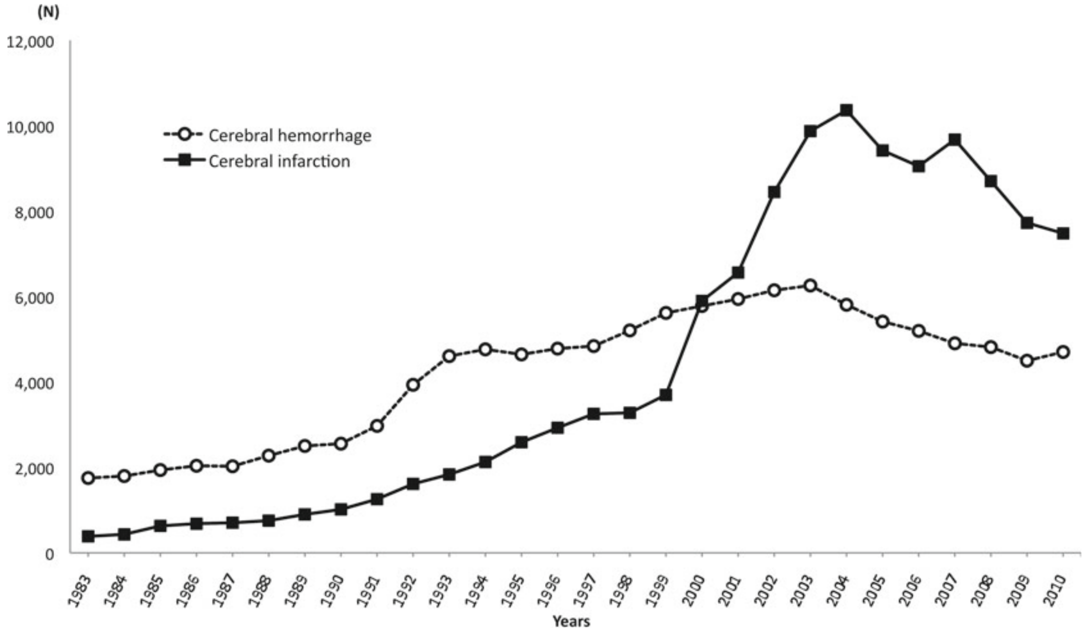

Fig. 2.1 The trend of deaths by stroke subtype among the elderly aged over 65 in Korea (data source: http://kostat.go.kr/wnsearch/search.jsp)

Lately, the incidence of stroke types in Koreans changed significantly from cerebral hemorrhage, previously a more frequent occurrence than CI, to CI [28]. A national statistical annual report shows that since 2000, the prevalence of CI has outpaced that of cerebral hemorrhage [6] (Fig. 2.1). This trend has been explained by changes in several factors, including dietary behavior and lifestyle.

Nutritional Status in Cerebral Infarction Patients

Several studies have assessed the nutritional status of patients with stoke, including CI [29–32]. Undernutrition is common in patients with stroke [29–32] and in patients before the episode [33], especially among the elderly [34]. A Korean study demonstrated that 74.0 % of patients with CI were moderately or severely malnourished based on their Patient-Generated Subjective Global Assessment (PG-SGA) score [35]. In addition, Westergren et al. [36] reported that 70 % of patients with CI were malnourished; however, other studies have reported that only 8–16 % were malnourished [29–32]. This discrepancy is potentially explained in two ways: variations in the assessment tools used for evaluating patients' nutritional status and the timing of the assessment in relation to when the stroke occurred, i.e., patients with acute stroke [37] or sometime after stroke onset [30]. It is noteworthy that the nutritional assessment yielded better results for patients with acute stroke or patients tested shortly after stroke onset, as compared to those patients in rehabilitation or those assessed sometime, i.e., from 2 weeks to 6 months, after stroke onset [30, 32].

Many previous studies have evaluated nutritional status in stroke patients using a combination of hematologic and anthropometric parameters [15, 33], while others have used a combination of methods to diagnose malnutrition, including a clinician's expert opinion [30, 31, 37]. There is no gold standard for determining nutritional status. However, the use of objective nutrition parameters (anthropometric, biochemical, and immunological) to assess nutritional status has been questioned due to the many non-nutritional factors (age, illness, and injury) which affect the results.

We assessed the nutritional status of Korean CI patients using two new tools [35, 38], e.g., the scored Patient-Generated subjective global assessment (PG-SGA) and the Mini Nutritional Assessment (MNA). The subjective global assessment (SGA) is a tool that experienced clinicians use to assess patients' nutritional status based on their medical history and physical symptoms [39]. It evaluates morbidity and quality of life with a high level of inter-evaluator consistency and maintains a high correlation with the objective parameters [37, 39]. The PG-SGA was modified from the SGA used by Ottery [40]. It included additional items on nutritional symptoms and short-term weight loss. The scored PG-SGA included the dietary history and disease status and its relation to nutritional requirements, metabolic demand, and physical examination. The total score of the PG-SGA is calculated by summing the scores obtained for each item. The total scores of the PG-SGA generally ranged from 0 to 35. The scores (0–4) of each component determine that item's influence on nutritional symptoms and status. The nutritional triage recommendations are as follows: 0–1, no intervention required at this time; 2–3, education required by dietitian; 4–8, intervention required by dietitian; and ≥9, intensive intervention required. By referring to the score, patients can be classified into three global assessment categories: well-nourished, moderately malnourished, and severely malnourished. Following this approach, we performed a study to assess the nutritional status of Korean CI patients and to investigate the relation between the quality of the patients' diet and their quality of life according to their nutritional status [35]. When patients with CI, categorized according to their nutritional status, were assessed with the PG-SGA, well-nourished patients had better food consumption patterns and a higher quality diet and had better quality-of-life scores [35]. According to our findings, the PG-SGA is a useful nutritional assessment tool for Korean CI patients with stable vital signs.

The MNA tool was developed to assess nutritional status in elderly patients, which is composed of simple measurements and brief questions and can be completed in less than 15 min [29, 41, 42]. It combines several factors such as anthropometric measurements, a general assessment, a dietary questionnaire, and a subjective assessment. The overall MNA score differentiates subjects as follows: adequate nutritional status (MNA ≥24), protein–calorie undernutrition (MNA <17), and at risk for malnutrition (MNA between 17 and 23.5) [42]. The validity of MNA scores has previously been verified via clinical nutritional status assessments in Europe and the United States [42]. We found that the vast majority of CI patients were at risk of malnutrition or were malnourished prior to CI onset (Table 2.2). The total scores from the MNA were significantly higher in the non-CI group; lower MNA scores indicate a higher intensity of malnutrition. The CI group scored lower in all categories. However, the nutritional status of patients of European descent may appear better because their MNA scores are comparably higher

Table 2.2 Nutritional and depression status of patients based on the mini nutritional assessment

Variables	Non-CI	CI
Nutritional status based on MNA[†††]		
Well nourished (≥24)	68 (93.2)[a]	5 (6.8)
At risk of malnutrition (17–23.5)	5 (6.8)	26 (35.6)
Malnourished (<17)	0 (0.0)	42 (57.5)
MNA total (score/30 points)	7.0 ± 1.8[b]	19.5 ± 4.4[***]
MNA subtotal		
Anthropometric assessment (score/8 points)	7.4 ± 0.8	5.8 ± 1.9[***]
General assessment (score/9 points)	8.9 ± 0.5	4.8 ± 1.7[***]
Dietary assessment (score/9 points)	7.3 ± 1.0	4.3 ± 1.9[***]
Self assessment (score/4 points)	3.5 ± 0.7	1.7 ± 1.0[***]

Adapted by Lim et al. [43] (*Nutritional Neuroscience*) with permission

CI cerebral infarction, *MNA* mini nutritional assessment, *BDI* Beck depression inventory

[†]Significant differences between groups by Fisher's exact test at [†]$p < 0.05$ and [†††]$p < 0.001$

[*]Significant differences between groups by Wilcoxon–Mann–Whitney test at [***]$p < 0.001$

[a]Values are *n* (%)

[b]Values are means ± SD

Table 2.3 Frequencies of consumption of the various food groups in CI patients and non-CI subjects in Korea

Variables (times/week)	Non-CI	CI
Grains	22.3 ± 5.1	24.9 ± 5.3[a**]
Beans	10.7 ± 9.4	2.4 ± 3.2[***]
Potato and sweet potatoes	2.7 ± 2.9	2.6 ± 2.5
Meat and eggs	6.6 ± 5.1	6.2 ± 3.0
Fish	10.5 ± 9.8	6.1 ± 4.1[***]
Vegetables	34.9 ± 26.3	27.5 ± 9.6[*]
Seaweeds	5.1 ± 6.7	1.5 ± 1.4[***]
Fruits	14.3 ± 13.9	5.7 ± 5.1[***]
Dairy products	8.3 ± 7.8	2.0 ± 1.8[***]
Fat and sugars	3.1 ± 4.6	3.3 ± 4.0
Fast food and nuts	1.7 ± 3.3	1.2 ± 1.9

Adapted by Lim et al. [43] (*Nutritional Neuroscience*) with permission
CI cerebral infarction
[*]Significant differences between the groups by Wilcoxon–Mann–Whitney test at $^{*}p<0.05$, $^{**}p<0.01$ and $^{***}p<0.001$
[a]Values are means ± SD

overall [29]. This may be attributed to higher average BMI scores and larger mid-arm and calf circumferences than is generally observed in East Asian populations. An important consideration is the need to improve the nutritional status in elderly in rehabilitation units [32]. Strokes are common in the elderly, and as they cause physical discomfort, concise MNAs could potentially be suitable for evaluating nutritional status for them.

Foods, Nutrients, and Dietary Patterns Related to Cerebral Infarction

Korean CI patients have been shown to be less likely to ingest preventive or beneficial foods such as beans, fish, vegetables, seaweeds, fruits, and dairy products (Table 2.3) [43].

The intake frequencies of beans, fish, vegetables, seaweeds, fruits, and dairy products were all associated with a reduced risk of CI prevalence and were found to be less frequently consumed in CI patients compared with non-CI subjects [43]. The consumption of dairy products was related to a decreased risk of CI [44]. A recent Finnish study observed the highest quintile of cream intake had a moderate decreased risk of CI (RR = 0.81; 0.72–0.92). However, there were no strong associations between intakes of total dairy, low-fat milk, sour milk, cheese, ice cream, or butter and risk of any stroke subtype [45].

In regard to fruits and vegetables, there are several mechanisms that show an apparent protective effect from fruits and vegetables on the risk of CI. The micronutrients, antioxidants, phytochemicals, and fiber in fruits and vegetables have been related to the prevention of stroke and other cardiovascular diseases in observational epidemiologic studies [46]. The reduced risk of stroke in Joshipura et al.'s study was most evident for the intakes of cruciferous vegetables; green, leafy vegetables; and citrus fruits including juice and citrus fruit juice alone [47]. Fruits and vegetables are rich sources of vitamins and minerals, such as vitamin C, beta-carotene, potassium, magnesium, and calcium, in addition to other nutrients such as folate and fiber [48]. However, in a study based on the Framingham cohort, Gillman et al. found that the protective effect of fruit was no stronger than that of vegetables [49].

In a previous study, according to the Dietary Reference Intakes for Koreans (KDRI), of calcium, phosphorus, iron, potassium, zinc, vitamin A, vitamin B1, vitamin B2, vitamin B6, niacin, vitamin C, folate, and vitamin E, intakes in the CI group were lower than in the non-CI group [38]. These results demonstrated that many CI patients have improper dietary intakes. Major food sources for these nutrients are fresh fruits, vegetables, and dairy products; therefore, there is a need to recommend foods through nutritional education. Although dietary fiber decreases the risk of stroke, we found that the dietary fiber intake in Korean CI women was significantly lower than in non-CI women [38].

There have been relatively few studies on the eating habits of CI patients [50, 51]. We investigated the eating habits of Korean CI patients (Table 2.4) [38] and found that those who usually skipped meals was 11.0 % in the non-CI group and 45.2 % in the CI group ($p < 0.001$). Subjects with irregular meal frequencies constituted 9.5 % of the non-CI group and 45.2 % of the CI group. The percentages of CI patients that frequently

Table 2.4 Eating habits of CI patients and non-CI subjects in Korea

Variable	Non-CI	CI
Frequency of skipped meals[†††]		
Usually	8 (11.0)[a]	33 (45.2)
Sometimes	7 (9.6)	15 (20.5)
Rarely	58 (79.4)	25 (34.3)
Regularity of meals[†††]		
Regular	46 (63.0)	26 (35.6)
Sometimes	20 (27.4)	14 (19.2)
Irregular	7 (9.6)	33 (45.2)
Degree of chewing[†††]		
Enough	9 (12.3)	9 (12.3)
Moderate	54 (74.0)	14 (19.2)
Not enough	10 (13.7)	50 (68.5)
Frequency of eating out		
>4–6 times/week	9 (12.3)	10 (13.7)
2–3 times/week	32 (43.8)	27 (37.0)
1–0 times/week	32 (43.8)	36 (49.3)
Taste preference[†††]		
Sweet	16 (21.9)	8 (11.0)
Salty	15 (20.5)	44 (60.3)
Sour	17 (23.3)	8 (11.0)
Spicy	28 (38.4)	30 (41.1)
Other	16 (21.9)	10 (13.7)

Adapted by Lim et al. [38] (*Nutrition Research*) with permission
CI cerebral infarction
[†]Significant differences between the groups were determined by the Chi-square test at $^{\dagger\dagger\dagger}p<0.001$
[a]Values are *n* (%)

skipped meals and/or had irregular meals were higher than for the non-CI subjects in South Korea [51, 52]. Only 7.0 % of the non-CI subjects in the study by Kim et al. had irregular meal times [52]. In addition, the CI patients preferred salty (60.3 % vs. 20.5 %) and spicy foods (41.1 % vs. 38.4 %) over the non-CI group ($p<0.001$). An analysis of the dietary characteristics of Koreans demonstrated that the typical consumption of sodium is 3 times greater than the recommended amount (1.5 g/day) [53]. Furthermore, 82.9 % of Koreans consumed more than 2,000 mg of sodium per day, which is the daily sodium intake goal and the level suggested by the WHO and the Food and Agriculture Organization of the United Nations (FAO) for the prevention of diet-related chronic diseases [53]. Therefore, Koreans consume 1,000 mg more sodium than individuals in the United States [54]. A majority of CI patients in a study preferred salty foods. A recent review study [55] clearly indicated that a reduction in salt intake is an effective prevention strategy for ischemic stroke. The results of a recent Korean study confirmed that CI patients prefer salty and spicy foods, such as kimchi (Korean spicy pickled vegetables), salted seafood, and traditional Korean spicy stews [38].

Because a number of foods have been shown to be associated with CI, the use of dietary patterns allows for examining the combined effect of foods. In addition, overall dietary patterns are easier to recommend to the public than individual foods or nutrients. The cumulative effects, including which nutrients and foods are consumed in combination, on disease risk may be best investigated by considering the entire eating pattern [56].

In a Japanese study, the relative risk for CI was less than one (0.68–0.94) in the highest quartile level of those consuming a Westernized dietary pattern, which suggests the possibility that the traditional Japanese diet, which has a very low fat intake, was likely to increase the risk of stroke [57]. In contrast, Fung et al. found that a high Western dietary pattern score, characterized by a high intake of red and processed meats, refined grains, high-fat dairy products, and sweets and desserts, is associated with an increased risk of stroke. While there was a suggestion of reduced risk with a high prudent pattern, a diet higher in fruits and vegetables, fish, and whole grains, score [58]. Several previous studies suggested that a number of the prudent pattern components have been associated with a lower risk of stroke [47, 59]. Few data are available on the components of the Western pattern and the risk of stroke. In a case–control study [60], an increased risk of stroke was seen when meat consumption was >4 times per week, but the association was no longer significant when CI and cerebral hemorrhage were analyzed separately. Another study indicated that the higher risk of CI observed with the Western pattern may be partially mediated by insulin response or the inflammation process [61].

Tools for Diet Quality Assessment

Assessments of Nutritional Adequacy

Comparison with the Dietary Reference Intakes for Koreans

The intake of energy and 15 nutrients were compared with the KDRI [62], which vary by age and gender. Nutrient scores were assigned on the basis of the percentage of the KDRIs attained on a continuous scale. Energy was calculated on the basis of the estimated energy requirements. Protein, calcium, phosphorus, iron, zinc, vitamin A, vitamin B1, vitamin B2, vitamin B6, niacin, vitamin C, and folate were calculated based on the recommended intake levels of the KDRI. Dietary fiber, potassium, and vitamin E were calculated using the adequate intake levels according to the KDRI [62].

Nutrient Adequacy Ratio and Mean Adequacy Ratio

The nutrient adequacy ratio (NAR) was calculated from the daily average nutrient intake of the subjects according to the following equation, where values greater than 1 were expressed as 1 to identify individuals with greater nutrient intakes [63]. Nutritional adequacy, a major component of overall dietary quality, was measured using the average NAR value of all assessed nutrients, that is, the mean adequacy ratio (MAR) [63, 64].

The formula for the NAR is

$$\text{NAR} = \frac{\text{the subject's daily intake of a specific nutrient}}{\text{the KDRI of that nutrient}}$$

Measurements of Dietary Pattern and Overall Dietary Quality

Foods were divided into five categories. All milk and milk products, including cheese but excluding butter and cream, were assigned to the dairy group. The meat group included all animal and plant protein sources. All grain products, potatoes, and rice were included in the grain group, but cakes, cookies, and pastries were excluded. The fruit group included all fresh or dried fruits and fruit juices [65]. The vegetable group included salad greens and all raw or cooked vegetables. In accordance with the established procedures, foods consumed in less than minimum amounts were excluded. The minimum reported amount for foods or food groups in the meat, grain, fruit, and vegetable groups was 30 g for solid foods and 60 g for liquid foods. For the dairy group, the minimum amount was 15 g for solid foods (cheese) and 30 g for liquid foods (milk and yogurt) [65].

Dietary Diversity Score

To determine the diversity of food groups, the dietary diversity score (DDS) was calculated for each subject as the number of food groups consumed during a day (total = 5; dairy, meat, grain, fruit, and vegetable (DMGFV)), as opposed to within a meal due to the nature of a typical Korean meal. In general, Koreans did not consume dairy products in every meal and perceive dairy products as a snack. Each food group represented 1 point [65], and therefore the maximum DDS was 5.

Dairy, Meat, Grain, Fruit, and Vegetable

The presence or absence of each food group in each subject's diet can be evaluated. With the five food groups (dairy (D), meat (M), grain (G), fruit (F), and vegetable (V)), the occurrence at two levels (present or absent) was recorded for each group. These combinations were defined as "the patterns of food group intake" and termed DMGFV, with the numbers 1 or 0 indicating the presence or absence of the food group, respectively. For example, a DMGFV of 11110 indicates a pattern in which all food groups but vegetables were consumed in a day. The minimum reported amount for foods or food groups corresponded to the DDS criteria [65].

Dietary Variety Score

To evaluate the variety of meals, the dietary variety score (DVS) was adopted and was determined by counting the number of food items consumed daily. Commodity consumptions that totaled at least half servings in a day were included after disaggregating food mixtures into component ingredients [66].

Diet Quality Index-International

For an overall measure of diet quality, the diet quality index–international (DQI-I) developed by Kim et al. [67] was used. The DQI-I focuses on concerns related not only to chronic diseases but also to the problems of malnutrition. Therefore, this measure can be used as a global tool to monitor diet healthfulness and explore the aspects of diet quality that relate to nutrition transition. The DQI-I is composed of four major aspects: variety, adequacy, moderation, and overall balance. Variety was assessed by the number of food groups consumed and the sources of protein in the diet (0–20 points). Adequacy (0–40 points) and moderation (0–30 points) were assessed by the amounts of foods consumed, and overall balance (0–10 points) was assessed by the macronutrient ratio and fatty acid ratio in the diet. Scores for each component were summarized in four main categories, and the scores for the four categories were summed to determine the total DQI-I score, which ranged from 0 to 100 [67], with a higher score indicating a better quality diet.

Table 2.5 Dietary qualities of CI patients and non-CI subjects in Korea

	Non-CI	CI
NAR[a]		
Protein	1.00 ± 0.02[b]	0.96 ± 0.11**
Vitamin A	0.89 ± 0.16	0.84 ± 0.24
Vitamin E	0.99 ± 0.04	0.91 ± 0.18***
Vitamin C	0.82 ± 0.17	0.77 ± 0.27
Vitamin B_1	0.88 ± 0.12	0.84 ± 0.20
Vitamin B_2	0.77 ± 0.24	0.67 ± 0.16***
Niacin	0.91 ± 0.12	0.84 ± 0.21**
Vitamin B_6	1.00 ± 0.02	0.93 ± 0.14***
Folate	0.72 ± 0.27	0.59 ± 0.18**
Calcium	0.76 ± 0.25	0.59 ± 0.16***
Phosphorus	0.99 ± 0.03	0.96 ± 0.11*
Iron	0.99 ± 0.05	0.94 ± 0.15*
Zinc	0.96 ± 0.09	0.90 ± 0.16*
MAR[c]	0.87 ± 0.08	0.83 ± 0.18
DDS[d]	4.3 ± 0.7	3.7 ± 0.7***
DVS[e]	35.5 ± 21.1	14.0 ± 5.5***
DQI-I (score/100)[f]	65.3 ± 12.3	60.3 ± 8.1**
Variety (score/20)	14.5 ± 1.6	11.3 ± 2.1**
Adequacy (score/40)	28.1 ± 2.2	25.7 ± 2.2**
Moderation (score/30)	22.7 ± 1.1	21.9 ± 1.3*
Overall balance (score/10)	3.3 ± 1.1	3.1 ± 1.1*

Adapted by Lim et al. [38] (*Nutrition Research*) with permission
CI cerebral infarction
*Significant differences between the two groups were determined by the Student's *t* test at $^{*}p<0.05$, $^{**}p<0.01$ and $^{***}p<0.001$
[a]NAR: nutrient adequacy ratio
[b]Values are means ± SD
[c]MAR: mean adequacy ratio
[d]DDS: dietary diversity score counts the number of food groups consumed daily from major five food groups (dairy, meat, grain, fruits, vegetables)
[e]DVS: dietary variety score counts the total number of foods consumed per day
[f]DQI-I: dietary quality index is summed across the four recommendations to assess a diet quality from 0 (poor quality diet) to 100 (excellent quality diet)

Assessment of Diet Quality Among CI Patients in South Korea

Although intake and diet quality in CI patients should well manage, few studies have assessed quality of diet, especially in a Korean population. We investigated the quality of diet in Korean CI patients compared to non-CI subjects, using several different assessment tools (Table 2.5) [38].

Nutrition Adequacy

The NARs of protein, vitamin E, vitamin B2, niacin, vitamin B6, folate, calcium, phosphorus, iron, and zinc in the CI group were significantly lower than those of the non-CI group [38] (Table 2.5). The NARs of these nutrients in Korean CI patients were less than 1, indicating that the intake was less than those indicated in the KDRI. However, the MARs in Korean CI patients were not significantly different from that of non-CI subjects, demonstrating that these subjects also did not consume an adequate amount of nutrients.

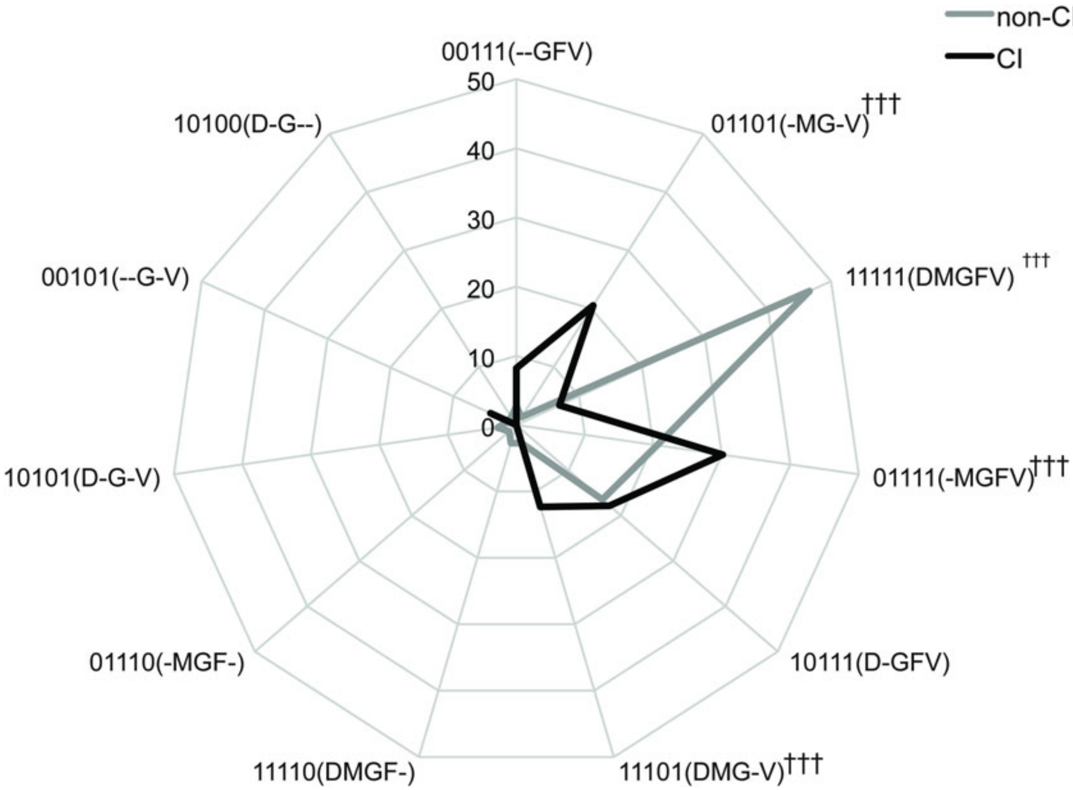

Fig. 2.2 Comparison of patterns of food groups consumed by CI patients and non-CI subjects in Korea. *CI* cerebral infarction. Significant differences between the groups were determined with the Chi-square test at $^*p<0.001$. *DMGFV* dairy, meat, grain, fruits, vegetables, *line* food group absent. 1 = food group present; 0 = food group absent. For example, DMGFV = 11111 means that all food groups (dairy, meat, grain, fruits, and vegetables) were consumed: DMGFV = 10111 means that four groups (dairy, grain, fruits, and vegetables) were consumed and one food group (meat) was not consumed

Dietary Pattern

The DDS scores of the non-CI and CI groups were 4.3 and 3.7, respectively, revealing that the average number of food groups consumed daily was significantly lower in the CI patients [38] (Table 2.5). The DVS scores of the non-CI and CI groups were 35.5 and 14.0, respectively, showing that the number of food items consumed daily in the CI group was also significantly lower than that in the non-CI group. Korean CI subjects consumed only a few food items daily, despite the fact that the Korean Nutrition Society recommends that over 20 food items should be consumed daily [68].

Figure 2.2 shows the patterns of food groups consumed by the Korean subjects, which were significantly different between the non-CI and CI groups [38]. The percentage of subjects who consumed all five food groups (DMGFV) was approximately half of the non-CI group and only 6.9 % in the CI group. In the CI group, the most frequently reported pattern was the omission of the dairy group (–MGFV; 30.1 %), followed by the omission of the dairy and fruit groups (–MG-V; 20.6 %) and the omission of the meat group (D-GFV; 17.8 %). The majority of the CI group (60.2 %) consumed four food groups (DMG-V, –MGFV, or D-GFV); however, only 42.4 % of the non-CI group consumed four food groups. The proportion of subjects who omitted more than two food groups was 11.0 % in the non-CI group and 32.9 % in the CI group, revealing that the CI group had a higher ratio of food group omission than did the non-CI group.

The CI patients had less diversity in their food groups and a reduced variety of foods within each food group. A larger proportion of the CI patients consumed diets lacking foods from one or more food groups compared to the non-CI subjects. The most frequently omitted food groups were the dairy or fruit group and both the dairy and fruit groups, which reaffirmed previous study results on the relationship between CI and low fruit and dairy intake [18, 47]. The primary reason that Korean CI patients avoided milk and other dairy products was lactose intolerance. One earlier study revealed that dairy calcium intake was inversely associated with the risk of ischemic stroke [69].

Overall Dietary Quality

There are currently few overall diet quality assessment tools available for CI or stroke patients. The DQI-I was developed for making international comparisons of diet quality [64]. A higher DQI-I score indicates a better quality diet. The overall measure of dietary quality, DQI-I, in the CI group was significantly lower than the non-CI group (non-CI, 65.3 vs. CI, 60.3) [38] (Table 2.5). The scores for each of the four categories (variety, adequacy, moderation, and overall balance) in the CI group were significantly lower than in the non-CI group. The mean DQI-I scores of CI patients in a Korean study were slightly lower than the calculated DQI-I scores of a group of Guatemalan adults with obesity or cardio-metabolic risk (males, 69.1; females, 65.5) [70]. However, these DQI-I scores are similar, or slightly higher, than those for Chinese and American populations [64]. The CI patients in a Korean study [38] consumed fewer dietary fats and empty calorie foods compared with patients in previous studies [64, 70]. Diets that lack foods from one or more food groups in sufficient or moderate amounts and lack balanced meals may be confounding factors that affect dietary quality. We conducted further analysis regarding associations between CI prevalence and dietary quality indexes. After controlling for age, gender, diseases, and other health-related factors, the high DQI-I scores (OR = 0.92; 95 % CI = 0.89, 0.95; $p < 0.0001$), particularly the variety (OR = 0.77; 95 % CI = 0.68, 0.86; $p < 0.0001$) and adequacy (OR = 0.83; 95 % CI = 0.76, 0.91; $p = 0.042$) components (desirable diet patterns and quality), exhibited a lower prevalence of CI [38].

Dietary Patterns According to Nutritional Status

The dietary patterns and quality of Korean CI patients according to their nutritional status are presented in Table 2.6 [35]. The average DDS scores of the well-nourished, moderately malnourished, and severely malnourished groups were 4.0, 3.9, and 2.9, respectively, revealing that the average number of food groups consumed daily was significantly lower in severely malnourished patients. The food group patterns consumed were significantly different among the groups. A very low percentage of patients consumed all five food groups. Around 75 % of well-nourished and moderately malnourished patients consumed four food groups (DMG-V, –MGFV, D-GFV); however, only 11 % of the severely malnourished group consumed four food groups. As expected, well-nourished patients with CI consumed a variety of food groups and an assortment of foods in each food group. A large proportion of the well-nourished patients consumed diets lacking in foods from one food group compared with the severely malnourished patients, whose diets lacked more than one food group. The most frequently reported pattern for the moderately or severely malnourished group was the omission of the dairy or the dairy and fruit groups. The number of food items (from the DVS) consumed daily was highest in the well-nourished patients (18.2 items), followed by those who were moderately malnourished (14.7 items) and, with the lowest number of food items (8.0 items), were the severely malnourished patients [35]. The number of food items was fewer than Korean elderly group.

Table 2.6 Diet quality of CI patients according to their nutritional status[1]

	Well nourished	Moderately malnourished	Severely malnourished
DDS[2]	4.0 ± 0.5[a]	3.9 ± 0.6[a]	2.9 ± 0.5[b]
5 (score/5)	2 (10.5)	3 (8.3)	0 (0.0)
4 (score/5)	15 (78.9)	27 (75.0)	1 (11.1)
3 (score/5)	2 (10.5)	5 (13.9)	13 (72.2)
2 (score/5)	0 (0.0)	1 (2.8)	3 (16.7)
DVS[3]	18.2 ± 4.1[a]	14.7 ± 4.6[b]	8.0 ± 5.0[c]
DQI-I (score/100)[4]	68.6 ± 4.2[a]	62.0 ± 5.0[b]	53.2 ± 3.8[c]
Variety (score/20)	14.5 ± 1.6[a]	11.3 ± 2.1[b]	7.8 ± 1.3[c]
Adequacy(score/40)	28.1 ± 2.2[a]	25.7 ± 2.2[b]	22.4 ± 1.8[c]
Moderation(score/30)	22.7 ± 1.1[a]	21.9 ± 1.3[a]	20.9 ± 1.8[b]
Overall balance (score/10)	3.3 ± 1.1[a]	3.1 ± 1.1[a]	2.1 ± 0.8[b]

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DDS dietary diversity score, *DQI-I* dietary quality index–international, *DVS* dietary variety score

[1]Values are means ± SD or numbers of patients (percentages). Different superscript letters in the same row are significantly different at $p < 0.05$ by Duncan's multiple range test

[2]Counts the number of food groups (dairy, meat, grain, fruit and vegetable) consumed daily. Significant differences in the categorical variables were determined by the Chi-square test at $p < 0.05$

[3]Counts the total number of food items consumed per day

[4]DQI-I scores are the sum of the four categories used to assess diet quality (0, poor diet; 100, excellent diet)

Overall Diet Quality According to Nutritional Status

Overall measures of dietary quality, including the DQI-I, were significantly higher in well-nourished patients. The well-nourished group scored higher in the variety, adequacy, moderation, and overall balance categories. According to the developer of the DQI-I [67], the quality of diet can be considered "poor" if the total DQI-I score is below 60 points. The DQI-I score of severely malnourished patients in a Korean study was 53.2 [35], indicating that severely malnourished patients had low-quality diets. In the variety category of the DQI-I, the scores were highest in well-nourished patients compared with malnourished patients. The variety category score of the malnourished patients was lower than scores observed in earlier studies [71, 72]. Our recent study confirmed that CI patients with poor nutritional status do not consume a variety of foods [35]. The most drastic difference in adequacy among the three groups was calcium intake. It can be inferred that this is due to the omission of the dairy food group seen in the malnourished patients. The severely malnourished CI patients in Korea consumed less dietary fat and empty calorie foods compared with those evaluated in the Kim et al. study [67]. However, all groups of CI patients consumed large amounts of sodium. A Korean study [15] previously reported a high-sodium diet as a risk factor for CI.

Dietary Quality in Diabetes Mellitus Patients with CI

There was a comparative study of diabetes mellitus patients with or without CI, which focused on nutrient intakes and dietary quality [73]. The study aimed to compare the food habits, nutrient intakes, and dietary patterns and diet quality in diabetic patients with CI and those without. Dietary quality, including the DDS, DMGFV, and the DQI, was significantly lower in the diabetic patients with CI. According to the results, diabetic patients accompanied by CI had poorer eating patterns and dietary quality, in accordance with poorer health-related behaviors, compared with the diabetic patients without CI.

How to Use the Diet Quality Measures in Practice

Korean CI patients tend to prefer saltier and spicier foods, to exhibit more irregular eating patterns (e.g., frequently skipping meals and having irregular meal times), and to have fewer beneficial foods (e.g., dairy products and fruits), which results in a diet low in nutritional density and a poor overall dietary quality, than subjects without CI. There are high associations among the variety in diet, adequacy of beneficial food intake, and the risk of CI [35, 38, 43, 73]. In terms of nutrient intake, Korean CI patients consumed more sodium (4,694 mg/day) than did Korean aged 65 years and above [43, 74]. It was previously reported that a high intake of sodium is one of the risk factors for CI [23]. Traditional Korean cuisine contains large amounts of salt. The elderly, who are especially accustomed to the traditional diet, may find it difficult to adopt a low-sodium diet. In addition, it is recommended that CI patients with several comorbidities, including hypertension, should consume low-sodium diets.

Since foods and nutrients are combined together, their cumulative effects on disease risk may be best investigated by considering the overall diet quality. Therefore, an analysis of dietary patterns and overall dietary quality assessment are important to determine the combined effects of foods on the occurrence of CI in a Korean population.

Dietary therapies are specific to each disease, and thus a need for nutritional therapy in CI patients would be advantageous to help control comorbidities while addressing poor eating habits associated with this disease. Therefore, the development of recipes and menus that replace the salty taste for CI patients is much needed, considering that patients would not be likely to find bland foods appetizing, given their strong preference for salty foods.

In addition, there were a relatively strong correlation between poor nutritional status and severe depression in Korean CI patients [43]. In light of this, integrated methods for the treatment of CI patients should be implemented, including medical nutrition therapy to improve nutritional status, depression management programs, and education.

Below we suggest an effective strategy for diet quality measurement and a protocol for eating-related management in the Korean population with CI risk factors:

1. Perform a nutritional assessment of Koreans over the age of 50 who have a family history of cardiovascular disease, including stroke and other related risk factors, such as high blood pressure, dyslipidemia, and high fasting blood glucose, before CI onset through a nutritional screening tool. The tool should consist of four parts: anthropometric, biochemical, clinical, and dietary assessments. The dietary assessment should focus on eating habits, dietary pattern, and overall diet quality and focus on Korean-specific dietary habits or criteria customized to the patient's medical history.
2. To assess diet quality, it needs new or revising established assessment tool of diet quality for Korean with risk factors of CI, because Korean CI patients generally consume foods high in sodium and pungent foods; tend to omit more than two food groups, in particular the fruit and dairy groups; and exhibit more irregular eating patterns, which results in a diet with a low nutritional density and a poor overall quality of diet, as compared to subjects without CI and other populations.
3. We should not overlook the consequences of depression and quality of life among Korean CI patients. These psychological factors also affect their diet quality.

Conclusions

Stroke is one of the major causes of death among adults over the age of 50 in Korea. It also causes permanent physical disability and can affect not only the patient but also their family members, damaging their quality of life. The prevalence of CI in Korea has gradually increased since 2000, as compared with steadily decreased cerebral hemorrhage. This trend has been explained by changes in several factors, including dietary behavior and lifestyle.

Malnutrition is common in Korean CI patients. The extent of malnutrition in the hospitalized patients with CI and its influence on outcomes are important issues. PG-SGAs and concise MNAs are thought to be suitable for evaluating the nutritional status of CI patients with stable vital signs, especially elderly CI patients since stroke is common in the elderly and causes physical discomfort.

Many dietary factors regarding foods and nutrient consumption in CI patients have been reported. Korean CI patients were less likely to ingest beneficial foods such as beans, fish, vegetables, seaweeds, fruits, and dairy products. It should be recommended to Korean CI patients that they should include these foods in their diets in order to improve their overall nutritional status, as well as to prevent the relapse of CI.

Korean CI patients also frequently skipped their meals and had irregular meal times. Furthermore, they preferred salty and spicy foods. In accordance with increasing the fat intake in Korea over the past 30 years, changes in eating behaviors and dietary patterns are believed to influence the recent increases in chronic diseases, including CI.

In regard to the quality of diet, the Korean CI patients consumed less diverse food groups and less variability of foods within each food group. A large proportion of the CI patients consumed diets lacking foods from one or more food groups compared to non-CI subjects. The most frequently omitted food groups were the dairy group, both the dairy and fruit group, and the fruit group. The overall measure of dietary quality, the DQI-I, in the CI patients was significantly lower than in the non-CI subjects. The scores for each of the four subcategories (variety, adequacy, moderation, and overall balance) in the CI patients were significantly lower than those in the non-CI subjects. After controlling for age, gender, diseases, and other health-related factors, the DDS, DVS, and DQI-I scores were also low in the CI patients, demonstrating that CI patients have less desirable dietary pattern and low quality of diet.

Although a dietary assessment of the patients would be helpful in preventing the recurrence of CI, few studies have assessed the quality of diets in Korea. Population level screening tools for dietary quality and/or nutritional status should be developed for Koreans who are prone to develop CI. In addition, active and customized medical nutrition therapy or management programs to improve the quality of diet are needed and should consider the individual patient's medical history and comorbidities, such as hypertension, diabetes, and dyslipidemia, as well as health-related behaviors. Population-based diet assessments are needed to more effectively examine traditional diets and eating behaviors.

Further, identification of malnutrition and appropriate nutritional interventions may affect rehabilitation and quality of life post-onset. Additionally, there was a significant correlation between poor nutritional status and severe depression in CI patients. In light of this, integrated methods for the treatment of CI patients should be implemented, including medical nutrition therapy to improve nutritional status, depression management programs, and education targeting families or caregivers to promote their cooperation.

Fortunately, all of these factors, including health-related habits, nutritional status, dietary pattern, and diet quality, can be modified positively prior to CI onset through individually tailored intensive management efforts. There is currently no medical nutrition therapy protocol for CI patients in South Korea. The development of such a protocol would assist in the management of CI patients. Further research is required to evaluate the effects of any proposed medical nutrition therapies, including coordinated programs addressing psychological factors such as depression.

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3 Diet Quality and Breast Cancer Risk

André Nkondjock

Key Points

- Greater adherence to the traditional Mediterranean diet or its variants is associated with a significant reduction in breast cancer risk.
- The Canadian Healthy Eating Index appreciably predicts the risk of hereditary breast cancer.
- The Healthy Eating Index may have little association with the risk of breast cancer.
- Women diagnosed with breast cancer may improve prognosis by scoring high in Healthy Eating Index (2005).
- Postmenopausal women who scored high on Recommended Food Score had significant estrogen receptor (ER)-negative breast cancer risk reduction.

Keywords

Breast cancer • Diet quality • Food frequency questionnaire • Prognosis • Nutrition

Abbreviations

AHEI	Alternate Healthy Eating Index
aMED	Alternate Mediterranean Diet Index
BMI	Body mass index
BRCA	Breast cancer
CHEI	Canadian Healthy Eating Index
CI	Confidence interval
DASH	Dietary approaches to stop hypertension
DQI-R	Diet Quality Index-Revised
EPIC	European Prospective Investigation into Cancer and Nutrition
ER	Estrogen receptor
FFQ	Food Frequency Questionnaire
HER2	Human epidermal growth factor receptor 2
HR	Hazard ratio
MET	Metabolic equivalent
MUFAs	Monounsaturated fatty acids

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V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health,
DOI 10.1007/978-1-4614-7315-2_3,

NHS	Nurses' Health Study
OR	Odds ratio
PUFAs	Polyunsaturated fatty acids
RFS	Recommended Food Score
RR	Relative risk
SFAs	Saturated fatty acids
USDA	US Department of Agriculture

Introduction

Breast cancer is the most common invasive cancer and the second leading cause of cancer-related deaths among women in most industrialized countries. The incidence of this disease in Western countries is about 5 times that of developing countries and Japan [1]. Over the last 50 years, the incidence of breast cancer has increased dramatically, such that today, one in eight women is expected to develop breast cancer during her lifetime.

Breast cancer has a complex etiology where susceptibility is influenced by both environmental and genetic factors. Considerable experimental and epidemiological evidence suggests that lifetime exposure to endogenous hormones, notably estrogens and androgens, promotes breast carcinogenesis. In population-based studies, factors related to increased estrogen and androgen exposure throughout a woman's lifetime, such as early menarche, late menopause, the use of oral contraceptives, and hormone replacement therapy, have been associated with a ~2-fold increase in breast cancer risk among premenopausal women [2, 3]. Other risk factors including age, family history, late age (>30 years) at first pregnancy or never been pregnant, high breast density [4], and also modifiable risk factors such as diet [5], alcohol, exercise, and tobacco use are also important in defining risk for breast cancer.

About 5–10 % of all breast cancer cases are due to a hereditary predisposition. The two most important genes that predispose to breast cancer when bearing a germline mutation are the *BRCA1* and *BRCA2* genes. It has been estimated that 5.3 % of breast cancers occurring in women under 40 years and 1.1 % of breast cancers in women from 50 to 70 years are due to mutations in either of these genes [6]. Both genes are considered to be tumor suppressor genes that play a role in DNA repair [7, 8] and mammary stem cell differentiation [9, 10]. Mutation carriers have an increased lifetime risk of developing breast cancer of 57 and 40 % and of developing ovarian cancer of 40 % and 18 % for *BRCA1* and *BRCA2*, respectively [11].

Over the past 2 decades, numerous epidemiological and laboratory studies have examined the effects of dietary patterns, which provides a comprehensive representation of dietary intake involving a large number of dietary components working together, food groups as well as single nutrients and other nutritional determinants on both sporadic and hereditary breast cancer risks [12]. While alcohol has been the only dietary factor associated consistently with sporadic breast cancer risk [13], it has been suggested that both caloric restriction and the combination of *BRCA* mutations as well as fruit and vegetable diversity may reduce the risk of breast cancer among women who carry a deleterious *BRCA* gene mutation [14, 15].

Based on dietary guidelines and according to recent scientific evidence, overall diet quality measurements have been suggested as a useful tool to assess diet-disease relationships. As a consequence, a number of diet quality indexes (DQIs) have been proposed to guide and assess an individual's dietary intake for the prevention of nutrition-related chronic diseases and the promotion of health [16–18]. The validation of some index scoring method with the use of data from large cohorts indicated that the total index score is estimated reasonably by the food frequency questionnaire (FFQ) [19]. The present chapter provides an overview of research relevant to diet quality scores and the risk of breast cancer.

The Recommended Food Score and breast cancer

The Recommended Food Score (RFS) is an index of diet quality that captures aspects of dietary guidance regarding foods to be included in the diet. The RFS was originally developed by Kant et al. [20]. They used a 62-item FFQ that included 23 different recommended foods and participants received 1 point for each of the recommended food that they consumed at least weekly and total score ranged from 0 to 23. In general, the RFS focused on fruits, vegetables, whole grains, lean meats or meat alternates, and low-fat dairy products. It is calculated by summing up these foods on the dietary questionnaire that are consumed at least weekly and the longer the questionnaire is, the highest the possible RFS score will be (Table 3.1).

In the Nurses' Health Study (NHS) [17] where breast cancer is the major cancer diagnosed, the RFS did not predict cancer risk after multiple adjustment (relative risk (RR) = 1.00; 95 % CI: 0.92–1.11). The authors concluded that the lack of association with the RFS implies that diet quality scores, and dietary guidelines in general, need to include both messages to consume more of certain foods (e.g., fruit, vegetable, and whole grains) and messages aimed at the quality of nutrient sources (e.g., consume more unsaturated than saturated or *trans* fats and eat more white meat than red meat). They also suggested that including additional dietary behaviors may improve the ability of the RFS to predict incident disease.

In a large prospective cohort [21] involving 3,580 cases of breast cancer during 18 years of follow-up, the authors reported an inverse association between RFS and ER-negative breast cancer risk. Postmenopausal women who scored high on RFS had a 31 % risk reduction (RR = 0.69; 95 % CI: 0.51–0.94; p trend = 0.003). For each 10 % increase in RFS, there was a significant 12 % reduction (p = 0.002) of risk for ER-breast cancer.

In the Breast Cancer Detection Demonstration Follow-up Project [22] involving 283,222 women at baseline in 27 cities across the United States and followed up for 9.5 years, no significant association was apparent between the RFS and incident breast cancer. However, the authors reported an inverse association between RFS and cancer mortality that was significant for colorectal and lung cancers and was borderline significant for breast cancer mortality (RR = 0.75; 95 % CI: 0.56–1.00; p trend = 0.06).

Fruits and vegetables contribute ~80 % of the total RFS score. These foods are important sources of nutrients including vitamin C, carotenoids, and other phytochemicals. Despite the existence of several plausible metabolic pathways linking these food components to breast cancer, no firm conclusion has been reached. In addition, high scores on the RFS do not capture differences in types of fat, which may contribute to the poor performance in breast cancer risk prediction. Lastly, RFS does not include alcohol intake and it is possible that alcohol-related breast cancer may dilute the RRs associated with intake of other food components. Overall, the evidence relating RFS to the risk of breast cancer is unconvincing, although in women already diagnosed with breast cancer higher scores on RFS may affect progression or survival.

Diet Quality Index and Breast Cancer

In 1994, the DQI was created in the United States due to concerns related to the major diet-related chronic diseases [23]. In 1999, the original DQI was revised to reflect current dietary guidance, to incorporate improved methods of estimating food servings, and to promote other important aspects of a healthy diet such as measures of dietary variety and moderation [16]. The scoring of the original scale was reversed in direction and expanded to a 100-point scale. The DQI-Revised (DQI-R) consists of ten components that measure the intake of three food groups (grain products, vegetables, and fruits), five nutrients (total fat, saturated fat, cholesterol, calcium, and iron), diet diversity (based on the sum of grain products, vegetables and fruits, milk products, meats, and alternatives), and diet moderation (amount of added fat, added sugar, sodium, and alcohol). The range of possible scores for each component was 0–10 points, depending on the level of intake, and the maximum possible DQI-R score was 100 points.

A limited number of studies have assessed the relationship between DQI-R and breast cancer. A Canadian case–control study [24] was carried out within a cohort of 80 French-Canadian families with 250 members involving 89 carriers of *BRCA* genes affected by breast cancer, 48 non-affected carriers, and 46

Table 3.1 Components and scoring criteria of diet quality score in breast cancer studies

Index	Dietary components	Foods included	Criteria	Score
RFS	Vegetables	All vegetables and vegetable juices		1 point for each item consumed at least weekly
	Fruits	All fruits and fruit juices		Same as above
	Protein	Chicken or turkey without skin, fish and seafood		Same as above
	Grains	Dark breads, whole-grain cereals, cooked cereals, oatmeal, brown rice		Same as above
	Dairy	Skim milk and skim yogurt		Same as above
DQI-R	Grains	All grains, breads, and grain products	≥9 servings/d	10; 1 point less for each 10 % less than the required intake for a full score
	Vegetables	All vegetables and juices	≥4–5 servings/d	Same as above
	Fruits	All fruits and juices	≥3–4 servings/d	
	Total fat	All foods supplying fat	≤30 % of total energy	10
			30.1–40 % of total energy	5
			>40 % of total energy	0
	SFAs	All foods supplying SFAs	≤10 % of total energy	10
			10.1–13 % of total energy	5
			>13 % of total energy	0
	Cholesterol	All foods supplying cholesterol	≤300 mg	10
			301–400 mg	5
			>400 mg	5
	Calcium	All foods supplying calcium	≥1,200 mg	10; 1 point less for each 10 % less than the required intake for a full score
	Iron	All foods supplying iron	≥8 mg	Same as above
	Diet diversity	Sum of the following four food groups: grain products, vegetables and fruits, milk products, meats and alternatives	≥0.25 serving/d of each food included in a food group = 1 point	Maximum of 2.5 points for each food group; maximum of 10 for total diversity

	Diet moderation	Added fat	<25 g/d	2.5
			25.1–50 g/d	1.5
			50.1–75 g/d	1
			>75 g/d	0
		Added sugar	≤12 tsp/d	2.5
			12.1–18 tsp/d	1.5
			18.1–24 tsp/d	1
			>24 tsp/d	0
		Sodium	≤2,400 mg/d	2.5
			2,401–3,400 mg/d	1.5
			>3,400 mg	0
		Alcohol	≤1 drink/d	2.5
			1.01–1.5 drink/d	1.5
			>1.5 drink/d	0
	Vegetables	All vegetables except potatoes and vegetable juices	≥4–5 servings/d	10; 1 point less for each 10 % less than the required intake for a full score
AHEI	Fruits	All fruits and fruit juices	≥3–4 servings/d	10; 1 point less for each 10 % less than the required intake for a full score
	Nuts and soy	Nuts, tofu, and soymilk	1 serving/d	Same as above
	Ratio of white to red meat	White (chicken, seafood) and red (red and processed) meats	4	Same as above
	Cereal fiber		15 g/d	Same as above
	Trans fatty acids	All foods supplying *trans* fat	≤0.5 % of total energy	10
			>0.5 and <4 % of total energy	1 point less for each 10 % increment
			≥4 % of total energy	0
	Ratio of PUFAS to SFAs		≥1	10; 1 point less for each 10 % less than the required intake for a full score

(continued)

Table 3.1 (continued)

Index	Dietary components	Foods included	Criteria	Score
	Duration of multivitamin use		≥5 years	7.5 points for ≥5 years regular use and 2.5 points for all others
	Alcohol	Beer, wine, whiskey, and spirits	0.5–1.5 serving/d	10; 1 point less for each 10 % less or above the required range intake for a full score
	Vegetables and fruits	All vegetables (except potatoes) and vegetable juices		1 point if number of serving/d > median intake of control groups; 0 point if this criterion is not met
aMED	Fruits	All fruits and fruit juices		Same as above
	Legumes	Beans, peas, and tofu		Same as above
	Nuts	Nuts and peanut butter		Same as above
	Whole grains	Whole-grain ready-to-eat cereals, whole bread, wheat germ		Same as above
	Red and processed meats	Beef, pork, hamburger, bacon, hot dogs		Same as above
	Fish	Fish and seafoods		Same as above
	Ratio of MUFAs to SFAs			1 point if value > median value of control groups; 0 point if this criterion is not met
	Alcohol	Beer, wine, whiskey, and spirits	5–15 g/d	1
			<5 or >15 g/d	0
	Grain products	All grains, breads and grain and enriched products	≥8 servings/d	10; 1 point less for each 10 % less than required intake for full score

CHEI	Vegetables and fruits	All vegetables, fruits, and juices	≥7 servings/d	Same as above
	Milk and milk products	Whole and low-fat milk, cheese, yogurt, cream, ice-cream	2–4 servings/d	10; 1 point less for each 10 % less or above the required range intake for a full score
	Meats and alternatives	Meats, poultry, fish, peas, beans, and lentils	2–3 servings/d	Same as above
	Vegetables	All vegetables and vegetable juices	≥3–4 servings/d	5; 1 point less for each 20 % less than the required range intake for a full score
DASH[a]	Fruits	All fruits and fruit juices	≥4 servings/d	Same as above
	Nuts and legumes		≥3–4 servings/d	Same as above
	Low-fat dairy products		≥2 servings/d	Same as above
	Whole grains	Whole-grain ready-to-eat cereals, whole bread, wheat germ	≥4–5 servings/d	Same as above
	Sodium		≤1,500 mg/d	5
			1,501–2,400 mg/d	1 point less for each 20 % increment
			>2,401 mg/d	0
	Sweetened beverages		≤3 % of total energy	5; 1 point less for each 20 % above the required range intake for a full score
	Red and processed meats		<6 oz/d	Same as above

[a]Not yet assessed in studies of diet quality scores and the risk of breast cancer

Table 3.2 Odds ratios[a] and 95% confidence intervals for breast cancer associated with diet quality scores in BRCA gene carriers (Adapted with permission from Nkondjock and Ghadirian [24])

	Tertiles			
Diet quality scores	Q1 (low)	Q2	Q3	*p* for trend
DQI-R				
Multivariate model[b] OR (95 % CI)	1.00	1.04 (0.43–2.52)	0.35 (0.12–1.02)	0.034
Multivariate model[c] OR (95 % CI)	1.00	0.54 (0.21–1.36)	0.21 (0.07–0.62)	0.001
AHEI				
Multivariate model[b] OR (95 % CI)	1.00	0.63 (0.24–1.64)	0.65 (0.24–1.79)	0.244
Multivariate model[c] OR (95 % CI)	1.00	0.47 (0.18–1.26)	0.38 (0.13–1.10)	0.081
aMED				
Multivariate model[b] OR (95 % CI)	1.00	0.85 (0.30–2.39)	0.59 (0.20–1.77)	0.244
Multivariate model[c] OR (95 % CI)	1.00	0.43 (0.16–1.20)	0.54 (0.17–1.72)	0.491
CHEI				
Multivariate model[b] OR (95 % CI)	1.00	0.42 (0.15–1.18)	0.18 (0.05–0.68)	0.006
Multivariate model[c] OR (95 % CI)	1.00	0.85 (0.30–2.35)	0.32 (0.10–1.03)	0.078

[a]Adjusted for age, vigorous physical activity, and total energy intake
[b]Comparing *BRCA* carriers affected (by breast cancer) with non-affected
[c]Comparing *BRCA* carriers affected with non-*BRCA* carriers non-affected

non-affected noncarriers. The authors adapted the DQI-R for their 164-item self-administered FFQ by collapsing vegetables and fruits into a single group, as suggested in Canada's Food Guide to Healthy Eating. A significant inverse association was apparent between the DQI-R and *BRCA*-related breast cancer risk. Women with *BRCA* gene mutations affected by breast cancer who scored high on the DQI-R had a significant 65 % reduction in risk (Table 3.2). A prospective study [25] of diet quality and quality of life involving 714 breast cancer survivors of the Health, Eating, Activity, and Lifestyle Study has shown that post-diagnosis diet quality using the DQI was positively associated with their subsequent mental and physical functioning. A direct and significant association was also reported between poor diet quality as assessed with DQI and self-reported depression in breast cancer survivors [26]. In contrast, the DQI-R was of limited value in predicting breast cancer risk in a prospective study [21] of post-menopausal women.

Recently, Kim et al. [27] analyzed data of 2,729 women from the NHS with invasive stage 1–3 breast cancer diagnosed between 1978 and 1998 with follow-up through 2004 during which 302 died from breast cancer. The authors found that higher scores on the DQI-R do not appreciably change the risk of death from breast cancer, although in women with low physical activity DQI-R was associated with a 48 % decrease in non-breast cancer-related mortality.

The DQI-R is a comprehensive index based on the Dietary Guidelines for Americans and Food Guide Pyramid from the National Research Council [16]. Its scoring criteria include diet diversification and moderation and give more points for a diet low in all types of fat, including unsaturated fats. Although meaningful for an overall healthy diet, these components have little or no relation to breast cancer risk. The DQI-R also allows individuals to score higher points if their diet is high in iron and calcium, which again, may not be consistently related to breast cancer risk. Overall, the evidence relating DQI-R to the risk of breast cancer is unconvincing, but a high score for DQI-R after breast cancer diagnosis may affect progression or survival by improving the wellbeing of breast cancer survivors.

Healthy Eating Index and Breast Cancer

In 1995, the Healthy Eating Index (HEI) was developed by the US Department of Agriculture (USDA) to monitor dietary intake and nutrition promotion activities for the US population [28] and to provide a single summary of diet quality based on different aspects of a healthy diet [29]. HEI includes ten equally weighted components, which reflect recommendations based on the Food Guide Pyramid and the Dietary Guidelines for Americans. Each component has a minimum score of 0 (for nonadherence) and a maximum of 10 (for perfect adherence); intermediate degrees of adherence to the guidelines are calculated proportionately. The scores from the ten components are added for a total HEI score ranging from 0 (worst) to 100 (best).

In 2002, McCullough et al. [17] created the alternative HEI (AHEI) based on both the 1992 Food Guide Pyramid [18] and the 1995 Dietary Guidelines for Americans [19] by refining fat categories (e.g., ratio of PUFAS to SFAs, *trans* FAs), eliminating others (e.g., total grains, total fats, all meats combined), and adding foods associated with chronic disease in recent studies (e.g., nuts and soy, cereal fiber). In general, this AHEI contains nine components: vegetables (without potatoes), fruits, nuts and soy, the ratio of white to red meat, cereal fiber, *trans* fat, the ratio of PUFAs to SFAs, long-term multivitamin use, and alcohol. Possible scores from each component ranged from 0 to 10, depending on the level of intake. The possible score for the multivitamin component was either 2.5 (<5 years) or 7.5 (≥5 years) to avoid overweighting. The maximum possible AHEI score was 87.5.

In 2005, the original HEI was revised to reflect the 2005 Dietary Guidelines for Americans (HEI-2005) [30]. It includes updated recommendations on whole grains, dark green and orange vegetables, and legumes (US, 2005). The HEI-2005 assesses dietary intakes on a per calorie basis rather than on the basis of absolute amounts of foods consumed; thus, it assesses the quality of the relative proportions of foods consumed rather than the quantity. The HEI-2005 is computed on a 100-point analytic scale that awards points for dietary diversity; higher intakes of grains, vegetables, fruit, and milk; and lower intakes of meat, total fat, saturated fat, cholesterol, and sodium.

Fung et al. [21] first examined prospectively the association between AHEI and the risk of breast cancer in postmenopausal women. They used data from the NHS and breast cancer according to ER. In that investigation, the AHEI score was inversely associated with ER-breast cancer. The RR comparing top and bottom quintiles of the scores was 0.78 (95 % CI: 0.59–1.04; p trend = 0.01). For each 10 % increase in AHEI, there was an 11 % reduction of risk ($p = 0.01$). In addition, a high score on the vegetable component in AHEI was associated with a lower risk (RR = 0.68; 95 % CI: 0.51, 0.91; p trend = 0.01).

In a multiethnic prospective cohort [31] including 670 women diagnosed with local or regional breast cancer, George and colleagues assessed the association between post-diagnosis diet quality with prognosis. After 6 years of follow-up from the 30-month post-diagnosis assessment, the authors found that breast cancer survivors consuming better-quality diet, as defined by higher HEI-2005 scores, had an 88 % reduced risk of death from breast cancer (HR = 0,12; 95 % CI:0.02–0.99). The same group found in another cross-sectional analysis involving 690 nurses with no history of cardiovascular disease, breast cancer, or diabetes found that women who score high in HEI-2005 have lower levels of chronic inflammation [32].

A cross-sectional investigation [33] assessed associations between lifestyle factors and quality of life among 753 older long-term breast, prostate, and colorectal cancer survivors. The authors found that better diet quality indicative of HEI-2005 scores >80 was positively associated with physical quality of life, improved physical functioning, and vitality, after adjustment for age, level of education, and number of comorbidities.

In contrast, a prospective study [34] of 67,272 women over a 12-years follow-up period revealed that HEI was inversely associated with cardiovascular diseases but not with breast cancer incidence. The authors concluded that the lack of association reflected a combined effect of the weak relationships between dietary components included in the HEI and risk of breast cancer and the shortcomings of the HEI in defining an optimal diet for prevention of breast cancer. In the Nurses' Health Study, although there was no significant association between AHEI and breast cancer mortality, in breast cancer survivors with low physical activity, AHEI was related to a 29 % decrease in risk of total mortality [27]. In a case–control study [24] of diet quality and *BRCA-related* breast cancer, there was no association between the risk of breast cancer and the AHEI after multivariate adjustment.

Over time, the original HEI was refined to increase emphasis on the quality of individual's diet rather than the quantity. Components such as whole grains, whole fruit, and dark green and orange vegetables were added to the revised version of the index. However, no major association emerged between each of the food components making up HEI or its variants and breast cancer risk. The HEI's potential to successfully predict breast cancer risk is not consistent but women diagnosed with breast cancer may improve prognosis by scoring high in HEI-2005.

Mediterranean Diet Index and Breast Cancer

In the early 1960s, the notion of the traditional Mediterranean diet was first introduced by Ancel Keys [35], with emphasis on diet low in saturated fatty acids (SFAs) and ecological association with low incidence of coronary artery disease. In the 1980s, great interest in the Mediterranean diet as an integral entity was renewed, and in 1995 Trichopoulou et al. [18] introduced a scale assessing conformity to the most important characteristics of the Mediterranean diet. The original score was based on the intake of nine food items: vegetables, legumes, fruits and nuts, dairy products, cereals, meat and meat products, fish, alcohol, and the monounsaturated: SFA ratio. In 2006, based on dietary patterns and eating behaviors that have been consistently associated with lower risks of chronic disease in clinical and epidemiological studies, Fung et al. [21] modified the original scale and developed the alternate Mediterranean Diet Score (aMED) by excluding potato products from the vegetable group, separating fruits and nuts into two distinct groups, maintaining fish group, eliminating the dairy group, including whole-grain products only, including only red and processed meats for the meat group, and assigning 1 point for alcohol intake between 5 and 15 g/d. The score range for the aMED is 0–9 and the possible scores for each item are 0 or 1. Intake above the median of the study population receives 1 point; all other intakes receive 0 point. Early ecological investigations [36] carried out in Mediterranean countries in the 1960s and the 1970s, when the traditional Mediterranean diet was omnipresent, showed that these countries experienced lower breast cancer mortality rates when compared with other European countries or the United States.

The NHS [21] found an inverse association between aMED and ER-postmenopausal breast cancer risk. Women who scored high on the aMED had a 21 % statistically significant reduction in breast cancer risk. The European Prospective Investigation into Cancer and Nutrition (EPIC) cohort [37] in Greece reported that conformity to the traditional Mediterranean diet was associated with lower breast cancer risk among postmenopausal women. In that cohort of 14,807 women in Greece, a statistically significant inverse association of increased conformity to the Mediterranean diet with breast cancer risk among postmenopausal women was apparent (HR per 2-point increment 0.78, 95 % CI: 0.62–0.98). The authors concluded that overall ~10 % of breast cancer cases could be avoided if all women shifted their diet toward one adhering more closely to the Mediterranean dietary pattern.

In a population-based case–control study [38] among Asian-American women, Wu and colleagues reported a significant inverse association between conformity to the Mediterranean dietary pattern and breast cancer risk. In that study involving 1,248 breast cancer cases and 1,148 control subjects, there was a significant trend of decreasing risk with increasing score (p trend = 0.009); women with the highest score showed a significant 35 % risk reduction compared with women with lowest score.

In the UK Women's Cohort Study [39] involving 33,731 women with a follow-up of 9 years, the risk of breast cancer was associated with increasing adherence to the Mediterranean diet in premenopausal women although the trend was nonsignificant. Women with maximal adherence experience a 35 % lower risk of breast cancer compared with minimal adherence. Also, a great number of studies carried out in Mediterranean countries have reported an inverse relationship of breast cancer risk with olive oil, which is central to the traditional Mediterranean diet [40, 41].

A recent systematic review and meta-analysis [42] of dietary patterns and breast cancer risk including 18 cohort and case–controls studies that had identified prudent/healthy dietary pattern with high-factor loadings for plant foods and low-factor loadings for red and processed meat, which is in line with the Mediterranean diet, found a significant decrease in the risk of breast cancer in the highest compared with the lowest categories of that dietary pattern (OR = 0.89; 95 % CI: 0.82, 0.99; p trend = 0.02).

Kim et al. [27] found that in inactive women with low physical activity (less than 9 METs/wk), aMED was associated with a significant decrease in both non-breast cancer-related and total mortality; the RR comparing the highest to the lowest tertiles was 0.39 (95 % CI: 0.20–0.75; p trend = 0.004) and 0.63 (95 % CI: 0.41–0.97; p trend = 0.002), respectively. In contrast, no significant association was apparent between the risk of hereditary breast cancer and aMED although the trend was negative [24]. A number of physiological mechanisms have been proposed and supportive evidence has been provided for a protective effect of the Mediterranean diet against the risk of breast cancer. It has been reported that a traditional Mediterranean diet significantly reduces endogenous estrogens [43] and greatly contributes to increased levels of sex hormone-binding globulin [38]. It has also been reported that the lipid composition of this diet may have inhibitory potential on HER2 expression [44]. Finally, squalene, which is an important compound of olive oil and the typical added oil in the traditional Mediterranean diet, has been reported to protect against oxidative DNA damage in normal mammary cells [45]. Taken together, available evidence suggests that diet quality, as reflected by aMED or its variants, appreciably changes the risk of breast cancer and may be highly important for women after breast cancer.

Canadian Healthy Eating Index and Breast Cancer

The Canadian Healthy Eating Index (CHEI) was first developed by Nkondjock and Ghadirian [24]. The CHEI was based on Canada's Food Guide to Healthy Eating [46], designed to help Canadians make wise food choices and to offer advice on how to promote health as well as how to reduce the risk of some specific diseases linked to poor diet. These guidelines place food into four groups (grain products, vegetables and fruits, milk products, meats and alternatives), and the scoring criteria were based on levels of intake of each food group. Possible scores for each group varied from 0 to 10. For example, 9 or more servings/d of grain products received a full score of 10, and each 10 % less than the intake required for the full score received 1 point less. The maximum possible score for the CHEI was 40.

A Canadian case–control study [24] of diet quality and hereditary breast cancer found a strong and significant inverse association between the CHEI and *BRCA*-related BC risk. The CHEI strongly predicted *BRCA*-related breast cancer, and women with a high adherence had up to 82 % reduction in breast cancer risk (OR = 0.18; 95 % CI: 0.05–0.68; p trend = 0.006). The CHEI encompasses four food groups and the authors found that none of these food groups or specific food components were individually related to breast cancer risk. They concluded that consumption of these food groups together, as suggested in Canada's Food Guide to Healthy Eating, may have a more beneficial influence on *BRCA-associated* breast cancer than consumption of either of these elements alone. Indeed, specific components may have small effects that emerge only when the components are integrated into a simple and unidimensional score. Other investigations assessing the potential of CHEI to predict sporadic breast cancer and the prognosis in breast cancer survivors are warranted.

Dietary Approaches to Stop Hypertension and Breast Cancer

In 1993 the trial Dietary Approaches to Stop Hypertension (DASH) was planned, and the goal was to identify a dietary pattern that lowers blood pressure and additionally was palatable and acceptable to the general population. The original DASH diet was designed to be lower in fat, at 27 % of kcal, and that was predominantly unsaturated fat (saturated fat was lowered to a total of 6 % of kcal). The diet was also higher in protein (at 18 % of kcal, predominantly from dairy products) and higher in carbohydrate (at 55 % of kcal), fiber was increased to about 31 g/d at the 2,000 kcal level, potassium was 4,700 mg, and magnesium was 500 mg on the 2,000 kcal diet. Calcium was increased to 1,240 mg/2,000 kcal with the introduction of low-fat or nonfat dairy products.

The DASH diet score was adapted from the original DASH eating plan developed by Fung et al. [47] which is based on eight components: fruits, vegetables (except potatoes and legumes), nuts and legumes, low-fat dairy products, whole grains, sodium, sweetened beverages, and red and processed meats. For each of the components, participants are classified according to their intake ranking. Higher intakes of foods related to lower risk of hypertension (fruits, vegetables, low-fat dairy, nuts, legumes, and whole grains) received higher scores. For example, quintile 1 is assigned 1 point and quintile 5 is assigned 5 points. For harmful dietary components (sodium, red and processed meats, and sweetened beverages), a low intake is desired. The lowest quintile was giving a score of 5 points and the highest quintile was given a score of 1 point. The components scores are summed up to give an overall DASH score ranging from 8 (lowest adherence) to 40 (highest adherence). Although the DASH diet shares similarities with the Mediterranean diet, the relationship between the DASH score and breast cancer occurrence or mortality has not been studied, despite being significantly inversely associated with cardiovascular diseases [47] and colorectal cancer [48].

Conclusions

On the basis of results reported from different studies carried out in industrialized countries, there is sufficient evidence to suggest that certain dietary scores affect the risk and prognosis of breast cancer. Higher scores in aMED appear to protect against breast cancer, while the evidence connecting the current dietary guidelines reflected by RFS, DQI, and HEI with breast cancer risk is unconvincing, though these dietary quality scores seem related to better prognosis after breast cancer. Although evidence is limited, the CHEI appears strong at predicting hereditary breast cancer, while studies addressing the relationship between DASH score and the risk of breast cancer are lacking (Fig. 3.1).

Further instruments are still needed in the prediction of breast cancer risk. The overall structure of such tools will integrate not only alcohol and up-to-date dietary guidelines but also other known modifiable components such as body mass index, waist circumference, and physical activity, which may provide more definite evidence regarding the possible role of high-quality diet in breast cancer prevention.

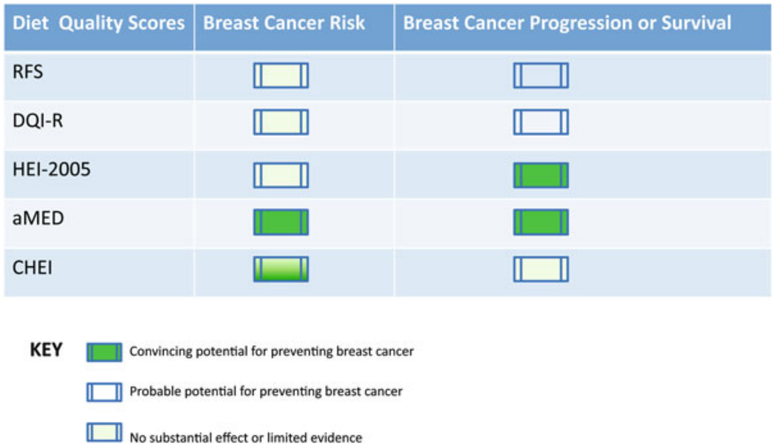

Fig. 3.1 Summary of conclusions

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Nonalcoholic Fatty Liver Disease in Adults: The Impact of Diet and Other Therapeutic Interventions on Clinical and Histological Outcomes

4

Madeline Erario and Zobair M. Younossi

Key Points

- Nonalcoholic fatty liver disease (NAFLD) is one of the most common causes of chronic liver disease worldwide.
- NAFLD is closely associated with central obesity and metabolic syndrome.
- The most accurate diagnostic modality for NAFLD and its subtypes rely on a liver biopsy.
- The NASH subtype of NAFLD can progress to cirrhosis.
- Although a number of pharmacologic and dietary regimens have been used to treat NAFLD, currently, there is no established treatment with proven efficacy.

Keywords

Nonalcoholic fatty liver disease • Nonalcoholic steatohepatitis • Dietary intervention • Weight loss • Behavior modification • Imaging steatohepatitis • Pharmacotherapy for nonalcoholic fatty liver disease

Abbreviations

ALT	Alanine aminotransferase
ANA	Antinuclear antibodies
ASMA	Anti-smooth muscle antibody
AST	Aspartate transaminase
BMI	Body mass index
CK18	Cytokeratin-18 fragments
CT	Computed tomography
ELF	Enhanced liver fibrosis
GI	Glycemic index
GREACE	Greek Atorvastatin and Coronary Heart Disease Evaluation trial

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V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health,
DOI 10.1007/978-1-4614-7315-2_4, © Springer Science+Business Media New York 2013

HDL	High-density lipoprotein
HFE	Human hemochromatosis protein (*HFE* for *H*igh iron *Fe*)
HMG-CoA	3-Hydroxy-3-methylglutaryl CoA
MR	Magnetic resonance imaging
MUFA	Monounsaturated fatty acid
NAFLD	Nonalcoholic fatty liver disease
NAS	NAFLD activity score
NASH	Nonalcoholic steatohepatitis
PIIINP	Procollagen III N-terminal propeptide
PIVENS	Pioglitazone Versus Vitamin E versus Placebo for the Treatment of Nondiabetic Patients with Nonalcoholic Steatohepatitis trial
PPAR-γ	Peroxisome-proliferator-activated receptor-γ
PUFA	Polyunsaturated fatty acid
TIMP-1	Tissue inhibitor metalloproteinase
TZDs	Thiazolidinediones
UDCA	Ursodeoxycholic acid
VLDL	Very low-density lipoprotein

Introduction

Nonalcoholic fatty liver disease (NAFLD) is generally characterized by hepatic steatosis by imaging or histology in the absence of secondary causes for hepatic fat accumulation, such as significant alcohol consumption, hepatitis C or other chronic liver disease, hereditary disorders, or steatogenic medications. NAFLD is further subgrouped into nonalcoholic steatohepatitis (NASH) and simple steatosis depending on the histological presence of inflammation with hepatocellular injury in the former (NASH) and lack of hepatocyte injury in the latter. The natural history of simple steatosis is a very slow or no histological progression of simple steatosis. In contrast, NASH can exhibit rapid histological progression and ultimately develop cirrhosis [1, 2]. Accordingly, patients with NASH, but not simple steatosis, have an increased liver-related mortality. However, NAFLD patients as a group have a higher overall mortality compared to matched control populations, with cardiovascular disease being the leading cause of death both subgroups [3–8].

The prevalence and incidence of NAFLD in the general population have not been systemically investigated. Data regarding rates of prevalence and/or incidence that are published in the literature vary significantly depending on the patient population studied and the imaging modality applied for identifying NAFLD. With these limitations in mind, the worldwide prevalence of NAFLD has been estimated to range from 6.3 to 33 %, while the prevalence of NASH with hepatocellular injury (ballooning) with or without fibrosis is lower, ranging from 3 to 5 % [1].

The majority of NAFLD patients have associated metabolic risk factors such as obesity, type II diabetes mellitus, and dyslipidemia. Thus, as the prevalence of metabolic syndrome, obesity, and diabetes continues to increase globally, NAFLD becomes a major epidemic. While other parameters, such as age, gender, and ethnicity, or endocrine disorders, such as hypothyroidism, hypopituitarism, hypogonadism, and polycystic ovary syndrome, have also been reported to have an association with NAFLD, the prevalence of the disease in these conditions is much lower than those reported with metabolic risk factors. Visceral obesity and increasing body mass index (BMI) are both well-recognized risk factors for NAFLD with the prevalence of NAFLD exceeding 90 % among severely obese patients undergoing bariatric surgery [1]. Similarly, the prevalence of NAFLD in patients with type II diabetes mellitus and those exhibiting high serum triglyceride and low high-density lipoprotein (HDL) levels are estimated to be between 50 and 69 % range [9, 10]. Indeed, the presence of metabolic syndrome has been shown to be a strong predictor for the presence of steatohepatitis in patients with NAFLD [2, 11–13], which may be used to target patients who would have a higher yield from liver biopsy.

Noninvasive Techniques for Identifying Steatohepatitis and Advanced Fibrosis

Because the natural history of NAFLD is critically dependent on the presence of steatohepatitis and the extent of fibrosis, it is extremely important to have a sensitive and reliable technique for identifying these histopathological abnormalities. While liver biopsy is the current "gold standard" for making the diagnosis and characterizing the extent of hepatocellular damage, it is generally accepted that sampling error may underestimate the magnitude of liver pathology. Moreover, given the invasive nature of the biopsy procedure and the associated morbidity and mortality, monitoring disease progression with repeat biopsies is impractical. Blood tests that assess liver biochemistries can provide insight into the presence and extent of hepatocellular inflammation and injury, but they are not sensitive. Imaging studies, such as ultrasound, computed tomography (CT), and magnetic resonance imaging (MR), do provide a higher sensitivity for detecting steatohepatitis than liver biochemistries. Moreover, imaging allows noninvasive monitoring of disease progression over time, without exposing the patient to undue risk. However, it has been reported that even these advanced imaging techniques may not reliably identify steatohepatitis and fibrosis in NAFLD. More recently, transient elastography (not commercially available in the United States) was introduced to noninvasively measure liver stiffness, which could potentially identify advanced fibrosis in patients with hepatitis B, hepatitis C, and NAFLD [2]. However, given the association of visceral obesity with NAFLD, there was a high failure rate among individuals with large body habitus and high BMI. Additional studies using MR and ultrasound elastography as well as molecular imaging targets in patients with NAFLD are currently under investigation.

Beyond imaging, there has been parallel interest in developing new serum biomarkers as well as clinical prediction rules to improve the identification of steatohepatitis and advanced fibrosis in patients with NAFLD [2]. Circulating levels of cytokeratin-18 fragments (CK18) represent one potentially promising biomarker for identifying steatohepatitis in patients with NAFLD. Preliminary studies have shown markedly increased plasma CK18 fragments in patients with NASH compared with patients with simple steatosis or normal biopsies [2, 14]. However, the assay for CK18 measures is not widely available and there is no widely validated threshold for plasma CK18 value to identify patients with steatohepatitis. Two clinical prediction methods have been introduced to noninvasively identify advanced fibrosis in patients with NAFLD: (1) the NAFLD Fibrosis Score [15] and (2) Enhanced Liver Fibrosis (ELF) panel [16]. The NAFLD Fibrosis Score is calculated on the basis of six variables: age, BMI, hyperglycemia, platelet count, albumin, and AST/ALT ratio. In a meta-analysis of 13 studies consisting of 3,064 patients, NAFLD Fibrosis Score of <−1.455 yielded a sensitivity of 90 % and specificity of 60 % to exclude patients with advanced fibrosis, whereas a score of >0.676 produced a sensitivity of 67 % and a specificity of 97 % to include patients with advanced fibrosis. However, NAFLD Fibrosis Score data between −1.455 and 0.676 was indeterminate. The ELF panel, which consists of plasma levels of only three matrix turnover proteins—hyaluronic acid, tissue inhibitor of metalloproteinase (TIMP-1), and procollagen III N-terminal propeptide (PIIINP)—yielded a sensitivity of 80 % and a specificity of 90 % for detecting advanced fibrosis [16]. The ELF panel was recently approved for commercial use in Europe but is not commercially available in the United States. Whether these prediction models and biomarkers can be used to monitor disease progression, response to therapeutic intervention, or predict patient outcomes remains unknown.

Potential Targets for Therapy: The Liver and Metabolic Comorbidities

The clinical management of patients with NAFLD consists of treatments that target the liver and the associated metabolic comorbidities. Because liver-related mortality is increased in NASH but not in simple steatosis (without steatohepatitis), treatments aimed at improving liver disease should be limited to those with NASH. Regarding metabolic comorbidities, potential targets for therapy include (1) pharmacotherapy and (2) weight loss. Weight loss can be achieved through combined exercise and dietary counseling, dietary intervention and behavior modification for sustained weight loss, or bariatric surgery. To date, treatment options remain limited and are founded primarily on weight loss and improvement in insulin resistance.

Pharmacotherapy for NAFLD: Pharmacotherapy for NAFLD involves a number of agents that target different pathways which could potentially be involved in the pathogenesis of NASH. These include drugs used for weight loss, as well as drugs targeting insulin resistance, oxidative stress, and hyperlipidemia.

1. *Weight loss using enteric lipase inhibitor* (*Orlistat*): Given that weight loss is difficult to attain with diet and exercise alone, research has focused on medications that may be used to augment weight reduction. The enteric lipase inhibitor, orlistat, has been studied extensively in this regard, and studies have shown that nearly one-third of subjects treated with orlistat, as an adjunct to low-fat diet, lose 5–10 % of body weight with 1 year of therapy [17]. By inhibiting gastric and pancreatic lipase, orlistat blocks the absorption of nearly 30 % of dietary triglycerides.

   There are two randomized, prospective, controlled trials in the literature that have evaluated the incremental value of orlistat to conventional lifestyle modification [18, 19]. In the first double-blind randomized placebo-controlled trial of orlistat for the treatment of NAFLD for 6 months [18], the group receiving orlistat in conjunction with lifestyle modification demonstrated twofold greater reduction in serum alanine aminotransferase (ALT) levels when compared to the control group who were on lifestyle modification alone. BMI decreased significantly in both groups but were not statistically different or greater in the orlistat group. Moreover, steatosis improved on ultrasound only in the orlistat group, which could not be ascribed to weight reduction alone. While comparable improvement in histopathology was observed in both the orlistat and control groups, it is worth noting that only 40 of 52 randomized subjects had NAFLD confirmed by liver biopsy at the entry, and only 22 of the 40 had a repeat biopsy at the end of the study. Thus, the relatively small number of subjects (11 in each group) who agreed to undergo a second liver-biopsy examination may have limited the power for identifying histopathological differences between the two groups. In the second randomized, prospective trial [19], in which 50 overweight subjects with NASH were randomized to receive a 1,400 kcal/day diet plus vitamin E (800 IU) daily with or without orlistat (120 mg 3 times a day) for 9 months, with liver biopsies obtained before and after 9 month treatment, orlistat did not show improvement in liver histopathology, liver enzymes, nor in measures of insulin resistance [19].

   Sibutramine, a neurotransmitter reuptake inhibitor, is another weight-loss drug that has been studied in obese patients with NAFLD. One uncontrolled study found an improvement in aminotransferases in conjunction with weight loss [20]. Additional data regarding benefits of this drug are lacking since the manufacturer withdrew the drug from the market in 2010 after data from clinical trials revealed an increased risk of heart attack and stroke.

2. *Insulin-sensitizing agents*: Insulin resistance is a significant problem in most patients with NASH. Accordingly, several investigators have turned their attention to insulin-sensitizing agents, such as metformin and thiazolidinediones (TZDs), as the most promising form of pharmacologic therapy, especially in NASH patients with progressive liver fibrosis.

   Metformin is an insulin-sensitizing agent, approved for clinical use in type II diabetes mellitus, which alters cellular bioenergetics of hepatocytes (major site of action is the mitochondria) by reducing hepatic glucose production and increasing peripheral glucose utilization without inducing weight gain. Encouraging experimental studies of metformin in the fatty liver of mice along with a favorable side effect profile have led to several publications with this agent in treating NASH. While most of the early studies were open-label studies and performed in small number of subjects, a large randomized control trial of metformin vs. placebo, where both groups had a similar dietary and exercise intervention, failed to show major benefit for metformin in this patient subset [21]. A recent meta-analysis [1] concluded that up to 1 year of metformin therapy plus lifestyle modification did not improve aminotransferases or liver histology, when compared to lifestyle modification alone, independent of the metformin dose administered or the presence of diabetes mellitus. Accordingly, metformin is not recommended as a specific treatment for liver disease in adults with NASH.

TZDs is a group of therapeutic agents that act as ligands for the peroxisome-proliferator-activated receptor-γ (PPAR-γ), which regulates gene expression of enzymes involved in lipid and glucose metabolism. They are approved for clinical use in type II diabetes mellitus. The greatest effect of TZDs is in adipocyte differentiation, which is often associated with increased peripheral but decreased central adiposity. Because PPAR-γ receptors are not highly expressed in liver cells, the potential benefit of TZDs in NASH patients will likely involve indirect mechanisms. In a randomized clinical trial [22], the administration of pioglitazone (45 mg/day) in patients with NASH who had impaired glucose tolerance or type II diabetes mellitus resulted in significant improvement in aminotransferases, steatosis, ballooning, and inflammation, despite a significant interim weight gain (mean 2.5 kg) with pioglitazone. In a subsequent randomized clinical trial of 74 patients with NASH [23], where 30 mg/day of pioglitazone vs. placebo was added to lifestyle modification for 12 months, there was a significant improvement in hepatocellular injury and fibrosis in the pioglitazone group. In the PIVENS multicenter clinical trial [24], 247 nondiabetic NASH patients were randomized to pioglitazone (30 mg/day), vitamin E (800 IU/day), or placebo for 24 months. The primary end point for improvement was prospectively defined as NAS ≥2 points with at least 1 point improvement in hepatocellular ballooning and 1 point in either the lobular inflammation or steatosis score and no increase in fibrosis score. This predefined primary end point was achieved in 43 % of the vitamin E group compared to 19 % of the placebo group ($p=0.001$). While 34 % of pioglitazone group also achieved the primary end point, the statistical significance of $p=0.04$ vs. placebo was greater than the p-value of 0.025 that was set for statistical significance a priori due to the study design of comparing two primary comparisons: pioglitazone vs. placebo and vitamin E vs. placebo. A recent meta-analysis [1] of all five randomized clinical trials concluded that pioglitazone can improve steatosis and inflammation in patients with NASH, but not fibrosis.

While both pioglitazone and rosiglitazone have shown salutary effects on aminotransferases and liver histology in adults with NASH, most of the pivotal randomized multicenter clinical trials were carried out with pioglitazone. This is largely due to increased risk of coronary events in patients on rosiglitazone, which is no longer marketed in Europe, and its clinical use in the United States is highly restricted. There is considerable debate regarding the long-term safety of pioglitazone as well. A recent meta-analysis [25] of 19 clinical trials, enrolling a total of 16,390 patients with type II diabetes mellitus, showed a higher rate of congestive heart failure with pioglitazone (2.3 % vs. 1.8 % in the control group, $p=0.002$). However, there was an overall reduction in the primary outcome of death, myocardial infarction, or stroke in the pioglitazone-treated patients. Thus, it may be prudent to avoid using pioglitazone in type II diabetic patients with NASH who also have impaired left ventricular function.

3. *Antioxidants—vitamin E*: Vitamin E refers to a family of tocopherols and tocotrienols that exhibit antioxidant activity. In human studies, reduced lipid peroxidation and cytokine levels have been shown with vitamin E therapy. Since oxidant stress is considered to be an important mechanism for hepatocellular injury and disease progression in NASH, an

antioxidant such as vitamin E may have beneficial effects in NASH.

Pilot studies and two randomized controlled studies have produced varying results with vitamin E [24, 26–29]. Comparison of these trials are further complicated by varying doses of vitamin E, combining vitamin E with vitamin C and other antioxidants, unclear formulation of vitamin E (pure form of α-tocopherol vs. other combination), varying patient criteria for entry into the study, and lack of histological data to asses outcomes. Nonetheless, based on the PIVENS multicenter trial [24], vitamin E (α-tocopherol) at a daily dose of 800 IU does seem to improve liver histology in nondiabetic adults with biopsy-proven NASH. There is also some controversy as to whether vitamin E increases all-cause mortality. Thus, until further data become available, vitamin E is not currently recommended to treat NASH in diabetic patients, NASH cirrhosis, cryptogenic cirrhosis, or NAFLD without liver biopsy.

4. *Antihyperlipidemic agents*: Potential antihyperlipidemic agents that have been studied in NAFLD include fibrates, statin drugs (3-hydroxy-3-methylglutaryl CoA [HMG-CoA] reductase inhibitors), and omega-3 fatty acids. Fibrates act on peroxisome-proliferator-activated receptor-α (PPAR-α) receptors that are located primarily in the liver, heart, muscle, and kidney, which increase fatty acid uptake, mitochondrial beta oxidation, peroxisomal oxidation of fatty acids, and fatty acid in the P-450 system. However, histology-based studies of fibrates have not shown significant beneficial effects in NAFLD [30–32].

Statins are an important and well-established class of agents for treating hyperlipidemia. In patients with suspected or established chronic liver disease with dyslipidemia, including NAFLD and NASH, there is great reluctance of using statins. While elevated aminotransferases can be generally seen in patients treated with statins, serious liver injury from statins is quite rare. This becomes particularly important, since patients with NAFLD and NASH are at increased risk for cardiovascular events [3–8]. Randomized clinical trials as well as multitude of retrospective and prospective studies over the past decade [33–37] have shown that the administration of statins in patients with liver disease is safe and there is no increased risk for serious liver injury in patient with chronic liver disease, including NAFLD and NASH. While there are no randomized clinical trials with histological end points using statins to treat NASH, a recent post hoc analysis of the cardiovascular outcomes study, Greek Atorvastatin and Coronary Heart Disease Evaluation trial (GREACE) [38], showed significant improvement in liver function tests and cardiovascular outcomes in NAFLD patients treated with statins. Other smaller studies have provided additional support to the notion that statins may improve liver biochemistries and histology in patients with NASH [39–44]. However, until randomized clinical trials with histological end points prove their efficacy, statins should not be used to specifically treat NASH. On the other hand, statins can be used to treat hyperlipidemia in patients with NAFLD and NASH.

Among a large number of agents used for treatment of NAFLD, omega-3 fatty acids are important to mention. Omega-3 fatty acids have been shown to significantly decrease serum triglyceride levels by reducing very low-density lipoprotein (VLDL) production. Patients with predominant hypertriglyceridemia, asymptomatic persistent elevated serum transaminase, with evidence of hepatic fat infiltration on ultrasonography and liver biopsy were treated with omega-3 fatty acid (5 mL 3 times daily) for 24 weeks, and serum transaminase, lipid levels, and liver ultrasonography were repeated at the conclusion of the treatment period [45]. A decline in transaminase levels and normalization of ultrasonographic evidence of fatty liver were observed on treatment with omega-3 fatty acids in patients with hypertriglyceridemia. These findings should be considered preliminary, until randomized clinical trials with histological end points prove the efficacy of omega-3 fatty acids in NAFLD.

5. *Cytoprotection with ursodeoxycholic acid*: The potential benefit of ursodeoxycholic acid (UDCA) in NAFLD derives from its effects on mitochondrial membrane stability, improved regional blood flow, and immunomodulation. There are a number of proof-of-concept-type studies, in small number of patients, in which UDCA administered in conventional and high doses showed improvement in serum aminotransferase levels and steatosis in NAFLD, as well as improvement in liver histology in NASH patients [46–48]. However, a subsequent large multicenter randomized trial showed that UDCA did not offer histological benefit over placebo in patients with NASH [49]. Accordingly, UDCA should not be used for the treatment of NAFLD or NASH.

Weight loss with bariatric surgery: Among severely obese patients with NAFLD who fail to lose their body weight despite aggressive life modifications with caloric intake and exercise, bariatric surgery may be an alternative option. Variations of gastric bypass or gastric restriction are becoming rather common surgeries, although they are not without risk, particularly risk of hepatic decompensation [50]. As the majority of patients undergoing bariatric surgery have associated fatty liver disease, investigators have recently directed their attention to foregut bariatric surgery and its impact on NASH. In a prospective study of 381 adult patients with severe obesity, clinical and metabolic data along with liver histology was collected before, 1 and 5 years after the bariatric surgery [51]. Compared to baseline, the authors showed a significant improvement in the prevalence and severity of steatosis and ballooning at 1 and 5 years following bariatric surgery. Among the subset of 99 patients with probable or definite NASH, there was a significant improvement in steatosis, ballooning, and NAFLD activity score (NAS) at 1 and 5 years following bariatric surgery. Of interest, most of the salutary histological benefits were evident at 1 year with no further improvement in liver histology between 1 and 5 years after bariatric surgery. Importantly, there was no clinically significant worsening in liver fibrosis that could be attributed directly to the bariatric surgery. Two subsequent meta-analysis papers confirmed that steatosis, steatohepatitis, and fibrosis appear to improve or completely resolve after bariatric surgery [52, 53]. When considering the available data in the literature, foregut bariatric surgery is not contraindicated in otherwise eligible obese individuals with NAFLD and NASH without established cirrhosis. However, in the absence of randomized clinical trials, it would be premature to recommend foregut bariatric surgery as an option to specifically treat NASH.

Dietary intervention and behavior modification for sustained weight loss: Diets that are rich in carbohydrate and/or fat can increase serum fatty acid levels, decrease insulin sensitivity, and cause hepatic steatosis. In the absence of long-term, controlled studies of dietary intervention and outcome of patients with NAFLD, the overall evidence in the literature suggests that lifestyle modification of dietary caloric intake and exercise diminish liver fat content and steatosis in patients with NAFLD. Most published clinical studies evaluating a broad spectrum of different caloric restriction intensities and macronutrient composition that consisted of low- vs. high-carbohydrate diets, low- vs. high-fat diets, saturated vs. unsaturated fat diets have consistently shown reductions in weight and plasma aminotransferase concentration and hepatic steatosis, measured either by ultrasound [54, 55] or MR spectroscopy [56]. More recent studies have also shown improvement in hepatic steatosis on histopathological liver-biopsy specimens with lifestyle modification [57, 58]. However, it is important to point out that these studies were largely uncontrolled and generally performed in only small number of subjects. In a pilot study where the effects of a low-carbohydrate, ketogenic diet were evaluated in obese patients with fatty liver disease, there was a significant improvement in liver histology over a 6-month period [57]. This finding was only seen in patients who adhered to the diet. The authors could not assess if these findings were the result of the specific diet or more broadly to the weight loss. In another study, a diet with a macronutrient breakdown of 40–45 % of daily calories from carbohydrates, 35–40 % from fats, and 15–20 % protein was studied in patients with BMI greater than 25 kg/m^2 and biopsy-proven NASH. After 1 year, 9 out of 15 patients had an improved histological response on biopsy. In addition, these patients had a significantly greater weight loss (nearly 3.5 kg on a 1,400 kcal/day diet) than those with unchanged histological scores [58].

Aside from the beneficial effects of caloric restriction to achieve greater weight loss, it is possible that the composition of the diet itself may influence the development or regression of NAFLD. For example, in a randomized study of NAFLD patients to hypocaloric diets containing either 60 % carbohydrates/25 % fat or 40 % carbohydrates/45 % fat (15 % protein in both groups) for 16 weeks, despite achieving equal weight loss in the two groups, patients receiving the lower carbohydrate diet had lower ALT concentrations [59]. In another study, where NAFLD patients were placed on either an energy-restricted (1,200–1,500 kcal/day) or a carbohydrate-restricted (<20 g/day) diet, despite achieving similar weight loss, patients following the low-carbohydrate diet had a more significant decrease in hepatic triglyceride level (55 %) when compared to the low-caloric diet group (28 %, $p=0.008$) [60]. Moreover, the specific type of carbohydrate consumption, such as simple carbohydrates (e.g., fructose, sucrose) vs. slow-release carbohydrates also termed low-glycemic index (GI) foods (e.g., oats), may influence NAFLD progression. Unlike glucose, fructose promotes weight gain by stimulating de novo fatty acid synthesis directly. High-fructose diets have been linked with complications of the metabolic syndrome as well as increased in liver enzymes [61, 62]. Although there are no clinical studies examining the effects of low-GI foods specifically in NAFLD patients, a randomized controlled study in other subjects has shown a decrease in the ALT levels by 35 % in patients following a low-carbohydrate/low-GI diet when compared with those following a high-carbohydrate/high-GI diet [63].

Regarding fat intake, western diets tend to contain more saturated fat, n-6 polyunsaturated fatty acid (PUFA), and less n-3 PUFA. While there are no clinical studies that directly link diets high in saturated fatty acids with NAFLD, experimental evidence in rodents suggests that high dietary saturated fatty acids worsen insulin resistance, cardiovascular disease, and NAFLD [64, 65]. On the other hand, given the favorable anti-inflammatory and cardiovascular benefits of monounsaturated fat (MUFA) in epidemiologic studies, incorporating a Mediterranean-style diet rich in MUFA, such as olive oil (73 % MUFA), at the expense of saturated fatty acids, may reduce the risk of metabolic syndrome and NAFLD [66, 67]. Clinical trials in patients with NAFLD have shown that n-3 PUFA intake (1.0–2.7 g/day) for 6–12 months improve hepatic steatosis, inflammation, and fibrosis [68, 69]. Other studies have shown that increased n-3 PUFA consumption improves dyslipidemia (decreasing plasma triglyceride levels by 25–50 %) that characteristically accompany NAFLD [70].

These data suggest that beyond weight loss, the composition of the macronutrient in the diet of NAFLD patients may be equally important to help reduce hepatic fat and inflammation. A diet that is low in carbohydrates and saturated fat and high in fiber and n-3 PUFA may be beneficial. Since very few clinical studies have examined the effect of dietary protein consumption in NAFLD, a definitive statement regarding its beneficial effect in subjects with metabolic syndrome or NAFLD cannot be made at this time. Thus, in order to develop definitive evidence-based dietary guidelines for NAFLD patients, it is important to first conduct well-designed dietary trials that investigates all of these specific dietary macronutrients. Of course, dietary modification is best achieved when accompanied with behavioral modification. Patients often need practical instruments to not only achieve their dietary and exercise goals but to maintain them for a prolonged period by incorporating them into their lifestyle. The ultimate goal should be sustainable changes in lifestyle and behavioral modification that naturally result in weight loss.

Weight loss through combined exercise with dietary counseling: Despite best efforts of dietary counseling, some patients will not lose weight unless it is combined with an exercise regimen.

In a randomized trial of 31 obese subjects with NASH, the group that performed 200 min/week of moderate physical exercise for 48 weeks in conjunction with intensive dietary modification demonstrated significantly greater weight loss when compared to the control group of dietary counseling alone (9.3 % vs. 0.2 % in control arm) [71]. Importantly, those exhibiting ≥7 % weight loss had significant improvement in steatosis, lobular inflammation, ballooning, and NAS. Similar weight-loss-related histological improvements were observed in another clinical trial of 50 overweight subjects with NASH who were randomized to receive a 1,400 kcal/day diet plus vitamin E daily with or without enteric lipase inhibitor for 36 weeks [71]. The subset of patients who lost ≥5 % body weight exhibited improved steatosis and insulin sensitivity, whereas those who lost ≥9 % body weight had additional histological improvements in ballooning and lobular inflammation, as well as improvements in adiponectin level and NAS [71].

Based on the totality of the findings in the literature, it can be concluded that weight loss (achieved either by caloric diet alone or in combination with exercise) generally reduces hepatic steatosis and the degree of hepatic fat reduction seems to be proportional to the intensity of the lifestyle modification. While a loss of nearly 3–5 % of body weight appears necessary to improve steatosis, a much greater weight loss of nearly 7–10 % may be needed to improve hepatocellular inflammation and injury. Exercise alone (without caloric restriction or dietary modification) may reduce hepatic steatosis but its ability to improve other aspects of liver histology remains unknown.

Although weight loss along with exercise are effective treatments for NAFLD, it is important to point out that excessive dietary restrictions and rapid weight loss (>2.5 lb/week) may actually worsen liver injury. In prior bariatric procedures that involved jejunoileal bypass, sudden weight loss often worsened steatohepatitis in these patients, with subsequent progression to cirrhosis and liver failure [72, 73]. In patients with NAFLD and advanced liver disease, the goal should be slow and controlled weight loss over time at a rate of 1–2 lb/week.

Conclusions

When evaluating patients with suspected NAFLD in clinical practice, a history of ongoing or recent alcohol consumption that exceeds 21 drinks on average per week in men and 14 drinks on average per week in women constitutes significant quantities of alcohol consumption [74]. Once a history of alcohol consumption and other causes of chronic liver disease are excluded, patients presenting with symptoms attributable to liver disease or have abnormal liver biochemistries and hepatic steatosis on imaging should be suspected for and worked up for NAFLD. Liver biopsy should be considered in patients with NAFLD who are at increased risk to have steatohepatitis and advanced fibrosis. On the other hand, among subjects with incidental finding of hepatic steatosis on imaging who are asymptomatic from a liver standpoint and have normal liver biochemistries and aminotransferases, it is reasonable to (1) assess for the triad of metabolic risk factors (obesity, diabetes mellitus, dyslipidemia) and treat the risk factor(s) aggressively, as well as (2) search for alternate causes for hepatic steatosis, such as medications. However, liver biopsy in such patients is not indicated.

When a patient with newly suspected NAFLD is being evaluated, it is important to exclude coexisting etiologies of chronic liver disease such as hemochromatosis, autoimmune liver disease, chronic viral hepatitis, and Wilson’s disease. Mildly elevated serum ferritin or autoantibodies are rather common in patients with NAFLD and are generally considered to be an epiphenomenon [75]. However, NAFLD patients exhibiting persistently high serum ferritin and iron saturation should be tested for genetic hemochromatosis (homozygote or compound heterozygote C282Y mutation in the HFE gene) and, if positive, may warrant a liver biopsy to assess the degree of hepatic iron deposition and fibrosis [76]. Similarly, persistently high serum titers of autoantibodies (ANA ≥1:160 or ASMA ≥1:80) in association with other features of autoimmune liver disease, such as high globulin or very high aminotransferases, should warrant a liver biopsy.

Regarding prevention, some may argue that systemic screening for NAFLD among high-risk individuals, such as obesity and type II diabetes mellitus, may limit the number of individuals progressing to cirrhosis and liver failure. Likewise, there are anecdotal studies suggesting familial clustering and heritability of NAFLD, with a higher prevalence of first-degree relatives with cirrhosis [77–80]. Unfortunately, there are significant gaps in our scientific knowledge regarding the natural history of NAFLD and whether early diagnosis and treatment will translate to improved patient outcome. Until such studies are performed, screening high-risk patients for NAFLD is not recommended. Recent studies have shown that significant weight loss through dietary modification that is low in carbohydrates and saturated fat and high in fiber and n-3 PUFA and pharmacologic treatment with vitamin E may offer some short-term histological benefits. In addition, foregut bariatric surgery may improve histology in obese individuals with NASH. However, whether such histological improvements will ultimately translate to prevention of cirrhosis and liver failure and consequently improve patient outcome remains untested.

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C-Reactive Protein and Diet Quality in Children

5

Chrystalleni Lazarou and Elena Philippou

Key Points

- C-reactive protein (CRP) is one of the markers most frequently used to evaluate the presence and degree of subclinical inflammation, a parameter directly associated with early atherosclerotic changes.
- Although there is a well-established association between CRP and obesity, both in adults and in children, the available evidence linking CRP and other lifestyle factors including diet is insufficient, and especially in childhood populations, the evidence is scarce.
- In the majority of the studies reviewed, a number of foods and nutrients that are generally considered as health-protecting (e.g. grains, vegetables, fruits, dairy fatty acids, eicosapentaenoic acid, zinc, iron, magnesium and folate) were inversely related to CRP concentration.
- Foods and nutrients that are generally considered as unhealthy (e.g. total fat, saturated fat, meat and French fries) were not significantly related to CRP concentration in most of the reviewed studies with the exception of two studies reporting that CRP concentration was positively related to 'unhealthy' food consumption.
- Existing evidence points to the direction of focusing future research on the additive role of 'unhealthy' foods/components.

Keywords

hs-CRP • Adiposity • Inflammation • Atherosclerosis • Diet • Children • Dietary indices

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Abbreviations

BF%	Body fat percentage
BIA	Bioelectrical impedance analysis
BMI	Body mass index
CE	Cholesterol esters

V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health, DOI 10.1007/978-1-4614-7315-2_5, © Springer Science+Business Media New York 2013

CRP	C-reactive protein
CVD	Cardiovascular disease
F	Female
hs	High-sensitivity
KIDMED	Mediterranean Diet Quality Index for children
M	Male
Mg	Magnesium
n	Number
OR	Odds ratio
PL	Phospholipids
RDA	Recommended Daily Allowance
SDS	Standard deviation score
SES	Socioeconomic status
WC	Waist circumference
WHR	Waist to hip ratio

Introduction: Atherosclerosis and Biochemical Markers

Atherosclerosis, as it is well known, begins in childhood [1]. The pathophysiology of atherosclerotic disease both in adults and in children is associated with low-grade systemic inflammation [2–4], which can be evaluated using certain biochemical markers including soluble adhesion molecules (e.g. E-selectin, P-selectin, intracellular adhesion molecule-1, vascular cell adhesion molecule-1), cytokines (e.g. interleukin-1β, -6, -8 and -10 and tumour necrosis factor-α), acute-phase reactants (fibrinogen, serum amyloid A and C-reactive protein) and white blood cell count [5, 6]. These biochemical substances are secreted in response to injury caused by known atherosclerosis risk factors including cigarette smoking, hypertension, unhealthy diet, atherogenic lipoproteins, hyperglycaemia, obesity, sedentary life and stress [5, 6]. C-reactive protein (CRP) is one of these markers that has most frequently been used to evaluate the presence and degree of subclinical inflammation, a parameter directly associated with early atherosclerotic changes in children [2].

Previous studies have shown that CRP concentration may be modified by certain lifestyle factors, including obesity [3], physical activity [7] and diet [7]. Although the association of CRP and obesity is now well established, both in adults [8] and in children [9], available evidence on the association of CRP to other lifestyle factors including diet is not sufficient, and especially in childhood populations, the evidence is scarce and limited. Provided that the process of atherosclerosis is known to begin in early childhood, data that document the presence of inflammation in relationship to the aforementioned risk factors for atherosclerosis in children is very important in planning successful public health preventive programs. Thus, a review of the research evidence on the association(s) of CRP concentration to diet quality, which is one of the important factors that may influence the initiation and progression of atherosclerosis in childhood populations, was carried out, aiming to summarise the available evidence. It is hoped that this will contribute towards identifying any research gaps in this area with the ultimate aim of better understanding the development and potential mechanisms contributing to the prevention of atherosclerotic disease.

C-Reactive Protein: What Is It, How Is It Assessed and What Is Considered a 'Normal' Value?

CRP is a serum marker, secreted from the liver, which increases during the initial stages (within 4–6 h) of acute stress resulting from injury (e.g. trauma, surgery). Since it is released at the onset of an acute infection, it belongs to a group of proteins known as 'acute-phase proteins' [10]. It can increase as much as 1,000-fold and it begins to decrease when recovery begins [11]. In response to chronic subclinical inflammation caused by atherosclerosis, a moderate increase in serum CRP is observed, and to detect slightly elevated CRP concentrations, a different CRP test, called 'high-sensitivity CRP (hs-CRP) test' [11] may be used.

With regard to CRP and cardiovascular disease (CVD) risk, the healthcare professionals from the Centers for Disease Control and Prevention and the American Heart Association

[5] set CRP cut-offs for low, average and high CVD risk, based on studies from >15 populations and >40,000 adults, as <1.0, 1.0–3.0 and >3.0 mg/L, respectively. These values correspond to approximate tertiles of hs-CRP with the high-risk tertile corresponding to an ≈2-fold higher relative risk compared with the low-risk tertile [5]. Since no specific threshold values have been set so far in children, the adults' cut-offs are used instead. It should be mentioned, however, that some of the studies published to date among children have shown a significant relationship of hs-CRP with body mass index (BMI) using the threshold CRP value of >2.0 mg/L [12–14]. In a small study conducted by our research team (among 83 children, aged 9.2 ± 1.7 years old), it has been demonstrated that even the lower CRP cut-off concentration of 1 mg/L could be used to define a relationship with obesity-associated, subclinical inflammation [15]. Additionally, as shown recently by a large intervention trial among adults, CRP values of less than 1 mg/L can be protective against cardiovascular events [6]. As we have previously argued [15], the effect of children having a serum CRP value over 1 mg/L (vs. <1 mg/L) on several cardiovascular risk factors over a significant period of time should be investigated prospectively, considering that children lack potential confounders to inflammation present in adults (e.g. smoking), and thus a 'lower normal' value may be expected for childhood populations. Thus, in children, there is a need for threshold values and their associated clinical implications to be further explored in future studies.

Another issue to consider when interpreting research results is how hs-CRP was measured. According to the Statement for Healthcare Professionals from the Centers for Disease Control and Prevention and the American Heart Association [5], the hs-CRP assay should be performed in a metabolically stable person without obvious inflammatory or infectious conditions. Optimally, two measurements 2 weeks apart should be performed, and values should then be averaged [5]. If a concentration of >10 mg/L is identified, it must be discarded, and hs-CRP should be measured again in 2 weeks [5].

Studies Addressing the Association Between CRP Concentration and Diet Quality in Children

In order to identify the studies conducted on the possible association between CRP concentration and diet quality in children, an extensive search of the scientific databases PubMed, Scopus, ProQuest, Heal-Link (http://www.heal-link.gr/) and HighWire, as well as Google, was performed for papers published in the English language. The following key terms were used: 'C-reactive protein (or CRP)' combined with the terms 'child/children', 'diet', 'nutrition', 'foods', 'nutrients' and 'nutrient status/nutrition/diet quality/dietary patterns/habits'. In addition, article reference lists and website links were checked to identify any additional relevant articles. Publications were searched through December 2011.

In total, ten articles were retrieved, all of which are included in this review. All of these articles examined the association(s) of dietary aspects such as food consumption, dietary biochemical markers and nutrient intake consumed either through food or supplements, with CRP concentration in childhood populations, aged up to 18 years old.

CRP Concentration and Dietary Quality in Children: A Review of the Evidence

Table 5.1 presents an overview of the studies reviewed, presented by date of publication. The first paper published on this topic was in 2005, and until 2011, only ten papers have been published, all of which are included in this review. Of the ten papers presented, seven refer to only healthy subjects, whereas two included both healthy and overweight subjects, while one paper included only obese subjects.

In the majority of the studies conducted (7 from 10 studies reviewed), a number of foods and nutrients that are generally considered as health-protecting (e.g. grains, vegetables, fruits, dairy fatty acids, eicosapentaenoic acid, zinc, iron,

Table 5.1 Studies on the association between diet quality and hs-CRP concentration in children

Subjects	*n* (gender)	Age (years)	Dietary intake (diet assessment method)	Study type, year, study's name/ place	Association with hs-CRP	Comments	References
Healthy and overweight	120 (M/F)	12	Adipose tissue analysis	Cross-sectional analysis of a subsample of an ongoing randomised intervention study which began in 2002, Intervention Centered on Adolescents' Physical Activity and Sedentary Behavior Study (ICAPS)	↓ CRP with higher eicosapentaenoic acid (20:5n–3) and linolenic acid (18:3n–3) in CEs but only in overweight subjects → of total SFA, PUFA:SFA, 18:2n–6, 22:6n–3 in phospholipids and CEs and 18:3n–3, 20:5n–3 in phospholipids on CRP	Adjusted for gender, sexual maturity, physical activity, BF% and WHR	[16]
Healthy and overweight	79 (M/F)	6–14	Two 24-h dietary recalls and a 1-day weighted dietary record	Cross-sectional (year conducted not mentioned), convenience sample (study name not mentioned), Northern Switzerland	↑CRP with higher intake of total fat, percentage of energy as fat, plant oils, saturated fatty acid, polyunsaturated fatty acid and monounsaturated fatty acid → of dairy products, meat, plant oils, animal fat, vitamin C, vitamin E, β-carotene intake on CRP	Regressions after control for BMI-SDS and age. Study had insufficient power to detect weak associations	[17]
Healthy	5,007 (M/F)	6–17	Single, multipass 24-h recall	Cross-sectional, 1999–2002, National Health and Nutrition Examination Surveys, USA	↑ CRP with consumption of less than 75 % RDA of Mg → CRP on overweight children with Mg intake below the RDA compared to children with Mg intake above the RDA	Multivariate logistic regression analysis, adjusted for age, race, gender, BMI, income, exercise, fibre intake and total caloric intake	[18]
Healthy	164 (M/F)	12–13	7-day food diary	Cross-sectional (year conducted not mentioned),convenience sample, Wales	→ of total dietary fat or SFA intake on CRP	Student *t* test Pearson's product moment correlation coefficients without adjustments	[19]

Obese	60 (M/F)	6–10	Elemental zinc supplementation for 8 weeks	Triple-masked, randomised, placebo-controlled, crossover trial, 2008 (no name of study is given), Iran	In groups, hs-CRP decreased after receiving zinc but increased after receiving placebo	Wilcoxon signed-rank test	[20]
Healthy	4,110 (M/F)	5–16	Single, multipass 24-h recall	Cross-sectional, 1999–2002, National Health and Nutrition Examination Surveys, USA	↓ CRP with higher intake of grains, vegetables, dairy and selected individual food subgroups (e.g. fluid milk and 'citrus, melon and berry' consumption). Only effects of grains and vegetables were independent of BMI and WC → of meat/other proteins intake on CRP	Adjusted for age, gender, race/ethnicity, height, SES, sedentary behaviour Not adjusted for physical activity. Children with acute infections were not excluded	[21]
Healthy	285 (M/F)	13–17	127-item food frequency question-naire given at 2 times: 13th and 15th y, averaged	Longitudinal study (subsample of), February 1996 and January 2000 (no name of study is given), Minnesota	↓ CRP with higher intake of fruit, vitamin C and folate → β-carotene, fruit juice, vegetables, French fried potatoes, legumes and total or particular flavonoid intake on CRP	Relationship evaluated via Spearman partial correlation analyses adjusting for age, sex, race, Tanner stage, energy intake (kcal) and BMI	[22]
Healthy	83 (M/F)	6–12	FFQ	Cross-sectional, 2006–2007, Cy Families study, mountainous area of Cyprus	↑ CRP with high score of the dietary inflammation index (fried food, sweets, biscuits, chocolates, potato chips, puff pastries, delicatessen meats, fried potatoes and soft drinks) positively associated with CRP levels KIDMED did not show any relationship to CRP	Adjusted for age, gender, overall diet quality—as KIDMED score—and physical activity levels. Borderline statistical significance	[15]

(continued)

Table 5.1 (continued)

Subjects	*n* (gender)	Age (years)	Dietary intake (diet assessment method)	Study type, year, study's name/place	Association with hs-CRP	Comments	References
Healthy	1,174 (M/F)	5–12	24-h dietary recall interview	Cross-sectional, 1999, Second National Mexican Nutrition Survey, NNS-2, USA	↓ CRP with higher serum iron and percentage of transferrin saturation → of levels of total-iron-binding capacity on CRP	Adjusted for age, sex, area (rural or urban), geographic region, caregiver education and iron intake	[23]
Healthy	305 (M/F)	15	Blood analysis for PL fatty acid profile	Cross-sectional (associations from a subsample from a prospective study of obesity, insulin resistance and CVD risk factors in adolescents), 1998 (no name of study is given), Minnesota	↓ CRP with higher dairy fatty acids (15:0,17:0 fatty acids) in serum PL	Generalised linear regression models adjusted for age, gender, race, Tanner score, total energy intake, physical activity; BMI, dietary intake of calcium, potassium, phosphorus, vitamins A and D, protein and n–3 fatty acids, dietary intakes of total flavonoids	[24]

Shows the ten studies that have been conducted up to 2011 to investigate if there is a relationship between what children eat and the concentration of CRP in their blood. In brief, most studies showed that a healthy diet protects against inflammation in the body, while a few studies showed that if a combination of unhealthy foods are consumed, this increases inflammation. More research is needed to understand the effect of diet on inflammation in children better

M male, *F* female, ↑ increased, ↓ decreased; → no effect, *CRP* C-reactive protein, *SES* socioeconomic status, *BMI* body mass index, *WC* waist circumference, *SDS* standard deviation score, *Mg* magnesium, *RDA* Recommended Daily Allowance, *CEs* cholesterol esters, *WHR* waist to hip ratio, *PL* phospholipids, *KIDMED* Mediterranean Diet Quality Index for children, *hs* high-sensitivity

> In the majority of the conducted studies, a number of foods and nutrients that are generally considered as health-protecting were inversely related to CRP concentration. On the other hand, foods and nutrients that are generally considered as unhealthy were not significantly related to CRP concentration individually but an intake of several unhealthy foods resulted in an increase in CRP concentration.

Fig. 5.1 Key finding of the review

Anti-inflammatory diet components High intake of:	Inflammatory diet components High intake of:
eicosapentaenoic acid	total fat
linolenic acid	percentage of energy as fat
dairy fatty acids	plant oils
zinc	saturated fatty acid
iron	polyunsaturated fatty acid
vitamin C	monounsaturated fatty acid
folate	fried food, sweets, biscuits, chocolates, potato chips, puff pastries, delicatessen meats, fried potatoes, and soft drinks (synergistic effect of foods expressed via a dietary inflammation index)
magnesium	
grains	
fruit	
vegetables	
dairy	

Fig. 5.2 Summary of studies' findings. Relationship of diet components to CRP concentration in children

magnesium and folate) were inversely related to CRP concentration [16, 18, 20–24]. On the other hand, foods and nutrients that are generally considered as unhealthy (e.g. total fat, saturated fat, meat and French fries) were not significantly related to CRP concentration in four [16, 19, 21, 22] out of a total of six studies, and only two [15, 17] of the six studies that examined such associations reported that CRP concentration was positively related to 'unhealthy' food consumption. In one of the aforementioned studies, positive associations were reported between CRP concentration and total, saturated, polyunsaturated and monounsaturated fatty acids [17], while in the other study, the additive effect of several 'unhealthy' foods as estimated using a dietary index was found to be positively associated with CRP concentration (Fig. 5.1) [15].

Figure 5.2 presents a summary of important relationships between dietary components and CRP concentration shown in reviewed studies. In general, the direction of the documented relationships was as expected on the basis of the available evidence in adults, with the exception of monounsaturated fatty acids. However, this positive relationship was only reported by one study.

It is worth noting that the sample sizes of the studies reviewed, varied from less than 100 participants (in three studies) to more than 1,000 (another three studies). The remaining four studies included between about 100–300 participants. In all three studies including more than 1,000 participants, there were significant inverse associations between a healthy diet, assessed by food consumption and nutrient(s) biomarkers, and CRP concentration.

With regard to study design, all studies except one study (i.e. nine studies out of ten) of healthy children were cross-sectional, and with the exception of one study, the remaining eight studies adjusted for a number of potential confounders. In these cross-sectional studies, adjustment for the confounders gender, obesity classification, physical activity and Tanner stage which may significantly influence the association(s) under investigation were made in six, five, four and three studies, respectively, while adjustment for all of the above potential confounders was done in only one study [24]. The study [20] that included only obese children was interventional, showing that zinc supplementation had a beneficial effect on CRP levels.

It should be noted that there are certain limitations in the studies reviewed. Firstly, since the majority of the studies were cross-sectional, the directionality of the detected associations is questionable. Secondly, in these cross-sectional studies, the adjustments for potential confounding factors and stratification of analyses by certain demographic factors are limited; thus, the results may have been biased. Thirdly, the sample sizes of most studies were rather small, and thus, they may have not been sufficiently powered to ascertain significant relationships. It is worth noting that power calculations were not mentioned in any of the studies.

The Relationship Between CRP Concentration and Dietary Quality in Children: Is There an Additive Effect of Food Components?

There is preliminary evidence that a healthy diet in childhood can be protective against inflammation as shown by a lower CRP concentration. The direction of evidence regarding the role of specific dietary components or markers of an 'unhealthy' diet on CRP concentration is less clear, but existing evidence points to the direction of focusing future research on the additive role of these foods/components [15].

This hypothesis was further tested in a sample of the Cy Families study, used in the study by Lazarou et al. [15]. In brief, 83 children (aged 9.2 ± 1.7 years old) were studied. Body fat percentage (BF%) was measured via leg-to-leg bioelectric impedance analysis (BIA), physical activity was assessed using a pedometer and diet quality was evaluated by applying the Mediterranean Diet Quality Index (KIDMED) [25]. The subjects' CRP concentration was assessed using a high-sensitivity (hs) immunoassay. Two inflammatory foods' indices composed of three and two foods/food groups, respectively, were also calculated based on the available evidence regarding CRP concentration/inflammation and diet, reporting that inflammation is associated with the consumption of fried foods, sweets, junk and fatty foods, often referred to as 'inflammatory' [26]. It should be noted that a dietary index is a method of assessing the diet as a whole and was recently used in adult populations to examine the synergistic effect of diet to CRP concentration [7]. The association(s) between the aforementioned foods and CRP concentration was explored firstly individually via Spearman correlations (Table 5.2), and then the predictive value of the foods producing significant associations was tested via logistic regression analysis as food combinations via the two dietary indices (Table 5.3).

As shown in Table 5.2, only two foods/food groups, i.e. potato chips, corn shells and delicatessen, out of the nine tested (via Spearman correlations) were significantly associated with CRP concentration. However, it should be acknowledged that the sample size of the study used to test these potential associations is quite small ($n = 83$) and therefore of insufficient power to detect significant associations. It is noteworthy though that there was a remarkable tendency for these foods to positively correlate with CRP concentration since the sizes of most correlations tested were above 0.150.

Table 5.2 Results of correlation analysis[a] that evaluated the relationships between C-reactive protein concentration and individual foods

Individual foods	Correlation to CRP
Fried foods	0.026
Sweets	0.202
Biscuits	−0.092
Chocolates	0.106
Potato chips and corn shells	0.265*
Puff pastries	0.151
Delicatessen	0.286*
Fried potatoes	0.160
Soft drinks, squashes and fruit drinks	0.146

Shows the relationship of different foods with the marker of inflammation, CRP, in children. In summary, the higher the consumption of potato chips and corn shells as well as delicatessen foods, the more the inflammation in the body
[a]Spearman's rho
*$P<0.05$

The predictive value of the above foods to CRP concentration was also tested via a logistic regression analysis model, in which several potential confounders, i.e. age, gender, dietary quality (determined by KIDMED score), physical activity (determined by pedometer steps) and percentage of body fat (determined by BIA) were controlled for [15] (Table 5.3).

With regard to the three single foods tested, only the potato chips and the corn shells were shown to predict CRP concentration. While puff pastries were not significantly correlated with CRP concentration in simple correlations (Table 5.2), a borderline significant result was found when tested by logistic regression (Table 5.3). When intake of puff pastries and delicatessen were tested together as part of the Inflammatory Foods Index, their predictive value

Table 5.3 Results from logistic regression analysis evaluating the association between diet quality (dependent) and CRP concentration (independent)[a]

Variables[b]	OR (95 % CI) Model for Inflammatory Foods Index (a)[c]	Model for Inflammatory Foods Index (b)[d]	Model for delicatessen[e]	Model for puff pastry pies[e]	Model for potato chips and corn shells[e]
CRP levels ≤0.10 mg/dL vs. ≥0.10 mg/dL	5.13 (1.13–23.66)	8.30 (1.52–45.23)	0.44 (0.39–8.67)	6.14 (0.92–40.65)	9.58 (1.69–54.39)
Boys vs. girls	0.15 (0.03–0.67)	0.62 (0.14–2.72)	0.21 (0.43–0.99)	0.19 (0.03–1.08)	1.32 (0.31–5.65)
Age (per 6 months)	1.31 (0.74–2.31)	0.61 (0.33–1.16)	1.12 (0.60–2.11)	0.65 (0.31–1.37)	0.39 (0.52–1.67)
%BF <30 vs. % ≥30 %BF	1.38 (0.32–6.00)	0.13 (0.02–0.95)	0.41 (0.07–2.54)	0.10 (0.01–1.24)	1.37 (0.30–6.27)
KIDMED score (continuous)	0.99 (0.89–1.11)	1.04 (0.93–1.16)	0.97 (0.85–1.11)	1.07 (0.92–1.24)	0.99 (0.89–1.11)
Inactive/low vs. moderately/ highly active	5.25 (0.29–94.63)	3.37 (0.15–74.92)	0.65 (0.38–11.11)	2.04 (0.062–66.83)	2.31 (0.15–36.83)

Shows the statistical analysis carried out aiming to predict which foods or combinations of foods increase CRP concentration, i.e. inflammation. The results show that frequent consumption of potato chips and corn shells by children either as individual foods or combined with delicatessen and pastry pies increases inflammation. Inflammation also increases when children frequently consume the combination of delicatessen and puff pastry pies
OR odds ratio, *%BF* % body fat
[a]All models have been adjusted for age, gender, quality of diet (determined by KIDMED score), physical activity level (determined by pedometer steps) and body fat percentage
[b]First category is the reference category
[c]Dependent variable Inflammatory Foods Index (a) (composed of delicatessen, pastry pies, score range 0–6; category 1 (reference): 0–3 points vs. category 2: 3.01–6 points)
[d]Dependent variable Inflammatory Foods Index (b) (composed of potato chips and corn shells, delicatessen, pastry pies, score range 0–9; category 1 (reference): 0–5 points vs. category 2: 5.01–9 points)
[e]Dependent variable *delicatessen, pastry pies, potato chips and corn shells* category 1 (reference) consumption less than 6 times/week vs. consumption ≥6 times/week

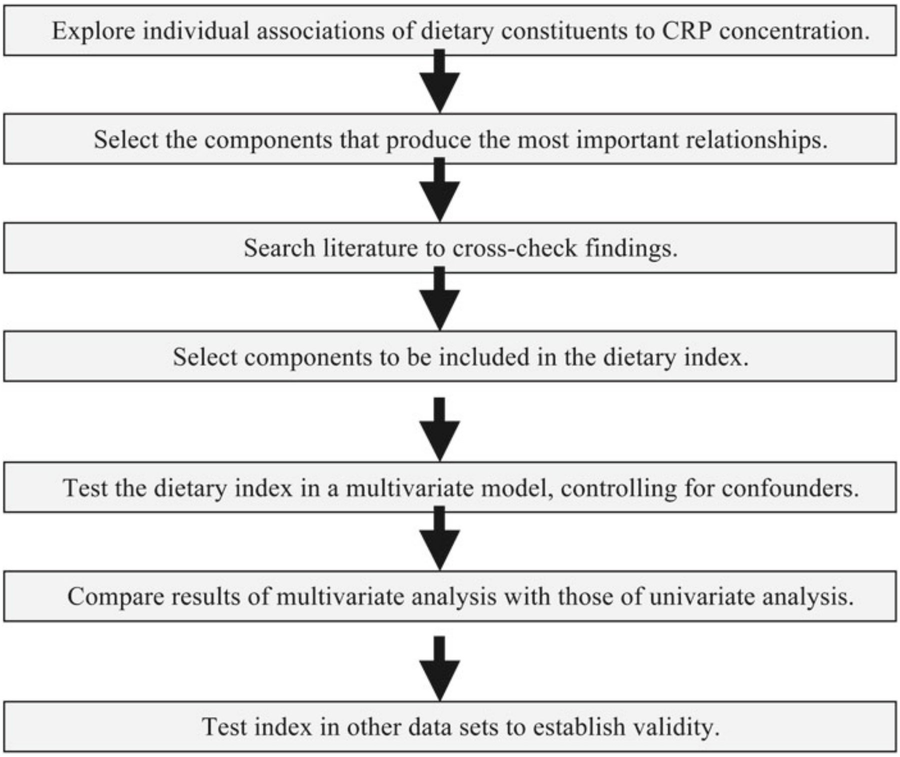

Fig. 5.3 Flowchart illustrating the procedure for developing a dietary index in order to test the synergistic role of dietary components to CRP concentration

on CRP concentration was significant and the effect size produced (as measured by odds ratio (OR)) was important (Table 5.3). In order to test the synergistic effect of all three foods/food groups, another Inflammatory Foods Index was constructed, composed of all three foods. The OR produced was of similar effect size as the one observed when food group 'potato chips and corn shells' was tested individually. A summary of the procedure of developing a dietary index to test the synergistic effect of dietary components is illustrated in Fig. 5.3.

Noteworthy, the hypothesis of the additive role of food components on the modulation of inflammation via a Dietary Inflammatory Index has been tested in another study, as well, among adults. Data used for testing this hypothesis was from a longitudinal study among ~600 adults, who were observed for 1 year [27]. The dietary index was composed of 41 dietary items (including foods, macronutrients, different types of fatty acids, vitamins, minerals, antioxidants and energy intake), selected on the basis of literature findings regarding the role of diet constituents on inflammation. It was shown that an increasing Inflammatory Index score (indicating movement towards an anti-inflammatory diet) was associated with a decrease in hs-CRP, after controlling for a wide variety of potential confounders [27].

Conclusions

At present, no definitive conclusion regarding the relationship between CRP concentration and diet quality in children can be drawn since the number of existing studies is very small and there is considerable heterogeneity in the findings, the dietary markers used, the participants' ages and the studies' sample sizes.

However, there is preliminary evidence that a healthy diet can be protective against inflammation in children as assessed by CRP concentration. At present, although the role of unhealthy dietary components or markers on CRP concentration in children is not clear, preliminary evidence suggests that future research should focus on the additive role of foods or food components generally considered unhealthy in order to better understand this relationship.

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Part II

Eating, Behaviour and Psychology

6 Family Meals and Diet Quality

Sarah J. Woodruff and Rhona M. Hanning

Key Points

- Family meal frequency has been positively associated with nutrient intake and diet quality in children/adolescents.
- Family meal frequency has been associated with other nutrition behaviors (e.g., less sugar-sweetened beverage consumption, less breakfast skipping, greater self-efficacy and parental support for healthy eating, and higher fruit and vegetable availability in the home).
- Future prospective research needs to investigate the effectiveness of promoting family meals as a strategy to increase diet quality in children/adolescents.
- The positive associations between family meals and diet quality may be mediated by television watching, location of the meal, and family cohesion/parenting style.
- Although current research evidence is not strong, the association between family meals and healthier body weight status in children/adolescents merits further investigation.

Keywords

Diet quality • Family meals • Obesity prevention • Television watching • Body weight status

Introduction

Nutrition behaviors of children have been known to track into adulthood [1, 2]; thus, it is important to develop healthy eating attitudes/behaviors at a young age. Health promotion professionals have looked for effective/easy/cost-effective strategies to support healthy eating in children and families. A social ecological perspective to health

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V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health, DOI 10.1007/978-1-4614-7315-2_6, © Springer Science+Business Media New York 2013

promotion recognizes that individuals can be influenced by their environment, including physical environments (e.g., home), and interpersonal relationships such as those within the family. Encouraging family dinners/meals has recently become a strong public health strategy to promote healthy eating (e.g., British Columbia Dairy Foundation's *Better Together*, Jamie Oliver's *Food Revolution*) and reduce potential unhealthy body weights (e.g., Ministry of Health and Long-Term Care report *Healthy Weight*, *Healthy Lives*, 2004, the American Medical Association Expert Committee *Recommendations for Childhood Obesity*). Interestingly, many countries (e.g., Malaysia, Thailand, Japan) promote family meals in their national food guide recommendations. For example, the *Malaysian Nutrition Guide for Early Childhood Care* suggests "making mealtimes an enjoyable experience," and in Japan, "happy eating makes for happy family life; sit down and eat together and talk; treasure family taste and home cooking" is suggested. In North America, most health promotion recommendations include family dinner as a means to increase healthy eating behaviors; however, there is no reason to believe that the benefits of eating the evening meal together would differ from eating other meals (e.g., breakfast, lunch) and/or snacks together. This chapter will examine the associations between family meals and diet quality, including mediating factors and the potential impact on body weight status.

Family Meals and Diet Quality

Research on family dinner/meal frequency has supported a positive influence on diet quality. In 2008, we [3] published a systematic literature review on the current status and strength of evidence for family meals and diet quality. Since then, several other authors have contributed to the literature surrounding family meals and diet quality (see Table 6.1 for the positive and negative associations between family meals and diet/nutrient intake). It is apparent that family meal frequency is associated with more healthy food intake and behaviors, including more fruits and vegetables [4–11], whole grains [9, 11], calcium-rich foods [9], and protein [9]; less fried food and sugar-sweetened beverages[9, 12–14]; and more micronutrients from food [8, 9]. This was further illustrated by a recent study of ~1,000 grade seven students from Southwestern Ontario, Canada [15]. Even though participants fell short of Canadian nutrition recommendations (e.g., Eating Well with Canada's Food Guide), with fewer servings of *vegetables and fruit* and *milk*

Table 6.1 Family dinner/meal associations with food and dietary intake in children and adolescents

References	Positive associations	Negative associations
Gillman et al. [8]	Fruit/vegetables, minerals, vitamins	Fried foods away from home, sugar-sweetened beverages
Neumark-Sztainer et al. [9]	Fruit/vegetables, grains, dairy, protein, vitamins	Sugar-sweetened beverages
Videon and Manning [11]	Fruit/vegetables, dairy	
Utter et al. [10]	Fruit/vegetables	
Fulkerson et al. [7]	Fruits/vegetables	
Verzeletti et al. [12]		Sugar-sweetened beverages
Woodruff and Hanning [13]		Soft drink consumption
Welsh et al. [14]		Sweets, sugar-sweetened beverages
Bauer et al. [6]	Fruit/vegetables	
Andaya et al. [4]	Fruit/vegetables	Soda and chips
Fitzpatrick et al. [5]	Fruits/vegetables	Fruits/vegetables[a]

This table illustrates the reported positive and negative associations of family dinner/meal (taken from referenced works)

[a]Decreased linearly with television watching for family meals

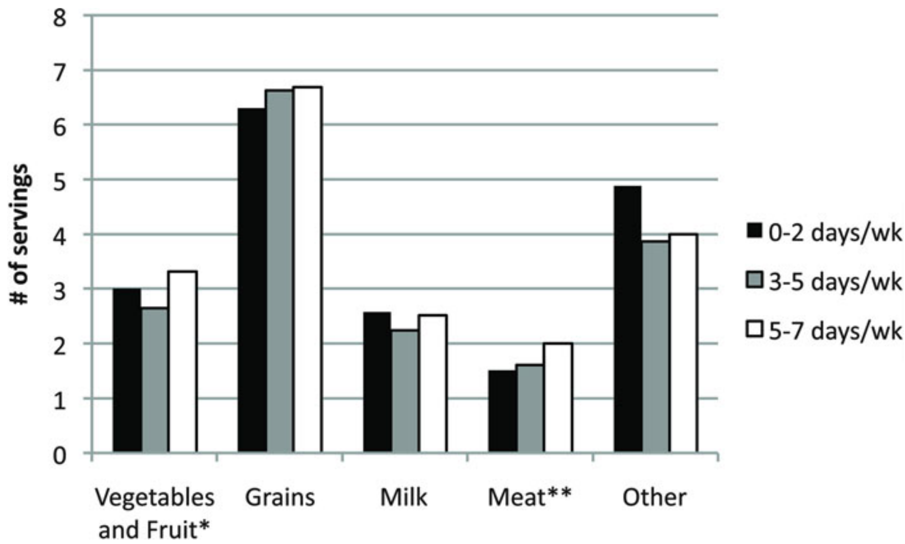

Fig. 6.1 Number of servings consumed from Eating Well with Canada's Food Guide and weekly family dinner frequency among ~1,000 grade 7 students from Southwestern Ontario, Canada. *Servings of vegetables and fruit is statistically different among weekly family dinner frequency, $p = 0.013$. **Servings of meat and alternatives is statistically different among weekly family dinner frequency, $p < 0.001$. This figure illustrates the number of servings consumed and weekly dinner frequency among a sample of ~1,000 grade seven students from Southwestern Ontario, Canada (unpublished data)

and alternatives, and slightly more *Grain Products*, those with more frequent family dinners fared better. Participants reported significantly more servings from the *Vegetables and Fruit* food group when family dinner frequency was 6–7 day/week compared to 3–5 days/week ($p = 0.013$) and more servings of *Meat and Alternatives* with family dinners on 6–7 days/week compared to 0–2 and 3–5 days/week ($p < 0.001$) (Fig. 6.1).

Family Meals and Diet Quality Indices. Many nutrition professionals find difficulty in quantifying *healthy eating*, given the complexity of food and nutrient intake. To overcome potential bias resulting from using only one/two measures to assess the diet, researchers have developed composite indices to assess overall quality of diet intake. Dietary quality indices evaluate a combination of different nutrients/foods/dietary constituents in relation to current dietary guidelines and/or specific health outcomes [16, 17]. By analyzing the diet using an index, it is likely that certain aspects will not be overlooked or overshadow all of the other components. Several cross-sectional studies investigating family meals using diet quality indices have shown positive benefits. For example, Veugelers et al. [17] reported that consuming family dinner 5–7 times/week was associated with a 14 % decrease in risk for lower diet quality relative to consuming family dinner less than once/week. Similarly, mean diet quality scores (Healthy Eating Index-Canadian: HEI-C which range from 0 to 100) were 62.1 (SD 13.2), 62.8 (SD 13.2), and 66.2 (SD 12.5) for Ontario participants ($n \sim 1{,}000$ grade 6–8 students) who reported family meals on 0–2, 3–5, and 6–7 days/week, respectively [18]. Controlling for sex, grade, body weight status, and underreporting status, HEI-C scores increased by 3.7 points (adjusted $p = 0.033$) as family dinner frequency increased from 0–2 to 6–7 days/week [18]. While the *needs improvement* diet quality rating (e.g., HEI-C scores ranging from 50 to 80) still existed among the participants, the increase in points was related to positive differences, such as an additional piece of fruit and/or serving of milk and alternatives.

Table 6.2 Mean (standard deviation) Healthy Eating Index-Canada (HEI-C) scores by family dinner frequency

Family dinner frequency	HEI-C scores (SD)
0–2 days/week (*n*=76)	65.48 (12.08)[AB]
3–5 days/week (*n*=139)	64.34 (11.95)[A]
6–7 days/week (*n*=733)	68.54 (12.40)[B]

This table illustrates the mean diet quality scores by family dinner frequency among a sample of ~1,000 grade seven students from Southwestern Ontario, Canada (unpublished data)
Unadjusted, $p<0.001$
[A] A is significantly different than B
[AB] It is not different the A or B

Moreover, among the sample of ~1,000 grade seven students from Southwestern Ontario, Canada [15], the HEI-C scores increased by 4.37 points (95%CI: 1.69–7.06, adjusted for ethnicity $p=0.004$) (see Table 6.2).

Family meals and other nutrition behaviors. While diet quality relates principally to food group and nutrient intake, many health professionals/researchers focus on food behaviors to better understand the relationship between family meals and diet quality. Several studies have shown the benefits of family meals with lower sugar-sweetened beverage consumption [4, 8, 9, 12, 13] and more frequent breakfast consumption [7, 10, 11, 13]. Sugar-sweetened beverage/soft drink consumption is concerning due to the high intakes [19], particularly among adolescent males, and their potential negative effects on body weight status through *empty calories* and the displacement of more nutrient-dense beverages such as milk and/or 100 % fruit/vegetable juice. Our own work [13] showed that participants (*n*=3,223 grade 6–8 students) who consumed soft drinks 2–6 times/week (OR 1.54), once/week (OR 1.93), once/month (OR 1.94), or rarely/never (OR 1.79) were likely to have a higher family dinner frequency compared to participants consuming soft drink at least once/day. Moreover, among this same sample, we also reported that family dinner frequency was positively associated with breakfast eating (vs. skipping; OR 1.81), even after adjusting for sex, grade, body weight status, dieting status, and concerns over high body weight [13]. Families who are more likely to eat dinner together may also be more likely to consume breakfast together. It is also possible that family dinner/meals are a time to teach/learn about the importance of healthy food behaviors [20], thus carrying over to the importance of consuming breakfast. Lastly, a longitudinal study reported lower soft drink consumption and more breakfast consumption in young adulthood with greater family meal frequency during adolescence [21], further strengthening the argument that family meals are protective against certain negative food behaviors. Finally, more frequent family dinners have been associated with higher self-efficacy for healthy eating at home with family and during social times with friends [13], greater parental support for health eating [10, 22], more fruits and vegetables available in the home [10, 22], greater frequency of bringing lunch from home [10], and less self-reported concern regarding body weight [13].

Longitudinal Effects of Family Meals on Diet Quality

Research suggests that family meals during adolescence may have a lasting effect on diet quality as individuals move into young adulthood. The majority of longitudinal studies on family meals and diet quality have been published using data from Project EAT in which a large sample (*n*=4,746) of ethnically and socioeconomically diverse middle/high school students from St. Paul/Minneapolis, Minnesota, were studied at baseline and then followed up 5 years later (*n*=2,516). Results suggest that more frequent family meals at baseline were associated with greater consumption of fruit [21, 23], vegetables [21, 23, 24], dark-green and orange vegetables [21], calcium-rich foods [24], starchy foods [23], fiber [24], and several micronutrients [24] at follow-up. Similarly, family meal frequency during high school predicted lower intakes of soft drinks [21] and snack foods [23] and less breakfast skipping (in females only [21]) during young adulthood. Lastly, Larson [21] reported that for both males and females, more frequent family meals at baseline predicted more frequent dinner meals ($P<0.05$), higher priority for meal structure ($P<0.001$), and higher priority for social eating ($P<0.001$) 5 years later.

Family Meals, Diet Quality, and Other Mediating Factors

The positive association between family meals and diet quality may be mediated by several factors, such as television watching, location of the meal, and family cohesion and parenting style.

Television watching during meals. Over 20 years ago, a review paper was published [25] which suggested that besides sleeping, children spend more time watching television than doing any other single activity. Interestingly, we have only begun investigating the full effects of television during childhood, likely due to the recent trends of declining physical activity rates and increased obesity prevalence. In 2004, Statistics Canada reported that children (aged 2–11 years) and adolescents (aged 12–17 years) spent approximately 14.1 and 12.9 h/week, respectively, in front of the television (Stats Canada). Not only is watching television sedentary but also may be associated with unhealthy eating.

Within a small population ($n=534$ 10-year-olds) of French-Canadians, 18 % (girls) and 25 % (boys) reported eating in front of the television every day [26]. The authors illustrated that eating in front of the television was positively correlated with children's consumption of French fries/poutine, salty snacks, ice cream, candies/sweet treats/chocolate, pastries, sweetened cereals, fruit beverages, and soft drinks and negatively correlated with overall consumption of raw vegetables and whole grain bread. Moreover, eating dinner while watching television (regardless of who else was present) was negatively associated with diet quality (as assessed using the Diet Quality Index), including lower fruit and vegetable consumption, more soft drink and snack food consumption, a higher percentage of carbohydrate energy intake from sugar, and a higher percentage of total energy intake from fat [27].

While meals may/may not be *chemically* different if eaten in front of the television or at the dinner table (with/without family members), the cultural and psychological meaning is completely different [28]. For example, watching television may distract an individual from noticing how much they've consumed and/or may override their satiety cues. Further, communication/interactions with others (in this case the family) may be reduced/eliminated. Lastly, watching television increases exposure to food-related content and advertisements [29] which may influence and/or increase the preference for the advertised foods in the future [30].

Given the popularity of television watching while eating, it should come as no surprise that approximately one-quarter to one-third of adolescents report watching television during family meals [26, 27, 31, 32] and has been associated with poorer diet quality[4, 5, 31, 33]. For example, adolescents watching television during family meals had lower intakes of vegetables, dark-green/yellow vegetables, calcium-rich food, and grains and higher intakes of soft drinks compared to adolescents not watching television during family meals [31]. Moreover, students in grades 6–8 who watched television while eating meals together as a family consumed higher amounts of pizza, snack foods, and soda and less fruits and vegetables than children who did not watch television while eating together [33]. Although, in our own work [32], we found no association between television watching during family meals and overall diet quality among 405 grade 6 students, food-related behaviors were negatively affected. Eating as a family in front of the television was associated with more frequent breakfast skipping ($p=0.035$) and a higher frequency of fast food ($p<0.001$) and sugar-sweetened beverage ($p<0.001$) consumption than not having the television on during meals [32]. Lastly, even among young children (1–4 years), the benefits of family meals (e.g., each night the family ate dinner together), including positive associations with servings of fruits (OR = 1.14) and/or vegetables (OR = 1.15), were undone by watching television during family meals such that fruit (OR 0.95) and vegetables (OR = 0.90) decreased with each night the television was on during dinner [5]. Interestingly, Feldman et al. [31] reported that while the most healthful dietary behaviors were associated with adolescents reporting family meals without watching television, eating as a family (regardless of the television watching) was associated with a more healthful diet compared to adolescents not eating regular family meals [31]. Lastly, television is only one aspect of the media, and it is recognized that other screen time activities have infiltrated dinner time (e.g., videos, computer games, and social media) and warrant future investigations.

Location. The location of a family meal may influence the diet quality of the meal. In an earlier study by our group [34], 93 % of participants ($n=3{,}223$ grade 6–8 students) consumed dinner on the previous night inside the home vs. 5 % who ate at a fast-food outlet/restaurant, 1 % who ate at school or didn't eat, and fewer than 1 % who ate between places. Socially, most ate with family members (87 %) vs. 9 % who ate alone, 3 % who ate with friends, and 1 % who didn't eat. The food was most often prepared by family members (84 %), but 9 % of students ate food they prepared themselves, 4 % ate food prepared at a restaurant/fast-food outlet, 2 % didn't eat, and 1 % ate food prepared by friends. The diversity was also reflected in the source of the foods, often originally purchased at a grocery store (87 %) but also from a restaurant/fast-food outlet (7 %), or convenience store/vending machine(5 %). Using a cluster analysis to identify dinner patterns, six dominant patterns emerged and influenced diet quality. For instance, participants were likely to have a worse diet quality if they ate dinner at a restaurant/fast-food outlet with family members (OR = 0.51) or skipped the meal altogether (OR = 0.53) compared to those who ate at home with family members with food that was prepared by family members [34]. This cluster analysis study [34] agrees with similar studies from the United States (e.g., [35]) which suggest that food consumed inside the home from grocery items, vs. food consumed or prepared outside the home, is associated with better dietary intakes.

In terms of using food prepared/purchased outside the home for family meals, Boutelle et al. [36] reported that purchasing fast food for family meals at least 3 times/week, vs. less frequently, was significantly associated with greater availability of soda pop and chips in the home, less vegetables and milk during meals served at home, and higher intakes of fast food and salty snack foods. Among adolescents, the odds of being overweight/obese were 1.5–2 times more likely if their families purchased family dinner outside of the home (from a fast-food outlet, restaurant, delivery service, or take out) at least weekly compared to adolescents whose families did not make such purchases [37]. Lastly, Chan and Sobal [38] reported that the frequency of family meals from foods prepared away from home, vs. family meals from food prepared inside the home, was inversely related to BMI. Although somewhat difficult to rationalize, it would be worthwhile to study the effects of using take-out food consumed inside the home vs. at the restaurant for family meals as portion control may be easier in the home than in a restaurant. Regardless, the health promotion message to reduce fast-food consumption during adolescence is widespread as fast food has been associated unhealthy food intake, which may have a negative impact on body weight over time.

Family cohesion and parenting style. The benefits of family meals may extend beyond diet quality, as family meals may be a proxy measure for family connectedness and cohesion. In certain families, family meals may be routine, formalized, and ritualistic (e.g., Sunday night dinner), while others may be more haphazardous and occur less often. For those families with high family meal frequency, the routine of family meals may reinforce the importance of family and its members [3]. For instance, Franko et al. [39] illustrated that family meals during childhood were related to various health outcomes in adolescents through the mediating factors of family cohesion and coping skills using a large cohort ($n \sim 2{,}300$) of adolescent girls. Moreover, family connectedness, priority of family meals, and positive mealtime environment were positively associated with psychological well-being and inversely associated with depressive symptoms and unhealthy weight control behaviors among a diverse sample of at-risk-for-overweight and overweight youth [40]. Family meals tend to promote social integration, group identity, and cohesion, communication, and emotional well-being [41].

According to Berge [42], family meals can be considered a proxy variable for measuring family functioning, in that the organizing, preparing, and eating of a family meal can be a stress-inducing event (e.g., according to family systems theory, the manner that a family responds to a family meal is indicative of their overall functioning). Furthermore, for some families, not all family meals are idealistic (e.g., an ideal picture of all family members happily sitting around a table enjoying a home-cooked meal like Norman Rockwell's *Free from Want* painting). Burnier et al. [41] recently reported that for one-sixth of the Canadian population, family meals are unpleasant and regularly involve arguments between parents, among children/siblings, or between parents and children. In terms of diet quality, mealtimes that are mainly free from arguments (particularly between parent and child) were significantly related with higher total energy intake during the day likely due to the meal lasting longer, even after controlling for other factors including physical activity, eating in front of the television, mothers' education level, and number of overweight parents [41]. The increased total energy intake may not necessarily be desirable (e.g., positive energy balance), yet the higher volume of foods may increase the chance of achieving dietary recommendations. Future research and interventions need to focus on how to improve family functioning at the dinner table to better understand the mediating factor of family cohesion and overall diet quality.

Lastly, parenting style has also been associated with family meals. For example, Berge et al. [43] investigated parenting style and family meals over two time periods, 5 years apart, and reported that authoritative parenting style predicted higher frequency of family meals at time 2, yet the associations only existed between opposite sex parent/adolescent dyads. Cross-sectionally, however, adolescent girls indicated a positive association between maternal and paternal authoritative parenting style and frequency of family meals, yet for boys, only maternal authoritative parenting style was associated with more frequent family meals [43]. Authoritative parenting style has been associated with healthier diets including greater fruit consumption [44] and lower BMI [43] among adolescents, which may be a mediating factor supporting the positive association between family meals and diet quality.

Family Meals and Body Weight Status

Body weight status has been used as a proxy measure for diet quality, albeit, simplifying the many influences on body weight. Interestingly, the evidence is more robust for the protective nature of family meals against eating disorders compared to obesity. For example, in longitudinal studies, frequent family meals offered protection against extreme weight control behaviors (e.g., self-induced vomiting, laxative use, diet pills, or diuretics [45]) and the initiation of purging, binge eating, and frequent dieting [46]. If the social nature of eating can protect against undereating, presumably, parents might also be alerted to indicators of excessive eating.

Cross-sectional studies have sometimes [17, 47], but not always [18], observed that eating dinner together as a family was associated with decreased risk of overweight. Similarly, longitudinal studies investigating the impact of family meals and weight status have reported no [48, 49] or conflicting [50] associations. It is possible that ethnicity [50, 51] and age of participants [48, 49, 52] influenced the effects of family meals and overweight/obesity status in both cross-sectional and longitudinal studies. It is also possible that samples were too homogeneous or measures poor (e.g., self-reported vs. measured). Yet, even though family meal frequency was variable

Table 6.3 Family meal frequency by ethnicity

Ethnicity[a]	0–2 days/ week n (%)	3–5 days/ week n (%)	6–7 days/ week n (%)
White ($n=679$)	45 (7 %)	84 (12 %)	550 (81 %)
Black ($n=53$)	10 (19 %)	9 (17 %)	34 (64 %)
Arab ($n=49$)	6 (12 %)	16 (33 %)	27 (55 %)
South Asian ($n=32$)	3 (9 %)	4 (13 %)	25 (78 %)
Chinese ($n=18$)	0 (0 %)	4 (22 %)	14 (78 %)
Other ($n=112$)	12 (11 %)	20 (18 %)	80 (71 %)

This table illustrates family meal frequency among ethnicities among a sample of ~1,000 grade seven students from Southwestern Ontario, Canada (unpublished data)
[a]Family meal frequency was significantly different among ethnicities, $X^2=32.132$, $p<0.001$

among a very diverse sample of ~1,000 grade seven students from Southwestern Ontario, Canada [15] (see Table 6.3), and height and weight were accurately measured, no differences in body weight status were observed by family meal frequency. Further clouding the interpretation, results from the National Longitudinal Survey of Youth in 1997 [50] reported that family meal frequency was protective against overweight/obesity status up to 3 years later in white participants ($n=2{,}089$) but that higher family dinner frequency was occasionally positively associated with overweight status among blacks and Hispanics ($n=1{,}685$), although it is also possible that social factors (e.g., food security) intervened which were not reported.

Lastly, Neumark-Sztainer et al. [53] suggested that the relationship between family meals and weight status may depend upon various aspects of the family meal itself, such as the types and amounts of food served, rather than solely the frequency of eating together. In observational studies [54], families with obese children had an increased presence of sugary beverages, shorter meal length, and fewer adults at the table compared to normal weight children. Further, Moen et al. [55] reported maladaptive control strategies and less parental support at family meals for overweight children compared to controls.

Overall Family Meal Influence on Diet Quality

Dinner is the most often consumed meal throughout the day and is usually the most common family meal studied. One would expect that the benefits of eating the evening meal would be the same for the morning meal, and so some researchers have used all meals in their investigations [9, 24] rather than just dinner. Limited research exists focusing specifically on consuming breakfast [4] and/or lunch [4, 56] meals together as a family. For instance, Andaya et al. [4] reported that 84 % of children (4–10 years) who consumed breakfast with their families consumed fruit and vegetables 5 or more times/week, as did 85 % of those who ate lunch with their families. Interestingly, we [56] reported that participants in grades 6–8 showed a lower diet quality when consuming lunch at home with family members (e.g., therefore a family meal) compared to those who ate at school with their friends. However, the study did not ascertain specifics about the lunch meal that may have explained this finding (e.g., if parents vs. siblings were present for the meal, who prepared the meal, where was the food purchased). Although family meals may be difficult to define (e.g., whether one parent/guardian is present or when all or most of the family living in the house is there), it seems as though the presence of others from within the home may increase the types of foods consumed at that meal which may increase the likelihood of meeting the nutrition recommendations. For example, in an experimental condition which included 5–7-year-olds and their mothers, children consumed less energy from unhealthy snacks when their mother was present compared when they ate with their peers [57]. Lastly, research is currently lacking regarding how feeding styles (e.g., buffet/family-style/plated meals) influence diet quality of children and adolescents.

Family meals may play an integral part in achieving good diet quality due to the dynamic nature of family meals. For example, the social nature of eating together may increase the length of the meal, thus increasing the amount (and perhaps variety) of food consumed [58].

Consuming greater quantities of food may not necessarily have a positive affect (e.g., increased body weight), yet for some individuals, it may increase the chance of meeting nutrient requirements. Furthermore, family meals may be beneficial for diet quality since they can be used as a learning venue (e.g., food preparation/nutrition knowledge/table manners) thus increasing overall nutrition knowledge. Lastly, the familiarity of eating with the same individuals may produce imitation and/or modeling behaviors in others, which may influence eating norms among certain members of the family (e.g., the presence of a *big* or *small eater* may influence the permissible intake and delegitimize any norm [41]).

There is mounting evidence that suggests adolescents, particularly females, tend to copy food behaviors of those around them to facilitate social interactions and acceptance among peers [59]; however, very little has been done to investigate family relationships, patterning, and the food consumed during shared meals. However, children and adolescents likely learn food behaviors from their family and others around them [3, 60] simply by watching. A recent excerpt from an *American Journal of Clinical Nutrition* article focused on feeding practices for children stated that "there is evidence of a strong genetic influence on appetite traits in children, but environment plays an important role in modeling children's eating behaviors" [60], suggesting that if you want your children to eat fruits and vegetables, then parents should ensure they are served and modeled. For example, Vanhala et al. [61] reported that children were more likely to consume fruits, berries, and vegetables if their mothers ($p<0.001$) and fathers ($p<0.001$) consumed fruits, berries, and vegetables, regardless of body weight status. Further, in overweight children, parent's consumption of fruit, berries, and vegetables was the only significant predictor of the offspring's consumption of fruit, berries, and vegetables ($P=0.002$) [61].

Table 6.4 Future research questions

Factor	Specific research question
Interventions	Can we use family meals to improve diet quality?
Television watching and family meals	How does ethnicity mediate the relationship between family meals and diet quality?
Arguments at the dinner table	How do arguments at the dinner table influence specific foods/nutrients?
Use of take-out food	How does the use of take out (vs. consuming a restaurant meal in the restaurant) influence diet quality?
Feeding style	Does self-serve/buffet/plated feeding-style influence diet quality?
Increasing family meals	What is the best method of increasing family meals among families that do not currently eat together?

This table illustrates potential future research questions that should be addressed investigating family meals and diet quality (author generated)

Conclusions

This chapter reviews the associations between family meals and diet quality, including the mediating factors of television watching, location of meal, and family cohesion/parental support. A glaring, yet important, omission in the literature is whether family meals can be used as an intervention to increase diet quality (see Table 6.4 for a list of future research areas and questions). For instance, a module promoting family meals was developed and implemented with families participating in the *Women, Infants, and Children* program, which was successful in increasing family meal frequency [62]; however, changes in nutrient intake and/or diet quality were not measured. Based on the findings presented in this chapter, health promotion specialists should make efforts with families to increase family meal frequency, albeit with some caution. Using a blanket statement to promote family meals may not achieve the desired nutrition and health benefits, since clearly even meals eaten as a family can be associated with unhealthy foods or behaviors. Furthermore, other determinants of family life and/or health behaviors can impinge on family meals. For example, sport participation is a positive influence on health and body weights but may add to already busy family schedules and contribute to more meals away from home (e.g., tournaments/games/practices scheduled during

Table 6.5 Family dinner frequency by parental encouragement and support for physical activity and time spent in sedentary activities among ~1,000 grade 7 students from Southwestern Ontario, Canada

Variable		0–2 days/week	3–5 days/week	6–7 days/week	Significance
Parental encouragement for physical activity	Encourage ($n=779$)	55 (7 %)	107 (14 %)	617 (79 %)	$X^2=11.309$, $p=0.023$
	Neither ($n=121$)	15 (12 %)	22 (18 %)	84 (70 %)	
	Discourage ($n=20$)	4 (20 %)	4 (20 %)	12 (60 %)	
Parental support for physical activity	Supportive ($n=778$)	55 (7 %)	107 (14 %)	618 (79 %)	$X^2=14.727$, $p=0.005$
	Neither ($n=106$)	14 (13 %)	19 (18 %)	73 (69 %)	
	Unsupportive ($n=32$)	6 (19 %)	7 (22 %)	19 (59 %)	
Sedentary activities (after school until bedtime)	Hours (SD)	7.30 (4.9)	6.46 (4.1)	5.44 (3.7)	$p<0.001$

This table illustrates family dinner frequency and some measures of physical activity/sedentary activities/behaviors among a sample of ~1,000 grade seven students from Southwestern Ontario, Canada (unpublished data)

the dinner hour). By way of example, Table 6.5 illustrates that family meal frequency is different among levels of parental encouragement ($p=0.023$) and support ($p=0.005$) for physical activity and overall time spent in sedentary behaviors ($p \leq 0.001$), variables that are seemingly unrelated to family meals, yet may be masking other potential family-related influences. Moreover, families with parents working shift work or adolescents with after-school jobs may have trouble accommodating a family dinner. It will be important in future work to determine how best to increase family meal frequency in families scheduling difficulties.

Lastly, it is interesting to note that when adolescents voiced their opinion on family meals in focus groups, they confirmed the perceptions that they would eat more healthfully if they ate more meals with their families [63]. Moreover, with the positive associations between family meal frequency and diet quality, some literature is emerging on the impact of family-style meals and social eating with others such as in lunchrooms at schools [56] and/or in older adult facilities [64, 65]. Further research is needed with these environments, however, before health promotion activities should begin.

Overall, family meal frequency is associated with improved diet quality and food-related behaviors and may, in turn, support healthy body weights. Although, such associations do not mean that lack of family meals *causes* poor diet or that programs to increase family meal frequency will necessarily improve diet quality, the potential health, diet, and social benefits of family meals suggest the need for carefully controlled intervention research. Any program to encourage family meals must also address other factors to support healthy eating (e.g., diet planning, cooking skills, portion control) and healthy meal environments (e.g., with no television and positive family interactions). Ultimately, family meals may prove to be one of a menu of approaches to help support healthy eating and healthy body weights.

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The Influence of Motivations to Eat on Weight Status and Diet Quality

7

Jodi Cahill Holland and Jeanne H. Freeland-Graves

Key Points

- Overweight/obesity has increased dramatically over the past 3 decades and this trend is paralleled by an increase in food availability.
- Motivation to eat arises from environmental, biological, and psychological influences.
- A variety of measurement tools exist: Three-Factor Eating Questionnaire, Dutch Eating Behavior Questionnaire, and Eating Stimulus Index.
- Biological motivations to eat include taste and hunger; psychological motivations to eat include self-efficacy, emotional eating, and dietary restraint.
- Obese individuals have less availability of healthy foods, eat in response to environmental cues, and are more comfortable with their weight when surrounded by obese peers.
- Perceptions of taste, such as sensitivity to bitter 6-n-propylthiouracil, and hunger are associated with weight status.
- Greater self-efficacy and dietary restraint and reduced vulnerability to eating in response to emotional states are linked to a healthier weight status.
- Motivations to eat are related to weight status and predict food intake.
- Identification of motivations to eat may facilitate development of tailored interventions to improve diet quality and prevalence of obesity.

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V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health,
DOI 10.1007/978-1-4614-7315-2_7, © Springer Science+Business Media New York 2013

Keywords
Diet quality • Motivation to eat • Dietary intake • Overweight • Obese • Food choice

Abbreviations

BMI Body mass index
PROP 6-n-propylthiouracil

Introduction

Since the 1970s, the incidence of obesity has risen more than 20 % [1]. This dramatic increase in body weight is of paramount concern due to the high economic burden and associated reduction in mortality and morbidity. Expenses attributable to obesity may exceed $100 billion annually [2]. Obesity is linked to >100,000 excess deaths due to heart disease, diabetes, kidney disease, and certain cancers. This trend of weight gain has been paralleled by increases in food availability and intake. Per capita availability of food energy has risen approximately 700 kcal/day since the 1970s and energy consumption by 7 % in men and 22 % in women [3]. In contrast, fruit consumption has declined, and less than one third of Americans meet recommended intakes for fruit and vegetables [4]. To encourage intake of healthy foods (i.e., fruits, vegetables, and whole grains) and lessen that of energy-dense foods (i.e., fast food and sugar-sweetened beverages), an understanding of factors that motivate individuals to eat is warranted. Knowledge of the role of these influences is crucial to the development of interventions designed for prevention and treatment of obesity.

Food intake results from a network of complex interactions that form a psychobiological system [5]. Within this system are influences from the environment such as food availability, sight or smell of food, and social interactions; biological processes such as hunger/satiety and taste; and psychological processes such as dietary restraint, self-efficacy, and emotional state (Fig. 7.1). A summary of the various theoretical frameworks describing the influences on food

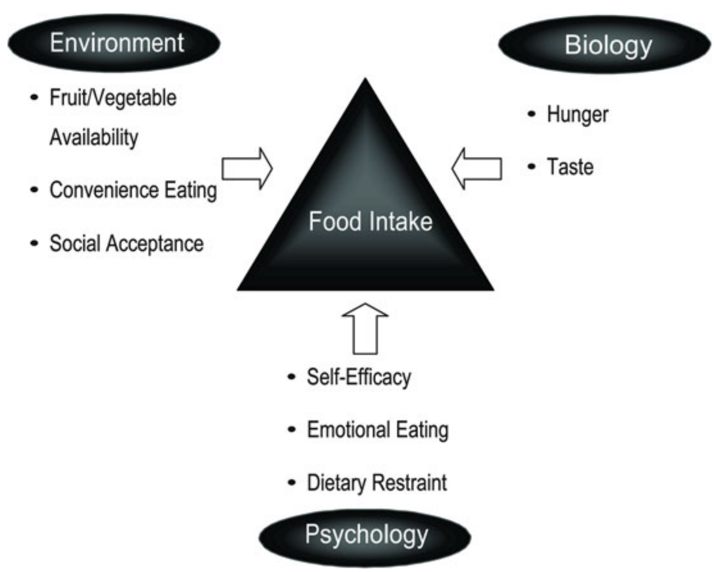

Fig. 7.1 Factor structure of the Eating Stimulus Index. Motivations to eat are categorized as environmental, biological, or psychological determinants. These factors influence food intake and thus diet quality and weight status. Unpublished

Table 7.1 Theoretical frameworks of influences on food intake

Theory	Origin of eating stimulus	Constructs	Rationale
Determinants of food choice [51]	Environmental/psychological	Situation	Situational cues and context influence the perceived appropriateness of food consumption
	Biological/psychological	Current internal state	Psychophysiological state (mood, thirst, hunger) affects food choice
	Biological/psychological	Hedonic likes	Taste preferences lead to food liking, subsequent food purchase, and then consumption
Homeostatic/hedonic regulation food intake [52]	Environmental	Hedonic	Palatable food in the environment stimulates the desire for food
	Biological	Homeostatic	Hunger/satiety signals regulate food intake
Dual factor model of food intake [53]	Environmental/psychological	Uncompensated factors	Factors that have no feedback mechanism encourage meal/snack consumption
	Biological	Compensated factors	Physiological responses to the feedback regulation of hunger/satiety influence eating behaviors
Control of food intake in the obese [5]	Environmental	Environmental processes	Stimulus from the obesogenic environment contributes to overconsumption
	Biological	Biological processes	Physiological regulation of hunger/satiety influences food intake
	Psychological	Self-imposed modulations	Dietary restraint is necessary to control food intake and regulate body weight

intake can be seen in Table 7.1. This chapter will discuss measurement tools used to assess motivations to eat and factors within this system that motivate eating and their influence on weight status and dietary quality.

Measurement Tools to Assess Motivations to Eat

A variety of instruments have been developed to assess motivation to eat (Table 7.2). The Eating Attitudes Test is a 26-item questionnaire designed by Garner and Garfinkel to measure attitudes towards healthy behaviors [6]. This scale is used frequently in the diagnosis of eating disorders. A psychometric analysis of this version was conducted in a sample of anorexia nervosa patients. Three factors were identified that accounted for 40.2 % of the variance: dieting, bulimia and food preoccupation, and self-control. Hoerr et al [7]. subsequently used the Eating Attitudes Test to identify eating disorders in college students. Eating disorders were more prevalent in women (4.5 %) than men (1.4 %).

The Emotional Eating Scale is a 25-item instrument that evaluates eating in response to negative emotions [8]. Validation of the instrument was conducted in a sample of obese women previously diagnosed with bulimia nervosa. Principal components

Table 7.2 Instruments that measure motivations to eat

Questionnaire	Scale overview	Validation sample	Items	Subscales
Eating attitudes test [9]	Dysfunctional eating attitudes; used in diagnosis of eating disorders	160 female anorexia nervosa patients	26	Dieting, Bulimia/food preoccupation, self-control
Emotional eating test [12]	Eating in response to negative emotions	47 obese females	25	Anger/frustration, anxiety, depression
Weight Loss Efficacy Lifestyle Questionnaire [14]	Self-efficacy with regard to weight loss	162 obese patients in weight loss program	20	Negative emotions, availability, social pressure, physical discomfort, positive activities
Food Craving Inventory [16]	Patterns of food cravings related to fats, sweets, carbohydrates, and fast food	379 university and community subjects	28	High-fat foods, sweets, starches, fast-food fats
Motivation to Eat Scale [19]	Psychological motivations to eat; predicts restricted eating and binging and purging	812 college students	20	Coping, compliance, social, pleasure
Three-Factor Eating Questionnaire [21]	Individual eating behaviors due to restrained eating, disinhibition, or hunger	220 subjects from weight loss program and community	51	Hunger, restraint, disinhibition
Dutch Eating Behavior Questionnaire [24]	Patterns of restrained, emotional, and external eating; used in the diagnosis of eating disorders	1,170 young adults	33	Restrained eating, Emotional eating I Emotional eating II, Emotional eating III External eating
Food Choice Questionnaire [26]	Determinants of food choice	358 university adults	36	Health, mood, convenience, sensory appeal, natural content, price, weight control, familiarity, ethical concern
Motivation for Eating Scale [28]	Motivations for eating related to situational triggers; identifies patterns of intuitive eating	298 subjects from university and community	43	Emotional, environmental, physical, social
Eating Stimulus Index [30]	Motivations to eat from environmental, biological, and psychological origins	179 low-income women in early postpartum	23	Fruit and vegetable availability, convenience eating, social acceptance, hunger, taste, self-efficacy, emotional eating, dietary restraint

analysis resulted in identification of three main psychological factors: anger/frustration, anxiety, and depression. Construct validity was established by correlation with the Binge Eating Scale, and a 7-day binge recall. Waller and Osman [9] provided further validation of the Emotional Eating Scale by examining its psychometric properties in a nonclinical sample of normal-weight women without an eating disorder. Significant relationships were discerned between body mass index (BMI) and both the anger/frustration and depression subscales. It should be noted that this scale is limited to psychological motivations to eat.

The Weight Efficacy Lifestyle Questionnaire measures eating self-efficacy with regard to five situational factors: negative emotions, availability, social pressure, physical discomfort, and positive activities [10]. The scale was validated in obese individuals enrolled in a weight loss program and a second sample of patients who sought hospital treatment for weight management. The negative emotions, availability, social pressure, physical discomfort, and positive activities subscales demonstrated sufficient internal consistency reliability in both samples. In weight loss intervention studies, this scale has the ability to detect changes in self-efficacy over time, but it did not correlate with weight loss [11].

The Food Craving Inventory is a self-reported measure of food cravings that discriminates between those who crave high fats, sweets, carbohydrates/starches, and fast-food fats [12]. It was validated in participants recruited from university and community settings. Adults with a higher BMI craved high-fat foods, while those with a high BMI and binge eating disorder craved sweets more often. Martin et al [13]. used the Food Craving Inventory to compare cravings after either low- or very low-calorie diets. Cravings decreased significantly in the very low-calorie diet group after 11 weeks of dieting. The Food Craving Inventory is another example of a scale that measures a single construct.

The Motivation to Eat Scale measures multiple constructs that are limited to psychological influences on eating [14]. Based upon a model for alcohol motivation, it intended to evaluate disordered eating patterns, such as restricted eating, binging, and purging. Psychological motivations for eating included coping, social, compliance, and pleasure constructs. The scale was validated in undergraduates enrolled in an introductory psychology course. Confirmatory factor analysis revealed the presence of the four distinct factors listed above. Convergent and discriminant validity were established by comparison to the Dutch Eating Behavior Questionnaire, Emotional Eating Scale, and Marlowe-Crowne Social Desirability Scale [15]. Preliminary data showed that women reported eating in response to coping motivations more frequently than men. Biological motivations such as experiencing hypoglycemia or reduced energy were excluded from the scale.

The Three-Factor Eating Questionnaire [16] measures multiple determinants of eating behavior including hunger, restrained eating, and disinhibition. Disinhibition is defined as a vulnerability to external eating cues. The Restrained Eating Theory states that intense dieting causes persistent hunger. Hunger leaves the individual more vulnerable to overeating during moments of weakness, such as during stress, anxiety, depression, fatigue, alcohol consumption, or exposure to highly palatable food. Latent obesity describes individuals who possess obese eating patterns, yet remain at a normal weight through conscious control of food intake. In a study of adults [17], the Three-Factor Eating Questionnaire was used to describe how these factors vary over a range of BMI values. Disinhibition was strongly correlated to BMI, and obese persons exhibiting a high degree of disinhibition had low dietary restraint. This measure has been used widely; environmental influences on food intake were not included.

The Dutch Eating Behavior Questionnaire assessed eating disorders and measured restrained, emotional, and external (or environmental) eating [18]. It is based on three theories of eating behavior: psychosomatic, externality, and restraint. Psychosomatic theory attributes emotional overeating to a confusion of internal arousal states and hunger. External eating is defined as eating in response to food-related stimuli. These theories relate the development of obesity to an individual's misperception of his/her internal state prior to eating. The confusion between the perception of hunger and actual hunger does not always result in obesity; therefore, restrained eating was included. In 2003, Van Strien and Ouwens [19] examined the ability of restrained, emotional, and external eating measured by the scale to predict cookie consumption after a preload. Only the emotional eating construct was related to intake; emotional eaters consumed more after a preload than those who did not exhibit this response.

The Food Choice Questionnaire identifies determinants of food choice in individuals [20] using 36 items. Nine constructs were identified by factor analysis from adults from university and community settings. Constructs included health, mood, convenience, sensory appeal, natural content, price, weight control, familiarity, and ethical concern. The stability of the scale over time was established through test-retest

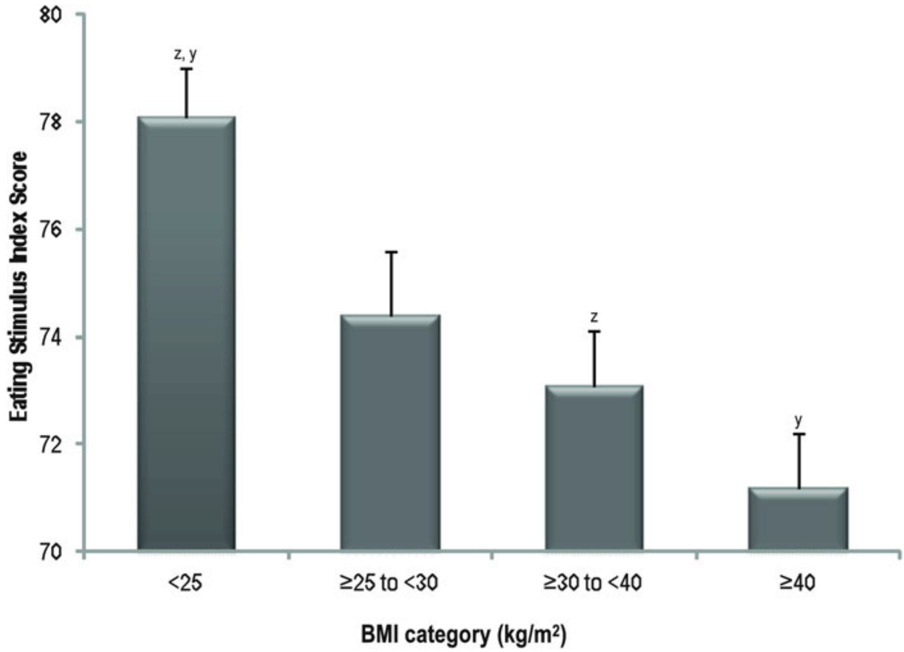

Fig. 7.2 Motivations to eat differ by weight status. Total Eating Stimulus Index scores were significantly different across BMI categories after adjusting for age. These results demonstrate the ability of the questionnaire to discriminate between normal weight and overweight/obese individuals (unpublished data). ^{z,y}Like superscripts indicate significant post hoc differences between groups ($P < 0.01$)

reliability (Pearson's $r = 0.70$). Chang et al [21]. modified this instrument for use in an American population and observed that cost of food and weight control intentions were related to fat intake in obese women.

The Motivation for Eating Scale [22] also measures multiple constructs that influence eating behaviors. Individuals were identified that followed an "intuitive eating" pattern (the ability to eat in response to internal hunger cues rather than environmental cues). This questionnaire was validated in university and community adults and contains four subscales: emotional, environmental, physical, and social eating. Normal-weight subjects were found to rely on physical hunger cues more than overweight subjects. Hawks et al [23]. compared the eating motivations of two different cultures, college students living in either the United States or Japan, using a truncated 12-item version of the Motivation for Eating Scale. Women in the United States reported eating more for emotional reasons, while those in Japan ate more for physical or environmental reasons.

The Eating Stimulus Index is an instrument created by the authors that was designed to measure motivations to eat in low-income women in early postpartum [24]. This instrument contains 23 items that capture determinants of food intake from environmental, biological, and psychological origins. Environmental determinants included convenience eating resistance, fruit and vegetable availability, and social acceptance. Biological factors were taste for vegetables and morning hunger/breakfast. Psychological influences included weight loss self-efficacy, emotional eating resistance, and dietary restraint. In a pooled sample of low-income postpartum women and college students, total scale scores were significantly different across BMI categories (Fig. 7.2). Mothers and students were combined to increase the range of BMI to include those in the normal-weight category. In low-income women, convenience eating resistance, emotional eating resistance, and dietary restraint were negatively related to BMI, so that women with higher scores exhibited lower BMIs.

Among the measures of motivation to eat described above, the most commonly used were the Three-Factor Eating and Dutch Eating Behavior Questionnaires. A new instrument developed by the authors, the Eating Stimulus Index, captures motivation to eat from the three primary influences on food intake and adds another method of examining this construct.

Motivations to Eat and Weight Status

Environmental

A changing environment is one of the main contributors to the obesity epidemic. Specific environmental aspects that influence the development of obesity are availability of healthful foods such as fruits and vegetables, eating in response to cues such as sight or smell of food, and a multiplicity of factors from the social environment. These factors include interactions between family, friends, and peers, such as modeling and social norms. Additionally, individuals that live in a geographic environment with a high density of fast-food restaurants are more likely to be obese. In contrast, an abundance of healthful foods in the environment may have the opposite effect and improve diet quality. For example, the presence of small neighborhood stores and vouchers for local farmers' markets enhances access to fruits and vegetables while simultaneously increasing their consumption. Novak and Brownell [25] have proposed that an environment conducive to behavior change must be created in order for interventions to reduce the prevalence of overweight/obesity.

Sensitivity to the visual presence or smell of food in the environment may enhance the risk for obesity, although not all researchers agree [26]. The pattern of eating in response to environmental cues and neglecting internal hunger signals has been defined as external eating. For example, individuals may eat more candy when it is placed in a convenient and visible location, as on a desktop versus hidden in a drawer or some distance away. A study by the authors [24] found that this type of eating, in the context of convenience eating, was related to BMI in a sample of low-income women. Moreover, overeating in response to environmental cues was the strongest correlate of weight gain after 20 years [27]. An external eating style also has been linked to food cravings, which may elicit episodes of binge eating. Since external eating can diminish with weight loss, the need for incorporation of skills for minimizing this response to environmental stimuli is needed for successful interventions in obesity.

Social influence is another component that is well known to affect food intake and weight status. In environments where being overweight has become the cultural norm, individuals report greater satisfaction with current weight even when they are overweight or obese [28]. A person's social environment also affects their readiness to lose weight and participation in weight loss behaviors. Weight loss interventions encouraging spousal involvement also have produced outcomes that are more successful [29]. Thus, interactions within the social environment are significant contributors to food intake and may have a profound influence on diet quality and weight status.

Biological

Both modifiable and nonmodifiable biological influences affect food intake and body weight, particularly taste and hunger. It is well known that taste is one of the most important determinants for meal selection. The ability to detect flavor in foods results from a combination of chemosensory mechanisms including taste, smell, mouthfeel, and chemesthesis (the ability of a chemical component from food to stimulate other senses, typically pain). Preferences for certain tastes may differ by race and can influence adiposity and risk for cardiovascular disease. Some taste preferences, such as sensitivity to bitter-tasting compounds in plants, have a genetic component. Sensitivity to the bitter compound 6-n-propylthiouracil is controlled by the TAS2R38 gene, with approximately 25 % of the population classified as "supertasters." But it may be that nontasters, those with low sensitivity, are at risk for weight gain due to a greater preference for a wide variety of foods, especially those high in fat. However, the data assessing the connections between taste sensitivity and BMI are contradictory [30, 31]. Relationships may be dependent on other factors such as level of dietary restraint [30] and salivary proteins related to gustatory function [32].

The sensation of hunger is another major biological component affecting motivations to eat. It is clear that feelings of hunger emerge with a decline in blood glucose levels, as a response to fluctuations in hormones related to appetite control. Differences in circulating hormone levels can contribute to varying intensities of hunger signals among individuals. These altered hunger signals may affect weight, since greater sensitivity to hunger has been positively correlated with BMI in women. In fact, Colles et al [33]. found that reductions in subjective hunger predicted weight loss after bariatric surgery in 129 obese adults. These findings suggest that the ability to attenuate hunger sensations may be an important strategy for weight loss.

Other dietary modifications are known to alter the perception of hunger. These include consumption of 4–6 small meals throughout the day, addition of lean protein to each meal snack, and reduction of simple carbohydrates. Thus, the impact of biology on motivations to eat cannot be denied; however, skills can be developed to alter sensations or responses to taste and hunger.

Psychological

The psychological state of the mind and cognitions are other major constituents of food choice. In particular, self-efficacy, emotional eating, and dietary restraint may have dramatic effects on eating behaviors and weight.

Self-efficacy is defined as the confidence in one's ability to perform a given activity. Persons who exhibit a greater self-efficacy for weight management behaviors exercise more often and are more successful in weight loss interventions than those with lower self-efficacy [34]. In fact, interventions that target improvements in self-efficacy achieve greater weight loss than those that do not enhance this concept. In addition, high levels of self-efficacy have been shown to correlate with dietary control, exercise, and weight management behaviors. Thus, it is crucial to embody improvement of self-efficacy as a significant component of behavioral change when designing a curriculum plan for weight loss.

Emotional eating is the tendency to overeat when experiencing emotional arousal or stress. Individuals sensitive to emotional eating tend to be overweight and are commonly affected by binge eating disorders. The psychosomatic theory indicates that those who are susceptible to this behavior confuse internal arousal states and hunger. This type of eating has been linked to obesity and weight gain over time.

Dietary restraint, or the cognitive ability to control food intake, has been studied extensively within the context of obesity, but with conflicting results. Herman and Mack [35] first developed the Restraint Theory, which states that strict control of food intake leaves an individual consumed with thoughts of food. This eventually leads to overconsumption and subsequent weight gain. Since then, dietary restraint has been related to high BMI [36], but others have noted a negative relationship [37]. It may be that the positive connection of dietary restraint and body composition is mediated by the psychological variable of disinhibition.

Disinhibition may be elevated in obese individuals and associated with future weight gain. Hays et al [38]. determined that individuals with high disinhibition and high dietary restraint gained less weight than those with high disinhibition and low dietary restraint. This finding suggests that dietary restraint may protect against weight increases over time. Thus, dietary restraint is an important weight management skill as it is associated with lower body weight, healthful eating, and long-term weight maintenance.

In sum, motivations to eat vary according to weight status and, thus, may be important targets for the prevention and treatment of obesity.

Motivations to Eat and Dietary Intake

Motivations to eat appear to affect weight status via their influence on dietary intake. A strong predictor of dietary intake is the vulnerability to environmental eating cues. In an observational study of women in the first year following childbirth, the authors [39] documented that those with a high resistance to convenience eating exhibited greater overall diet quality as measured by the Dietary Guidelines Adherence Index (Table 7.3). These mothers also consumed less discretionary energy (total excess calories from solid fat, alcohol, and added sugar). The implication of these findings is that individuals less sensitive to environmental food stimuli consume a more healthful diet. Additional evidence using the construct of external eating within the Dutch Eating Behavior Questionnaire supports these findings. External eating has been positively related to increased energy, fat, and carbohydrate intakes and sugar-sweetened soft drinks. Additionally, Van Strien et al [40]. discerned that external eaters consumed more snack foods while watching food-related commercials than did high external eaters viewing the neutral food-free advertisements. Remarkably, those who continued to exhibit lower levels of external eating after 4 years still maintained reduced energy intake [41]. Thus, strategies to decrease the sensitivity to environmental eating cues, such as stimulus control or the adoption of behaviors (i.e., packing healthy snacks), are vital elements for improving diet quality.

The availability of healthful foods such as fruits and vegetables must not be overlooked as a major influence on diet quality and intake. In a sample of low-income women after childbirth, the authors [39] demonstrated that fruit and vegetable availability was positively related to overall diet quality. Greater home availability was positively related to consumption of fruit, total vegetables, dark green vegetables, legumes, orange vegetables, and other vegetables. Kratt et al [42]. measured fruit and vegetable availability in parent–child pairs and observed that parents with the most availability also had the highest intakes. Given that access to fresh produce is a reported barrier to consumption in specific populations, strategies to increase home availability such as purchasing items in season and providing vouchers to local farmers' markets should be emphasized in educational programs.

The construct of dietary restraint has been frequently associated with decreased energy intakes. This observation is not surprising since restrained eaters consciously control their food intake in an effort to restrict calories for the purposes of weight control. Leblanc et al [43]. identified that restrained eaters consumed fewer calories throughout the day, but ingested more calories at breakfast and fewer calories after 5 pm. In contrast, disinhibited eaters consumed more energy throughout the day and as snacks after 5:00 pm. In a longitudinal study, Van Strien and Van de Laar [41] documented that after 4 years, increased restrained eating was associated with decreased intake of total and saturated fat. In low-income, minority women, high dietary restraint has been linked to healthful food choices and less frequent fast-food consumption, indicating that restraint is a predictor of dietary behavior in this population as well.

The Dutch Eating Behavior Questionnaire is an excellent instrument that categorizes eating behaviors. Van Strien et al [19]. documented increased food intake in individuals who were identified as emotional eaters. A study by the authors [44] found similar results, in which weight status in low-income women was followed over the first 12 months after childbirth. At the end of 1 year, women who were obese reported eating more often in response to emotional cues than did their overweight counterparts. In a Finnish sample of 1,679 men and 2,035 women, emotional eating was positively related to higher consumption of sweet energy-dense foods such as buns, biscuits, other sweet baked items, chocolate, and sweets [45]. Women classified as emotional eaters by the Dutch Eating Behavior Questionnaire were more likely to report overeating than nonemotional eaters, as well as overeating high-fat snacks in response to stress. However, others have not observed

Table 7.3 Correlation coefficients for subscales of the Eating Stimulus Index and overall diet quality and daily food group intake in low-income, minority women in early postpartum ($n = 115$)[a]

	Fruit and vegetable availability	Convenience eating resistance	Social acceptance	Morning hunger/breakfast	Vegetable taste preference	Weight loss self-efficacy	Emotional eating resistance	Dietary restraint
Dietary Guidelines Adherence Index	0.252*	0.352*	−0.013	0.051	0.233*	0.069	0.049	0.075
MyPyramid Food Group								
Grains (oz equivalents)	−0.026	−0.068	0.105	−0.053	−0.050	0.002	−0.034	−0.158
Fruit (cup equivalents)	0.203	0.293*	0.041	0.179	0.194	0.061	0.002	0.247*
Vegetables (cup equivalents)	0.274*	0.156	−0.224	−0.060	0.215	0.057	0.042	−0.118
Milk (cup equivalents)	−0.053	0.173	0.052	0.205	−0.122	−0.013	−0.102	0.015
Meat/beans (oz equivalents)	−0.053	0.173	0.052	0.205	−0.122	−0.013	−0.102	0.015
Discretionary energy (kcal)	−0.103	−0.361*	−0.014	−0.321*	0.017	−0.203	0.011	−0.090
Nutrient								
Energy (kcal)	−0.088	−0.233*	−0.162	−0.077	−0.012	−0.342*	−0.233*	−0.292*
Carbohydrates (g)	0.048	0.071	0.117	−0.073	0.077	−0.090	0.149	0.018
Protein (g)	0.088	−0.018	−0.083	0.132	0.039	0.195	−0.092	−0.068
Fat (g)	−0.002	−0.221	−0.140	0.043	0.001	0.098	−0.125	−0.079
Fiber (g)	0.259*	0.281*	−0.141	0.079	0.195	0.058	−0.154	−0.103
Folate (mg)	0.175	0.226	−0.126	0.225	0.031	0.166	−0.007	−0.067
Magnesium (mg)	0.221	0.376*	−0.001	0.171	0.127	0.064	−0.203	−0.054
Potassium (mg)	0.229	0.318*	−0.137	0.202	0.221	0.211	−0.113	0.007
Vitamin K (μg)	0.189	0.307*	−0.047	0.107	0.184	0.111	0.049	0.191
Vitamin C (mg)	0.285*	0.146	−0.050	−0.088	0.250	0.251	−0.013	−0.117
Source of meals								
Home	0.380*	0.075	0.054	0.139	−0.012	−0.013	−0.039	−0.058
Restaurants	−0.155	0.048	−0.181	0.126	−0.018	−0.044	0.129	0.101
Fast foods	−0.293*	−0.046	−0.006	−0.122	0.004	−0.033	0.101	0.130
Grocery carry out	0.187	0.099	−0.090	0.158	−0.007	0.044	0.083	−0.028

*$P < 0.05$ after Bonferroni adjustment (Unpublished data)
[a]Partial correlation coefficients after adjusting for total energy (kcal)

relationships between emotional eating and intake [41]. Nonetheless, the ability to respond to emotional states should be a critical element in the behavioral component of weight modification plans.

A preference for taste of vegetables has been found to be a significant predictor of intake. Using the Eating Stimulus Index [39], the authors determined that vegetable taste preference in postpartum women was positively associated with overall diet quality and fruit and total vegetable intake. When the sample was stratified by weight, the relationship was only seen in the obese women (Table 7.4). Our finding is similar to a study of 425 parent-preschool child pairs by Nanney et al [46]. in which favorable tastes for fruits and vegetables were strongly related to dietary levels of these foods.

Origination of a preference for healthful foods in children may develop from consumption of and exposure to fruits and vegetables as a child. Haire-Joshu et al [47]. examined childhood influences on subsequent fruit and vegetable intake in African American women. Those who reported eating more vegetables as a child had a stronger preference as adults. Although taste experiences in childhood influence intake in later life, it should be emphasized that taste preferences continue to change through the life cycle and acclimatization to new foods can occur after multiple encounters. Thus, the ability to taste is genetic, but preferences appear to be modifiable. Consequently, introduction and tasting of a variety of healthy foods should be a significant component of weight loss interventions.

Self-efficacy is yet another construct that has been associated with a more healthful diet. In 441 men, Hagler et al [48]. determined that those with higher self-efficacy consumed more fiber, fruits, and vegetables than those with lower self-efficacy. In African American women, Watters et al [49]. found that those in the highest tertile of self-efficacy scores consumed more servings of fruits and vegetables than those in the lowest tertile. A follow-up study in the same sample discovered that women with high self-efficacy had lower levels of dietary fat than those with low self-efficacy [50].

Collectively, the above investigations imply that weight loss interventions should include a component to increase self-efficacy. Examples of methods to increase self-efficacy are self-monitoring, stimulus control, and contingency management.

Conclusions

This chapter has discussed various motivations to eat and their influence on weight status and dietary intake. In a culture with an overabundance of food and increasing obesity rates, it becomes clear that body weight has not been regulated successfully. The authors have provided a review of the instruments available to assess motivations to eat. It supports the hypothesis that motivations to eat originate from environmental, biological, and psychological stimuli. For example, environmental factors such as availability of fruits and vegetables, eating in response to sight or smell, and interactions with the social environment are related to BMI and, thus, significant contributors to food intake. Biological influences such as a taste preference for vegetables and sensitivity to the perception of hunger also affect weight status and consumption patterns. Finally, psychological factors such as self-efficacy, eating in response to emotions, and dietary restraint are related to these outcomes in some populations. What motivates one to eat is quite varied. Some overweight people are more susceptible to external eating cues and hunger, while those with healthy weight may have increased eating restraint. Knowledge of the primary motivations to eat, whether from environmental, biological, or psychological origins, may facilitate development of tailored weight loss messages and increase the success of weight loss interventions designed to prevent and treat obesity.

Table 7.4 Regression analysis[a] of overall diet quality and food group intake using Eating Stimulus Index subscale scores in low-income, minority women in early postpartum

Category	Fruit and vegetable availability	Convenience eating resistance	Social acceptance	Morning hunger/ breakfast	Vegetable taste preference	Weight loss self-efficacy	Emotional eating resistance	Dietary restraint
All ($N=115$)								
DGAI[b]	0.278**	0.224*	−0.068	0.076	0.239**	0.000	−0.098	−0.066
Fruit[c]	0.180*	0.266**	0.037	0.159	0.172*	0.057	0.001	0.228**
Vegetables	0.223**	0.131	−0.184*	−0.049	0.175*	0.049	0.035	−0.100
Discretionary energy	−0.075	−0.277***	−0.009	−0.239***	0.015	−0.161*	0.010	−0.071
Overweight ($n=46$)								
DGAI	0.248	0.419**	0.028	0.179	−0.015	0.005	−0.112	0.184
Fruit	0.195	0.405**	−0.034	0.292*	0.144	0.100	−0.118	0.282
Vegetables	0.332**	0.290*	−0.179	0.152	0.107	−0.009	−0.113	−0.103
Discretionary energy	−0.108	−0.449***	−0.101	−0.312**	0.148	−0.066	−0.081	−0.196
Obese ($n=69$)								
DGAI	0.292*	0.064	−0.157	−0.016	0.421***	−0.007	−0.099	−0.235
Fruit	0.214*	0.102	0.028	0.090	0.225*	0.048	0.006	0.161
Vegetables	0.167	0.019	−0.195	−0.169	0.203*	0.073	0.111	−0.114
Discretionary Energy	−0.042	−0.087	0.054	−0.171	−0.066	−0.239*	0.092	0.038

*$P<0.05$ (Unpublished data)
**$P<0.01$ (Unpublished data)
***$P<0.001$ (Unpublished data)
[a]Models were conducted using each component of the ESI as independent variables and the DGAI[b] and food groups as dependent variables while controlling for energy intake. All values represent standardized beta coefficients
[b]Dietary Guidelines Adherence Index was used to assess overall diet quality
[c]All food group servings were computed in servings per day based on the MyPyramid recommendations

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The Role of Food Reinforcement in Food Selection, Energy Intake, and Diet Quality

8

Jennifer L. Temple

Key Points

- The types of foods that people choose to eat and the amounts of those foods consumed are influenced by many factors.
- For humans, non-homeostatic or psychological factors may play a more important role in food selection and energy intake than do homeostatic or biological factors.
- Energy density describes the number of calories per gram of food.
- Foods that are high in energy density are often preferred and more reinforcing, but these foods are typically lower in nutrient density.
- Motivation to get food is another major factor influencing food selection and intake.
- Motivation can be measured empirically in the laboratory.
- Hunger and food restriction can increase motivation to get food, while satiation and monotony can decrease motivation.
- Finding ways to reduce motivation to eat unhealthier food while increasing motivation to eat healthier food may improve diet quality and reduce obesity.

Keywords

Energy density • Food reinforcement • Motivation • Eating behavior • Energy intake • Obesity • Diet quality

Introduction

Eating occurs for many reasons. In some cases, eating is driven by physiological signals, such as low blood sugar or hunger pains. More often than not, eating is driven by other, non-homeostatic factors (reviewed by [1]). For example, school-aged children and many adults who have a fixed

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V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health, DOI 10.1007/978-1-4614-7315-2_8, © Springer Science+Business Media New York 2013

work schedule eat at a specific time of day, regardless of hunger or when and what was eaten previously. Another example of this is consumption of dessert, which typically occurs at the end of a meal, when hunger is diminished. In the current obesogenic environment, the list of non-homeostatic drivers of food intake is long and increasing, while the physiological mechanisms that regulate food intake remain stable and, may be becoming less relevant for humans [2]. This chapter will explore the factors that drive non-homeostatic feeding, why high-fat/high-sugar foods are more liked and more reinforcing, how factors that influence motivation to eat are measured, and how the current empirical research may be used to make positive changes in eating behavior and diet quality.

Energy Density and Food Choice

Have you ever wondered why we tend to like sweet and fat foods more than other foods? Perhaps it is because we have evolved to consume food that contains a large amount of energy in order to assure our survival through times of famine [3]. When we are born, we have an innate preference for sweet and fat foods [4]. In response to this preference (or perhaps as a cause of this preference), human milk has a high concentration of both lactose (48 % of energy) and fat (45 % of energy) [5]. As we are exposed to new foods throughout infancy and childhood, flavors that are predictive of energy content tend to be preferred over those that predict low energy [6]. Similarly, flavors that are predictive of food spoilage (sour) or poison (bitter) tend to be avoided [6]. This is often referred to as flavor-nutrient learning. Studies in both human and animal models consistently show pairing of novel flavors with greater energy results in greater conditioning and increases in liking for those flavors than when the flavor is paired with lower energy content [7]. This occurs even when an orally presented flavor is paired with an intragastric infusion of the nutrient, but not water, further supporting that the pairing of a flavor with energy increases its liking [8].

Although flavor-nutrient learning has been adaptive throughout evolution, in our current environment, this type of learning may contribute to higher energy intake, poor diet quality, and positive energy balance. For example, flavors that predict greater energy are found in foods that are high in fat (ex., potato chips) or high in sugar (ex., sweetened beverages) or high in both fat and sugar (ex., cookies, cakes, and ice cream). These foods are highly liked and widely consumed, which contributes to greater energy intake [9, 10]. This may also lead to poor diet quality if flavors that predict lower energy (ex., broccoli, carrots, or apples) are not preferred. Improving diet quality may, therefore, rely on fighting our innate dietary preferences in two ways: reducing liking of high-energy-density foods and increasing liking of low-energy-density foods. This is one of the major challenges in dietary interventions today.

One factor that influences the types of foods that we choose is energy density [11]. Energy density is defined as the amount of energy per gram of foods. For example, high-fat, high-sugar foods, such as potato chips, baked goods, and French fries, tend to have a high energy density (>4 kcal/g), whereas low fat, low sugar foods, such as fruits and vegetables, tend to have low energy density (<1 kcal/g). Energy density is often negatively associated with nutrient density (low-energy-density foods tend to be high in nutrient density and vice versa), but this is not always the case. For example, yogurt, cheese, and nuts can be high in energy density, but also contain many beneficial nutrients.

Motivation and Behavior

The choice to engage in a specific behavior (such as ingestive behavior) is driven by our motivations. Motivation can be thought of as a drive toward achieving goals. Motivation that comes from within an individual that is driven by enjoyment of the activity or task itself is referred to as intrinsic motivation. Examples of this are playing games, eating, or talking with friends. Extrinsic motivation is driven by factors that exist outside of an individual and may encourage an individual to engage in an activity that is not intrinsically motivating in order to reach a goal. Examples of extrinsic motivators are money, grades, or reduction in the probability of punishment. Intrinsic and extrinsic motivators may relate to one another. For example, if a student wants to get an A in an American Literature course and also finds reading American Literature enjoyable, both extrinsic and intrinsic motivations would support reading behavior. However, if a person in intrinsically motivated to eat donuts and watch television, but extrinsically motivated to lose weight, a decision must be made as to which motivations are going to prevail. These motivations are also tied into other factors, such as impulsivity, emotion, and memory and can represent very complex processes (reviewed in [12]). This chapter will focus on how these motivations relate to eating behavior specifically, but it should be noted that the interaction between intrinsic and extrinsic motivations plays a role in everyday decision making beyond just food selection.

It is important to study motivation as a way to understand factors that regulate food selection and diet quality. All animals have a primary motivation to reproduce and pass on genes to the next generation. However, in order to do that, energy intake must be sufficient not only for survival but for reproduction and assuring that the offspring survive to reproductive age. This requires sufficient energy intake. Thus, survival of the species depends on locating palatable food, being motivated to consume the food, and having a mechanism to store energy from that food to buffer times of food scarcity.

Once populations have stable access to food and are able to move beyond concerns about food scarcity, they can begin to address the topic of diet quality. Diet quality is also influenced by motivation, but instead of a general motivation to consume enough food, diet quality is influenced by trying to get food that is energy dense. For example, humans are, in general, intrinsically motivated to consume highly palatable foods that are typically of low quality [13]. However, for many people, there are extrinsic motivators which compete with the innate drives to reduce motivation to eat these foods. These motivators include desire to lose weight, social pressure, or knowledge of health risks [11]. It is the relationship between these different types of motivators that ultimately drives food selection and diet quality. In the next sections, we will discuss food-related motivation, how it is measured, and how it relates to diet quality and obesity.

Food Reinforcement: One Type of Motivation

A reinforcer is something that increases the probability of a behavior which it follows. For example, a child that is given a chocolate for cleaning his room may be more likely to clean his room than a child given no chocolate. Food reinforcement is the amount of behavior that a given amount or type of food will support. Food is a commonly used reinforcer for behaviors in both humans and animals. If you have ever been to a zoo or an aquarium and watched the trainers getting the animals to perform tricks, you have seen how food is given to shape and reinforce the desired behaviors. The use of food as a reinforcer throughout our life has also helped shape our behavior as well as our choices and preferences for food.

Measuring Food Reinforcement

There are a number of ways to assess food reinforcement. For example, in animals, one common technique used to measure food reinforcement is called lever pressing. In this case, an animal presses on a lever and, after a certain number of lever presses, a food pellet is given [14]. This is a classic technique used across species to examine, not only food reinforcement, but the reinforcing value of a variety of reinforcers, such as drugs and alcohol. In humans, there are different methods that are used as well. On method involves asking people to make a choice between a portion of a specified food and an alternative reinforcer, such as money. For example, a person may be asked "Would you rather have this piece of chocolate or $0.75?" In this

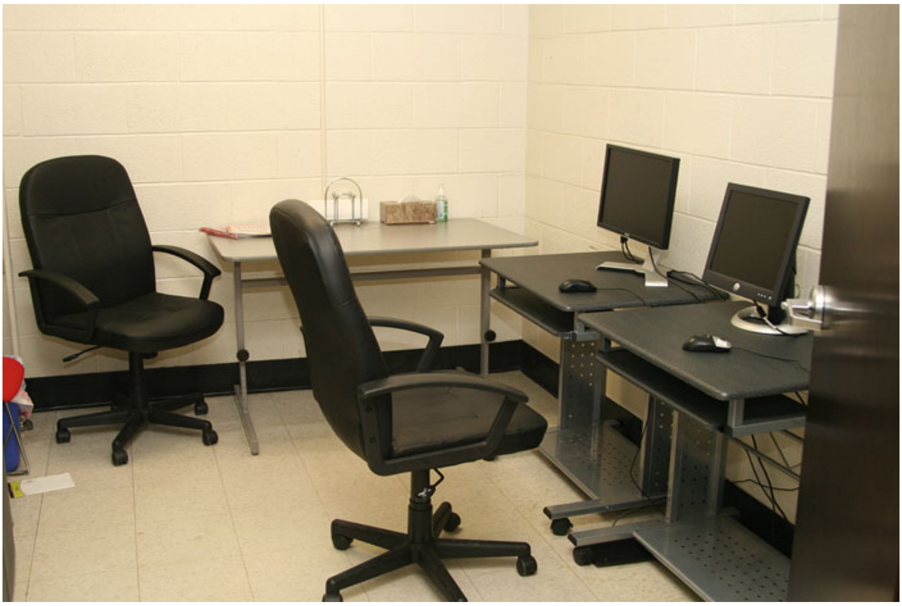

Fig. 8.1 Photograph of the Nutrition and Health Research Laboratory room for testing reinforcing value of food. On the *right* are two computer stations where participants could work for food and non-food alternatives or for two different types of foods. The table at the *top* of the picture is where interviews, questionnaire completion, and eating take place. The chair can easily be moved around the room so the participants can engage in activities as they choose. This figure has not been previously published

case, the monetary value would keep increasing until the person chose the money over the chocolate. The point at which the person switches would be considered the reinforcing value. Another way to measure food reinforcement is to use a more objective testing paradigm. This can be accomplished using a task that has been modified from the animal literature (lever pressing) to be used in humans. Briefly, participants make responses on a computer mouse under conditions where individuals are working only for access to food or conditions where participants work for food or another alternative, or in some situations, two different types of food [15, 16]. Another important component of this task is that after a reinforcer is earned, it becomes harder to earn the next one. These schedules of reinforcement are referred to as progressive ratio schedules that can increase in different increments. For example, a person could be required to push the mouse button 50 times for the first reinforcer, and the number of button presses could increase by 10 button presses each time or could double each time. The reinforcing value of food is assessed by evaluating the number of responses made for food or alternatives on these progressive ratio schedules of reinforcement [15, 16].

The experimental environment includes two computer stations with a swivel chair in the middle (Fig. 8.1). At one station is the computer on which participants can earn food. The other station has a separate computer on which participants may work for a non-food alternative (such as reading magazines) or for a different type of food (ex., low-energy-density foods on one computer and high-energy-density foods on the other). Based on these relationships, we can analyze a number of relationships. First, the total number of responses can be used as an indication of food reinforcement, with more responses indicating a higher reinforcing value of food. Second, the pattern of responding can be assessed by analyzing the number of responses across the different schedules of reinforcement. Third, the relative reinforcing value of high-energy-density food to a low-energy-density food or non-food alternative can be measured by comparing responses for each type of reinforce within individuals within the same session.

Advantages of the Computer-Based Reinforcement Task

One advantage of using the computer-based food reinforcement task is that it is less subjective than other measures that try and assess why people eat the way they do. For example, asking a person to report how much they like a food or how much they want to eat a food lets them know that the experimenter is measuring their feelings about food and may put an individual in a situation where they are self-conscious about their response. Using the computer-based task does not require people to report how much they want food. They are simply asked to make responses on the computer mouse for food, and when they no longer wish to earn more portions of food, they can stop. People often do not know exactly what is being measured, so they may not be as worried about the responses that they are making. This is not to say that there is no subjective influence over responding on this task. People certainly may be self-conscious about the amount of food that they have earned and may choose not to consume the food. However, we do believe that this task is more objective than other commonly used methods for assessing liking and motivation to eat.

Relationship Between Food Reinforcement and Energy Density

The influence of palatability on food reinforcement is well established. In general, high-energy-density foods that are high in sugar and/or fat are both highly liked and extremely reinforcing when compared to low sugar/low fat foods that may provide more nutrient value, but are rated as less palatable (reviewed in [17]). In addition, binge eating occurs for foods that are high in sugar, fat, or both (reviewed in [18]), but is not observed for foods that are low in fat, such as fruit, or low in sugar and fat, such as vegetables. This suggests that consumption of foods that are high in fat and/or sugar results in neural responses and perhaps neural adaptations that reinforce intake of those foods and, in some cases, lead to dysfunctional consumption patterns. Studies that have examined the reinforcing properties of food have been primarily restricted to foods that are high in fat (potato chips) or high in fat and sugar (cookies or candy bars). For example, Epstein and colleagues have used highly palatable snack foods in adults and children to demonstrate that weight status [19–22], dopamine receptor genotype [23, 24], and treatment with dopamine agonists [25] all influence the reinforcing value of highly palatable foods. In addition, our previous studies have demonstrated that daily intake of a high-energy-density snack food for 2 weeks significantly increases its reinforcing value in obese women while decreasing food reinforcement in non-obese women [19, 21]. All of these studies have been restricted to foods that are high in energy density, and our preliminary data suggest that these effects do not generalize to low-energy-density alternatives.

These findings support the work mentioned above demonstrating that flavor-nutrient learning is stronger for flavors that predict higher energy. These foods become liked and then they are preferred and become reinforcing. In addition to innate drives toward high-energy-density food consumption, these preferences are further reinforced behaviorally. For example, food is often used as a reward by parents for desirable behavior ("If you eat your broccoli, you can have dessert" or "If you use the potty, you can have some M&M's"). Behind the explicit use of food as a reinforcer, there are implicit rewards in that high-energy-density foods are often associated with celebrations, such as birthday parties and holidays. This association is reinforced several times per year, where on happy occasions where we are socializing with family and friends, we are also eating high-energy-density foods. Finally, this pattern of explicitly and implicitly using food as a reinforcer also has the opposite effect on healthy food. For example, if broccoli eating is something that constantly needs to be rewarded, then broccoli eating is perceived as less desirable. Similarly, when healthy eating is restricted to times that are less celebratory, healthy eating is not perceived as reinforcing.

Relationship Between Food Reinforcement and Obesity

Obese individuals find high-energy-density food more reinforcing than non-obese individuals [16]. This has been shown in both adults [19, 21, 23] and in children [22]. Higher food reinforcement for high energy density is positively related to ad libitum energy intake in the laboratory [23, 24] and to self-reported energy intake outside of the laboratory [23, 24, 26]. These data suggest that obese individuals will work harder to get access to high-energy-density foods than will non-obese individuals. As high-energy-density food becomes more reinforcing for obese individuals, low-energy-density foods and non-food alternatives may become less reinforcing. This is problematic for a number of reasons. First, if low-energy-density foods become less reinforcing, then intake of these foods may be reduced in the diet, contributing to poor diet quality. Secondly, non-food alternatives, such as physical activity, may be important competing motivators with eating, but if these become less reinforcing, then individuals may choose to spend more time eating high-energy-density foods and less time engaged in non-eating activities.

These relationships have been demonstrated in cross-sectional studies, but, to date, it is unclear whether chronic overeating of high-energy-density foods increases their reinforcing value or if individuals who are at risk for obesity or who are already obese have higher levels of food reinforcement. Studies on food reinforcement in children have shown that 8–12-year-old children at risk for obesity find food more reinforcing than those who are normal weight [22]. This suggests that this cross-sectional relationship is established early, but still does not demonstrate the direction of the relationship, since the children with higher food reinforcement are already heavier. Other studies in adults have shown that food reinforcement can be modified by manipulating the intake of high-energy-density snack foods. Specifically, consumption of 300 kcal portions of high-energy-density snack foods for 2 weeks decreases food reinforcement in non-obese participants, but increases it in obese participants [19, 21, 27]. These findings lend support to the idea that the chronic intake of high-energy-density snack foods can shift food reinforcement, but because the increase was observed primarily in individuals who are already obese, we are still unable to determine the directionality of the relationship (Fig. 8.2).

The current obesogenic food environment may act as a moderator of the relationship between food reinforcement and obesity. For example, if the amount of work required to obtain, to prepare, and to consume food was equivalent between low-energy-density and high-energy-density foods, then we would have the ability to conduct a fair comparison of the relationship between food reinforcement and diet quality. However, our current food environment is such that obtaining, preparing, and consuming high-energy-density foods is often easier than for low-energy-density foods. Fast-food establishments and quick service restaurants are easy for most individuals in the US population to access [28]. The majority of packaged, easy-to-prepare meals are high energy density and are of lower quality than an equivalent meal prepared from scratch [29]. Meals consisting of low-energy-density foods may require more preparation and may take more time than a quick meal or a drive-through meal at a fast-food restaurant. Therefore, in individuals who find high-energy-density foods more reinforcing and low-energy-density foods less reinforcing, it is difficult to imagine a way to alter their diet quality when the work required to obtain, prepare, and consume low-energy-density foods is greater.

Can Food Reinforcement Be Altered?

Food reinforcement is a relatively stable trait. Foods that we find reinforcing and not reinforcing tend to be the same over time. When we test

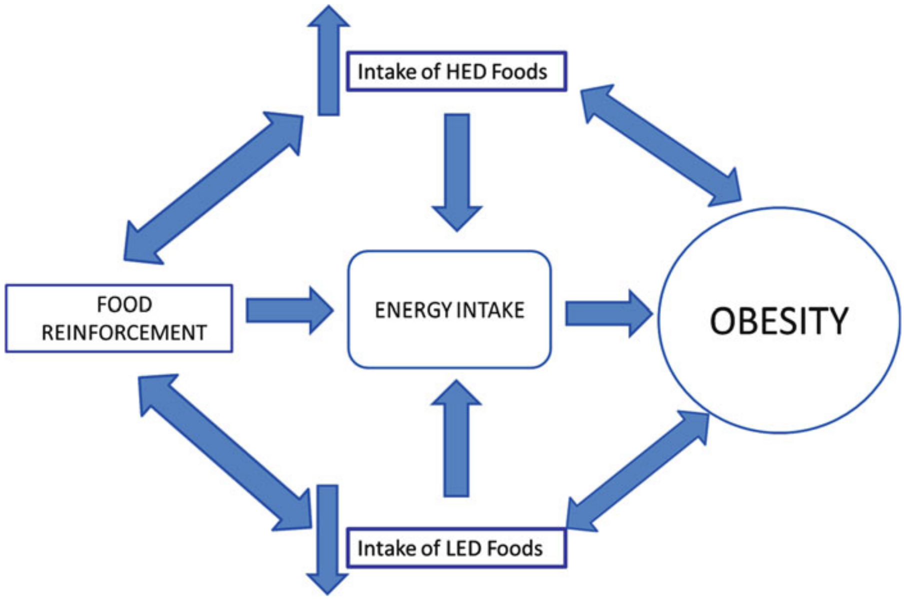

Fig. 8.2 Schematic model of the bidirectional and unidirectional relationships among food reinforcement, intake of high-energy-density (HED) and low-energy-density (LED) foods, energy intake, and obesity. The *bidirectional arrows* indicate that these factors influence each other in a reciprocal manner, and the *unidirectional arrows* indicate that the relationship typically moves in only one direction. This figure has not been previously published

this empirically by measuring food reinforcement at separate time points, we find a strong correlation between tests [30]. These data would suggest that food reinforcement is an established trait that cannot be changed. However, other studies have shown that there are factors that can modify food reinforcement. For example, the reinforcing value of food is higher when individuals are hungry than when they are fed [31]. This suggests that people will consume foods that they might otherwise not be motivated to eat if they are presented when hungry. This strategy is often recommended to parents when introducing new foods to infants, but may also be worth exploring in adults and older children. For example, if you are hungry, eat fruits or vegetables first. This may increase liking of these foods and improve diet quality. Another factor that influences food reinforcement is food variety. People will work harder for different foods than they will for a single, highly liked food [32, 33]. Dietary variety has also been shown to increase energy intake and food liking [32, 34–36]. Individuals who are successful weight losers have diets that are more varied in high-energy-density foods and less varied in high-energy-density groups [37]. Weight loss programs have begun recommending increases in variety of low-energy-density foods as a way to promote lower energy intake and improve diet quality. Finally, recent experience with a food can reduce food reinforcement and food liking [31]. Studies examining sensory-specific satiety have shown that recently eaten food is rated liked less than an uneaten food [35, 38, 39].

One possible strategy for reducing reinforcing value of high energy density is to utilize the principle of monotony. By definition, monotony is when the hedonic properties of a food are reduced after repeated intake over days or weeks. This is an extension of sensory-specific satiety, which is a decrease in hedonic value of an eaten food after a single meal. Although liking is different from reinforcing value, often changes in liking are associated with changes in food reinforcement. Our laboratory sought to determine if monotony could reduce reinforcing value of highly liked snack foods. In order to do this, we first measured baseline food reinforcement. We then provided participants with 14, 300 kcal portions of a highly liked snack food to consume daily. After 2 weeks, participants had food reinforcement measured again. Our hypothesis was that the monotony would reduce food reinforcement. In our first study, in non-obese participants, we found that this treatment did, in fact, significantly reduce food reinforcement [27]. In our next study, we decided to examine two additional questions. First, would obese individuals show the same reductions in food reinforcement? Second, is this effect dependent on portion size? We used the same monotony paradigm described above, except we compared obese and non-obese individuals and examined 0, 100, and 300 kcal portion size conditions. We found that, on average, obese individuals showed an increase in food reinforcement after the 2-week monotony period and that the increase in obese individuals and the decrease in non-obese individuals were dependent on portion size, as it was not observed in the 0 and 100 kcal conditions (Fig. 8.3; [21]). Finally, in a third study, we examined whether we could increase the reinforcing value of healthier food in obese and non-obese individuals using the same paradigm. We found that this effect was specific to high-fat and/or high-sugar snack foods, as it was not observed for fruits and vegetables [19]. When taken together, this series of studies demonstrates that food reinforcement can be altered by recent and prolonged food exposure, but it is in the opposite direction from what would be desired in obese individuals. Future work in our laboratory and others is focusing on understanding the mechanisms that underlie changing food reinforcement in order to improve functional applications.

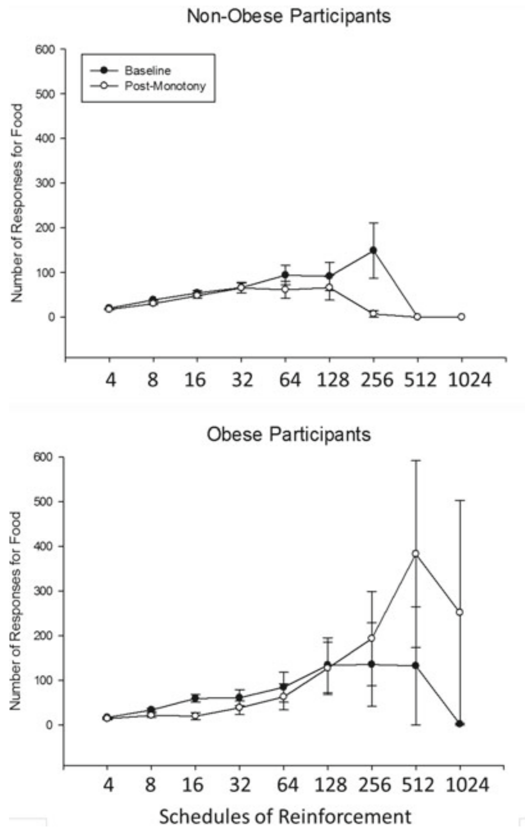

Fig. 8.3 Influence of snack food monotony on food reinforcement. These graphs represent data compiled across three studies in which participants had food reinforcement tested at baseline and again after 2 weeks of consumption of 300 kcal of high-energy-density snack food. Mean ± SEM number of button presses for high-energy-density snack food across different schedules of reinforcement in non-obese (**a**) and obese (**b**) participants at baseline (*black circles*) and after 2 weeks of daily snack food intake (monotony; *white circles*). The non-obese participants decrease food reinforcement after monotony, but the obese participants increase food reinforcement after this same manipulation. This figure has not been previously published

Implications of Food Reinforcement Research

The goal of food reinforcement research is to understand motivation to eat food. Eating is motivated by many factors other than physiological hunger. For example, often people eat because they enjoy the taste of food or because food provides a source of comfort [1, 2]. Food reinforcement research allows for these factors to be taken into account when examining motivational aspects of food intake. In addition, because the food reinforcement paradigm used in our laboratory is objective, the data are less influenced by social and psychological factors that may motivate dishonesty, such as impression management. The food reinforcement task is simple enough to use in both adults and children and has been shown to be highly reliable in repeated testing (reviewed in [16]). The strength of the methodology allows us to design studies to examine methods to reduce or increase food reinforcement, which is relevant for improving diet quality and for reducing obesity.

One implication of the work we have done so far is that food reinforcement is a predictor of food choice [19], energy intake [26, 40], and obesity [20, 22, 23]. In addition, we have demonstrated repeatedly that food reinforcement can be altered by recent, prolonged exposure to food [19, 21, 27]. Our goal moving forward is to build upon our previous findings and determine ways in which the reinforcing value of high-energy-density foods can be reduced and the reinforcing value of low-energy-density foods can be increased. Some potential mechanisms for reduction of high-energy-density food reinforcement include a longer period of monotony, pairing high-energy-density foods with unpleasant foods or consuming high-energy-density foods only when full. None of these experiments have been conducted, so we do not have any idea whether they will work or not. In terms of increasing the reinforcing value of low-energy-density foods, we also have some potential methods, including increasing variety of fruits and vegetables, teaching people novel ways to prepare fruits and vegetables, and consuming fruits and vegetables when hungry. If we could both decrease the reinforcing value of high-energy-density food and increase the reinforcing value of low-energy-density foods, we could vastly improve diet quality and reduce obesity.

Barriers to Manipulating Food Reinforcement

Although food reinforcement can be measured and manipulated in laboratory studies, there are several barriers to achieving this in the real world. In order for the laboratory-based research to be translated into prevention and treatment strategies, these barriers need to be addressed. The first barrier is food availability. In order to shift food reinforcement away from high-energy-density foods and toward low-energy-density foods, people need to have access to a variety of low-energy-density foods and have limitations on access to high-energy-density foods. Right now, in populations with the poorest diet quality and the highest risk of obesity, access to fruits and vegetables is poor and access to highly palatable, high-energy-density foods is both convenient and relatively inexpensive [41]. This limits the ability of researchers, physicians, and public health practitioners to recommend increasing fruit and vegetable intake. A second barrier to shifting food reinforcement is motivation itself. Studies that have examined factors that contribute to food selection have shown that health-related concerns about diet quality are often less important than factors such as food taste and food cost in people of low socioeconomic status [42]. This suggests that in order to shift reinforcing value of food in a direction consistent with improved diet quality, fruits and vegetables would need to be relatively less expensive than high-energy-density foods and they will need to be perceived as tasting good. There have been many proposals to deal with food cost, but they have been met with resistance from the food industry as well as from consumers [43]. Finally, a third barrier to shifting food reinforcement is time. Often people report that they choose high-energy-density foods because they are convenient and require less time to prepare. In many families, both parents work and children are engaged in after-school activities. This leaves less time for food preparation and makes fast food a desirable option, even in families that place a greater value on health. To complicate things further, many people are dealing with multiple barriers at the same time, which makes shifting food reinforcement that much more difficult.

Conclusions

The reinforcing value of food is an important contributor to diet quality. There are many factors that promote increases in the reinforcing value of high-energy-density foods. In order to improve diet quality and reduce weight gain and obesity, we are going to find ways to shift food reinforcement away from high-energy-density foods and toward low-energy-density foods. Laboratory-based studies have begun to develop, test, and refine potential methods for shifting food reinforcement. Once we identify ways to achieve this, the laboratory-based research can be translated to prevention and treatment strategies to improve diet quality and reduce obesity rates.

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9 Breakfast, Ready-to-Eat Cereal, and Diet Quality

Ann M. Albertson and Susan M. Wootten

Key Points

- Contributors to a healthful lifestyle include regular breakfast consumption, consistent physical activity, and a favorable nutrient profile.
- Consistent consumption of RTE cereal is linked to healthier BMI and more consistent body weight management and maintenance.
- Regular cereal consumers experience less snacking behaviors, more consistent energy intake and regulation, and improved macro- and micronutrient profiles, including increased calcium intake.
- RTE cereal consumption is related to less fat and sodium consumption, increased fiber and whole-grain intake, and reduced chronic disease risk factors.

Keywords

Breakfast • Ready-to-eat cereal • Nutrient profile • Nutrient density • Breakfast skipping • Healthful lifestyle • Diet quality • CVD risk factors • Health outcomes

Abbreviations

AS	Added sugar
BMI	Body mass index
CVD	Cardiovascular disease
DGA	US Dietary Guidelines for Americans
EAR	Estimated average requirements
EDI	Eating Disorder Inventory
FDA	US Food and Drug Administration
HDL	High-density lipoprotein
LDL	Low-density lipoprotein
MAR	Mean adequacy ratio
NGHS	US National Growth and Health Study
NHANES	US National Health and Nutrition Examination Survey
NHLBI	US National Heart, Lung, and Blood Institute
NTD	Neural tube defect
RDA	Recommended dietary allowance

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V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health,
DOI 10.1007/978-1-4614-7315-2_9,

RTE	Ready to eat
SES	Socioeconomic status
WHtR	Waist-to-height ratio

Introduction

Regular meal consumption, consistent physical activity habits, and a diet characterized by a favorable nutrient profile all contribute to a healthful lifestyle. An important determinant of a healthful lifestyle is a nutritious breakfast, which influences the composition of subsequent meals, regulates energy intake, boosts physical activity levels, and provides a crucial source of dietary micronutrients. These benefits are observed particularly when breakfast includes fortified ready-to-eat (RTE) cereal [1]. Significantly, consistent RTE cereal consumption has been shown to predict healthier measures of body composition, including body mass index (BMI), in children, adolescents, and adults [2–6]. Entering adulthood at a healthy body weight influences subsequent ability to maintain body weight and has a positive influence on other health factors [7]. This literature review examines a selection of US and international studies of breakfast consumption patterns and highlights the contribution of RTE cereal to diet quality and health outcomes.

The Rise of Breakfast Skipping and Diet Implications

International nutritional data reflect a decrease over several decades in the global consumption and nutritional quality of breakfast, along with an increase worldwide in lifestyle characteristics that include irregular meal intake, decreased physical activity, dieting behaviors, and inconsistent weight management characterized by overweight and obesity. Rampersaud notes numerous studies that document a relationship between dieting and breakfast skipping, particularly in children and adolescents, young females, and those of low socioeconomic status (SES), a trend that runs counter to physiologic needs during rapid growth periods in childhood and adolescence and leads to decreased nutrient consumption. Because breakfast is one element of a healthy lifestyle that may contribute to short- and long-term well-being, Rampersaud advises health practitioners to identify and address barriers to consistent breakfast consumption in children and adolescents, focusing especially on those most likely to skip [8].

Affenito et al. note that the phenomenon of breakfast skipping has become fairly common among US children and adolescents and is reported by up to 6 % of 2- to 10-year-olds and up to 25 % of 11- to 18-year-olds. The study's authors examined breakfast skipping in children and adolescents through an analysis of annual 3-day food diaries collected over a 10-year period as part of the longitudinal National Heart, Lung, and Blood Institute (NHLBI) Growth and Health Study (NGHS). Subjects were non-Hispanic white and African-American girls aged 9–19 years [1].

While young people may view breakfast skipping as a way to manage weight, the NGHS study revealed that dieting behaviors were actually related to overweight and elevated BMI levels. A significant percent of girls reported skipping breakfast; of particular concern was the percent of African-American girls who reported skipping breakfast, which was higher than the comparable population of white girls (see Fig. 9.1).

Breakfast skipping and dieting behaviors are a concern for the public health community. Breakfast provides children with more than 30 % of the body's daily calcium, iron, and B vitamin requirements while constituting less than 20 % of daily caloric intake [9]. US studies show that key nutrients not consumed when breakfast is skipped, including fiber, calcium, and some minerals and essential vitamins, are not recovered during the day's remaining meals [10–13].

In a US longitudinal study of breakfast skipping, weight gain, and weight loss in 9- to 14-year-olds, Berkey et al. found that children who were overweight may lose body fat by skipping breakfast, but normal-weight children do not. Normal-weight children who skipped breakfast also gained weight relative to other normal-weight children who regularly ate breakfast [14].

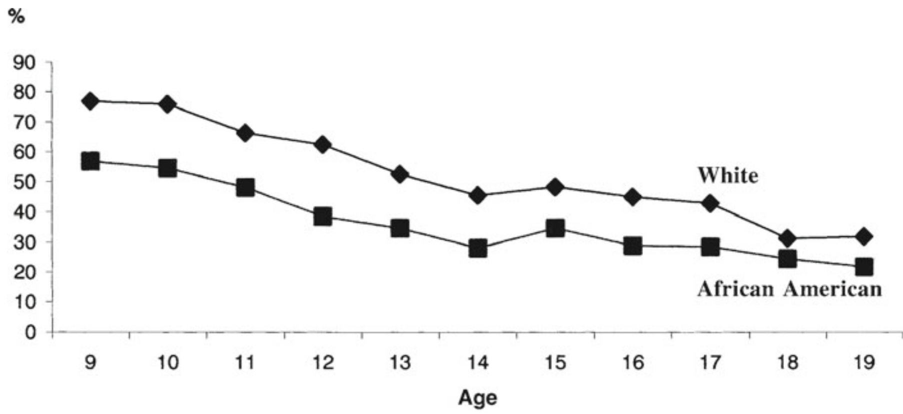

Fig. 9.1 Percent of African-American and white girls reporting breakfast consumption on 3-day food diaries collected at study visits when girls were aged 9 through 19 years in the National Heart, Lung, and Blood Institute Growth and Health Study. (*Note.* From "Breakfast consumption by African-American and white adolescent girls correlates positively with calcium and fiber intake and negatively with body mass index," by Affenito SG, Thompson DR, Barton BA, Franko DL, Daniels SR, Obarzanek E, Schreiber GB, Striegel-Moore RH. 2005, Journal of the American Dietetic Association, 105, p. 941. Copyright 2005 by Elsevier. Reprinted with permission)

International studies conducted in India [15], Canada [16], Belgium [17], the UK [18], and Australia [19] support the conclusion that breakfast skipping leads to poorer diet quality and reduced nutrient intake in child and adolescent populations. The trend continues into young adulthood. A European study of university students found breakfast was skipped by nearly twice as many dieters as non-dieters [20]. Other studies document an association between breakfast patterns and weight-related concerns. Researchers in Fiji found that more frequent breakfast skipping was associated with a greater probability of overweight and obesity in a geographic area undergoing rapid social and economic change [21]. Studies from Iran [22, 23], Germany [24], and Italy [25] documented similar associations between breakfast skipping, overweight, and obesity in children and adolescents.

Regular Breakfast Consumption and Favorable Dietary Outcomes

Breakfast eaters tend to consume less cholesterol, less fat, and more fiber [2, 10, 26, 27].

Developing consistent breakfast consumption habits provides one key to supporting a healthful lifestyle and addressing international concern over the increasing prevalence of overweight, obesity, and poor diet quality. Foods eaten at breakfast are likely influenced by multiple factors, including availability, cost, taste, and nutritional value. Data from the US National Health and Nutrition Examination Survey (NHANES) 2007–2008 reveal that RTE cereal and milk were the most frequently reported breakfast items, followed by sweetened, carbonated soft drinks; toast and bagels; breakfast meats, eggs, and egg products; fruit juice; pastries and muffins; pancakes, waffles, French toast, and cooked cereal [9]. When cost, availability, and nutritional value are sought in one nutrient-dense food item, RTE cereal is a logical, affordable choice and has a fraction of the calories, fat, and cholesterol of other common breakfast items [28].

Breakfast consumption patterns have been a dietary research focus for several decades. Notably, the 20-year Bogalusa (Louisiana) Heart Study, begun in 1973, was among the first to document long-term dietary experiences of US children in a biracial community, beginning in 1973. The study, an epidemiologic investigation into cardiovascular disease (CVD) risk, offers insight into dietary contributions to nutrient intake and potential health risks. Nicklas documents significant changes over time in subjects' meal consumption patterns and dietary content. Total energy intake remained similar across the study period, yet the macronutrient content of subjects' diets shifted considerably. More than 75 % of the children consumed more total fat, saturated fat, and cholesterol than dietary guidelines recommended. Nicklas noted that the longitudinal data show "U.S. children are consuming a diet that promotes the risk of cardiovascular disease…" [29].

The Bogalusa study subjects' breakfast consumption patterns were further examined as they grew from adolescence into young adulthood. Thirty-seven percent of young adults reported skipping breakfast, and a higher percentage of breakfast skippers did not meet the US Recommended Dietary Allowance (RDA) in use at the time of the study when compared to non-breakfast skippers. The study concluded that an important strategy in improving young adults' dietary quality was to emphasize the key role played by breakfast [30].

Regular breakfast eaters of all ages are more likely to consume daily diets characterized by a higher percentage of carbohydrates and a lower percentage of fats than are breakfast skippers or infrequent breakfast eaters. The US Dietary Guidelines Advisory Committee's *Dietary Guidelines for Americans* (*DGA*) *2010* reinforces the connection between breakfast consumption and weight loss, healthy weight maintenance, and improved nutrient intake. For both children and adults, nutrients that are underconsumed in the daily diet include vitamin D, calcium, potassium, and dietary fiber. *DGA 2010* notes that breakfast is a prime opportunity for ensuring the inclusion of these typically underconsumed nutrients [31].

Diet quality was the focus of an Australian study that examined nutrient intake in the breakfast diets of adolescent boys. Grieger and Cobiac noted the estimated prevalence of overweight and obesity in Australian boys between 9 and 16 years of age more than doubled between 1985 and 2011, from 11 % to 25 %. The authors found that RTE cereal eaters had higher levels of total micronutrient consumption and average calcium intake than both non-cereal eaters and breakfast skippers. They also consumed less fat and sodium, and more total sugars, than boys who did not eat breakfast cereal. The authors concluded that RTE cereal combined with fortified milk or other calcium-enriched foods may serve as a significant vehicle for improving boys' dietary quality and enhancing nutrient intake during rapid physiological development [32].

International research supports the finding that a regularly consumed breakfast provides significant benefits to the diet [17, 33–36]. Bellisle et al. note that when breakfast is a consistent part of the daily diet, it makes a substantial contribution to fiber intake and influences healthier food choices throughout the remainder of the day [20]. Cross-sectional studies provide evidence that children and adolescents may be able to maintain a healthier body weight as a result of consistent breakfast consumption. In a study of boys in Finland and Greece, Veltsista et al. found lower levels of overweight and obesity when breakfast was eaten regularly [37]. In a separate study from Greece, Kontogianni et al. concluded that children and adolescents who ate breakfast regularly had healthier BMI levels than breakfast skippers [38]. In Taiwan, Huang et al. observed that the rate of obesity in a study population decreased as the regularity of breakfast consumption increased [39].

In a second study of associations between breakfast consumption and BMI measures from the NHLBI Growth and Health Study (NGHS), Albertson et al. examined longitudinal data focused on breakfast history, BMI, and physical activity levels of 9- to 19-year-old girls, which were recorded at annual study intervals. BMI z-scores were calculated based on the data record. Two subscales of the Eating Disorder Inventory (EDI) were used to identify tendencies toward dieting behaviors. The study adjusted for variables of race, SES, physical activity, and total energy intake.

Among girls with high BMI measures at baseline who subsequently ate breakfast on more days than their peers, BMI measures were lower at year 10 compared to girls who ate breakfast on fewer days. Breakfast consumption patterns were initially associated with physical activity and body weight, and frequent breakfast consumption initially predicted lower BMI. It was also associated with higher energy consumption and higher activity level. However, after controlling for SES, total energy, and physical activity, the independent effect of breakfast was no longer significant except for the very heaviest girls. This indicates that *what* is consumed at breakfast is very important, since it may not be a simple breakfast effect, and also points to implications for nutrition education initiatives focused on consistent breakfast consumption, increased physical activity, and prudent food choices at breakfast [40].

Ready-to-Eat Cereal, Nutrient Density, and Health Outcomes

A growing body of breakfast research demonstrates that regular RTE cereal consumption is associated with more consistent body weight regulation, lower waist-to-height ratio (WHtR), healthier BMI measures, smaller waist circumference, lower body fat as a percentage of weight, reduced chronic disease risk factors, and improved blood lipid profiles (lower blood cholesterol and low-density lipoproteins). Among breakfast eaters, cereal consumers exhibit the highest mean adequacy ratio (MAR) for micronutrients [13].

RTE Cereal and Nutrient Profile

Fortified RTE cereal is not only an important source of micronutrients and dietary fiber but also contains less fat, sodium, sugar, and cholesterol in comparison to non-cereal breakfasts. When combined with low-fat milk, one serving of RTE cereal provides over 30 % of the recommended daily intake of iron, calcium, and B vitamins for children; represents a nutrient-packed breakfast meal with only 4 %, on average, of the day's caloric intake; and may provide protection from cardiovascular health risk factors driven by high fat and cholesterol content [9].

Albertson et al. found positive health outcomes related to cereal consumption in a study of young children aged 4–12 who reported eating RTE cereal at breakfast. Consistent cereal eaters (those who reported eating eight or more servings in a 14-day period) exhibited the healthiest BMI, were least likely to be overweight, and had more favorable nutrient intake profiles in comparison to children who did not eat cereal or consumed cereal inconsistently. These associations may be due in part to the nutritional composition of fortified RTE cereal paired with fortified milk [3] (see Tables 9.1, 9.2, 9.3, and 9.4.).

Studies demonstrate that fortified RTE cereal is a determinant of favorable dietary quality because very often it includes enriched levels of vitamins A, B1, B2, B6, B12, C, and E, folic acid, iron, magnesium, zinc, potassium, and dietary fiber. *DGA 2010* underscores the importance of choosing a diet that includes whole-grain breakfast cereals and milk fortified with calcium, vitamin D, iron, and folic acid. Vitamin D-fortified milk, some yogurt products, RTE cereals, margarine, orange juice, and soy drinks are commonly available, high-quality sources of dietary vitamin D in the USA. The most nutrient-dense breakfast foods include whole-grain

Table 9.1 Mean body mass index (BMI) by cereal consumption tertiles ($N = 603$)

Age group (years)	Cereal consumption in a 14-day period								
	≤3 Servings BMI		4–7 Servings BMI		≥8 Servings BMI		Total BMI		
	Mean ± SD	*n*	Mean ± SD	*n*	Mean ± SD	*n*	Mean ± SD	*n*	*P*
4–6	18.2 ± 5.0^{x}	59	16.8 ± 3.6^{xy}	72	15.9 ± 2.8^{y}	90	16.8 ± 3.8	221	0.0019
7–9	18.7 ± 5.9^{x}	56	17.6 ± 3.6^{xy}	60	16.1 ± 2.7^{y}	74	17.3 ± 4.3	190	0.0027
10–12	21.0 ± 4.3^{x}	58	19.4 ± 4.8^{xy}	59	18.1 ± 3.5^{y}	75	19.4 ± 4.4	192	0.0004
4–12	19.3 ± 5.2^{x}	173	17.9 ± 4.2^{y}	191	16.7 ± 3.1^{z}	239	17.8 ± 4.3	603	<0.0001

Means within the same row with the same superscript letter are not significantly different ($P < 0.01$)
SD standard deviation
Note. From "Ready-to-eat cereal consumption: Its relationship with BMI and nutrient intake of children aged 4 to 12 years," by Albertson AM, Anderson GH, Crockett SJ, Goebel MT. 2003, Journal of the American Dietetic Association, 103, p. 1616. Copyright 2003 by Elsevier. Reprinted with permission

Table 9.2 Proportion of children aged 4–12 years at risk for overweight[a] by cereal consumption tertiles ($N=603$)

	Cereal consumption in a 14-day period								
	≤3 Servings BMI		4–7 Servings BMI		≥8 Servings BMI		Total		
Age group (years)	% at risk for overweight	*n*	% at risk for overweight	*n*	% at risk for overweight	*n*	% at risk for overweight	*n*	*P*
4–6	47.5^{x}	59	34.7^{xy}	72	25.6^{y}	90	34.4	221	0.02
7–9	50.0^{x}	56	38.3^{xy}	60	16.2^{y}	74	33.2	190	<0.001
10–12	44.8^{x}	58	37.3^{xy}	59	21.3^{y}	75	33.3	192	0.011
4–12	47.4^{x}	173	36.7^{y}	191	21.3^{z}	239	33.7	603	<0.001

Proportions within the same row with the same superscript letter are not statistically significantly different ($P<0.05$).
[a]Based on 2000 Centers for Disease Control and Prevention definitions (17)
Note. From "Ready-to-eat cereal consumption: Its relationship with BMI and nutrient intake of children aged 4 to 12 years," by Albertson AM, Anderson GH, Crockett SJ, Goebel MT. 2003, Journal of the American Dietetic Association, 103, p. 1616. Copyright 2003 by Elsevier. Reprinted with permission

Table 9.3 Mean daily nutrient intake or children aged 4–12 years by cereal consumption tertiles ($N=603$)

	Cereal consumption			
Nutrient	≤3 Servings ($n=173$)	4–7 Servings ($n=191$)	≥8 Servings ($n=239$)	*P*
Mean ± standard deviation				
Energy (kcal)	1,726 ± 454	1,693 ± 437	1,681 ± 414	0.57
Carbohydrate (g)	219.4 ± 59.1	218.5 ± 60.8	227.4 ± 61.1	0.24
Total sugar (g)	108.5 ± 37.0	105.6 ± 38.3	113.0 ± 38.9	0.13
Fat (g)	$68.7^{x} \pm 20.9$	$65.9^{xy} \pm 20.0$	$61.7^{y} \pm 17.1$	<0.001
Saturated fat (g)	24.0 ± 7.4	23.4 ± 7.7	22.5 ± 7.1	0.11
Protein (g)	62.2 ± 17.7	61.2 ± 15.7	69.9 ± 14.1	0.33
Cholesterol (mg)	$216^{x} \pm 105$	197 ± 78^{x}	$170^{y} \pm 61$	<0.001
Sodium (g)	2,966 ± 818	2,929 ± 745	2,854 ± 720	0.31
Dietary fiber (g)	11.2 ± 3.5	11.2 ± 3.8	11.6 ± 3.5	0.35
Vitamin A (μg rae)	$559.5^{x} \pm 238.3$	$631.7^{y} \pm 211.1$	$738.3^{z} \pm 208.0$	<0.001
Vitamin E (mg α-tocopherol)	7.4 ± 2.5	7.0 ± 2.2	7.0 ± 2.5	0.21
Vitamin C (mg)	83.9 ± 44.2	81.3 ± 39.7	93.5 ± 47.4	0.011
Thiamin (mg)	$1.4^{x} \pm 0.4$	$1.5^{y} \pm 0.4$	$1.7^{z} \pm 0.4$	<0.001
Riboflavin (mg)	$1.6^{x} \pm 0.5$	$1.8^{y} \pm 0.5$	$2.0^{z} \pm 0.5$	<0.001
Niacin (mg)	$16.7^{x} \pm 4.6$	$18.1^{y} \pm 4.2$	$19.6^{z} \pm 4.0$	<0.001
Vitamin B-6 (mg)	$1.3^{x} \pm 0.4$	$1.5^{y} \pm 0.3$	$1.7^{z} \pm 0.4$	<0.001
Folate (μg)	$188.9^{x} \pm 68.2$	212.3y ± 59.1	$265.5^{z} \pm 68.4$	<0.001
Calcium (mg)	$784.4^{x} \pm 314.4$	$806.6^{xy} \pm 275.4$	$877.3^{y} \pm 296.4$	<0.001
Magnesium (mg)	200.9 ± 57.3	200.9 ± 53.8	213.9 ± 53.5	0.021
Iron (mg)	$10.6^{x} \pm 2.9$	$12.1^{y} \pm 2.9$	$13.9^{z} \pm 3.4$	<0.001
Zinc (mg)	$8.2^{x} \pm 2.4$	$8.9^{y} \pm 2.3$	$10.3^{z} \pm 2.5$	<0.001

Means within the same row with the same superscript letter are not significantly different ($P<0.01$)
Note. From "Ready-to-eat cereal consumption: Its relationship with BMI and nutrient intake of children aged 4 to 12 years," by Albertson AM, Anderson GH, Crockett SJ, Goebel MT. 2003, Journal of the American Dietetic Association, 103, p. 1617. Copyright 2003 by Elsevier. Reprinted with permission

Table 9.4 Percent of children aged 4–12 years not meeting their estimated average requirement (EAR) by cereal consumption tertiles ($N=603$)

Nutrient	Cereal consumption in a 14-day period ≤3 Servings ($n=173$)	4–7 Servings ($n=191$)	≥8 Servings ($n=239$)	Total ($n=603$)	*P*
Vitamin A (μg rae)	14.4^{x}	3.7^{y}	0.4^{y}	5.5	<0.0001
Vitamin E (mg α-tocopherol)	54.9	58.6	57.7	57.2	0.77
Vitamin C (mg)	7.5	4.2	2.1	4.3	0.03
Thiamin (mg)	1.2	0	0	0.3	NA
Riboflavin (mg)	0.6	0	0	0.2	NA
Niacin (mg)	1.7	0	0	0.5	NA
Vitamin B-6 (mg)	2.9	0	0	0.8	NA
Folate (μg)	59.0^{x}	42.4^{y}	8.8^{z}	33.8	<0.001
Magnesium (mg)	19.1	14.1	9.2	13.6	0.02
Iron (mg)	0.6	0	0	0.2	NA
Zinc (mg)	9.8^{x}	2.1^{B}	0.8^{y}	3.8	<0.001

Means within the same row with the same superscript letter are not significantly different ($P<0.01$).
Note. From "Ready-to-eat cereal consumption: Its relationship with BMI and nutrient intake of children aged 4 to 12 years," by Albertson AM, Anderson GH, Crockett SJ, Goebel MT. 2003, Journal of the American Dietetic Association, 103, p. 1617. Copyright 2003 by Elsevier. Reprinted with permission

breakfast cereals paired with low-fat milk, even when those foods also include small amounts of added sugars (AS) [31].

Among essential dietary nutrients provided by RTE cereal, folic acid intake has important implications for young women of child-bearing age, as well as for individuals with coronary artery disease. Because of a relationship between low levels of folic acid and congenital neural tube defects (NTD), Pitkin et al. note that cereal-grain foods in the USA began to be fortified with folic acid in 1998 under the direction of the Food and Drug Administration (FDA), which resulted in a significant reduction in NTDs [41]. Fortified RTE cereals remain the leading source of folic acid in the diets of both adults and children, contributing, on average, 18 % and 30 %, respectively, to the daily diet [9].

In an analysis of the prospective cohort data from the NHLBI Growth and Health Study (NGHS), Barton et al. examined an association between reported breakfast patterns, cereal consumption, and BMI *z*-scores of 9- to 18-year-old girls who ate cereal for breakfast. Unlike breakfast consumption patterns, the independent effect of consistent RTE cereal consumption (after controlling for demographics, physical activity, and energy intake) was significantly predictive of BMI *z*-scores and was linked to reduced risk of overweight and better dietary quality (see Fig. 9.2).

Girls who reported infrequent or no cereal consumption were 13 % more likely to be at risk for overweight. Those who reported consistent cereal consumption benefited from improved fiber intake, as well as improved levels of calcium, iron, folic acid, vitamin C, and zinc, and had reduced levels of fats and cholesterol. The analysis concluded that RTE cereal may be a marker for healthier BMI measures and body weight. Barton et al. posited that different "doses" of RTE cereal may affect various ranges of BMI *z*-scores in different ways. Any cereal consumption, whether consistent or not, was associated with differences at the very high end of BMI *z*-score levels. The authors note that this effect merits further study, as the NHLBI Growth and Health Study (NGHS) was not specifically designed to examine the relationship between BMI and cereal consumption [2].

Kosti et al. conducted a cross-sectional study of the effect of breakfast cereal on BMI measures of 2,008 urban, 12- to 17-year-old Greek adolescents from the Vyronas region of metropolitan

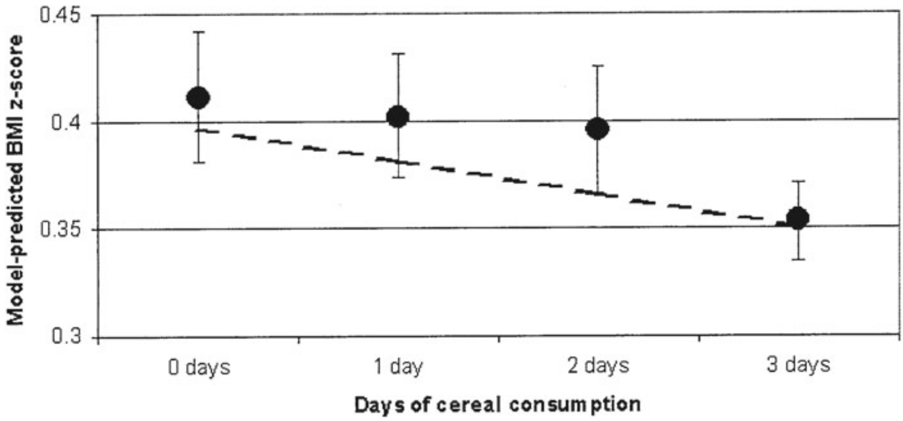

Fig. 9.2 Estimated body mass index (BMI)-for-age *z*-scores for 14-year-old girls who ate breakfast on 2 days, by days of cereal consumption, adjusted for study site, parental education, number of parents, physical activity, and energy intake. The *dots* show estimates for the final model with days of cereal consumption treated as an ordinal variable. The *bars* indicate 95 % confidence intervals for predicted BMI *z*-scores. The *line* shows the linear trend of days of cereal consumption in a model where days of cereal consumption was treated as a continuous variable, but all other aspects of the model were held constant (coefficients for days eating cereal = −0.015, standard error = 0.005, z = 3.41, P < 0.001). (*Note.* From "The relationship of breakfast and cereal consumption to nutrient intake and body mass index: the National Heart, Lung, and Blood Institute Growth and Health Study," by Barton BA, Eldridge AL, Thompson D, Affenito SG, Striegel-Moore RH, Franko DL, Albertson AM, Crockett SJ. 2005, Journal of the American Dietetic Association, 105, p. 1387. Copyright 2005 by Elsevier. Reprinted with permission)

Athens. Twenty-four percent of the boys were overweight or obese, and 15 % of the girls were also overweight or obese. While only 20.7 % of boys and 15.5 % of girls reported cereal as their first breakfast choice, those who consumed cereal had lower BMI measures, regardless of age or physical activity status. More pronounced results were seen in adolescents who consumed cereal daily, as well as in those who had more than two daily servings at breakfast. Cereal consumption was positively associated with a decreased likelihood of overweight or obesity, regardless of age, gender, or physical activity status. Kosti et al. suggest that the results have relevance for adolescent nutrition education [42].

RTE Cereal, Nutrient Intake, and Added Sugars

Morgan et al. studied the breakfast consumption patterns of a cross section of 5- to 12-year-old US children to evaluate their average daily nutrient intake. Results showed that breakfast was a significant contributor to diet quality. Children who ate RTE cereal at breakfast consumed only slightly more total sugar on average than non-RTE cereal eaters at breakfast, and the amount was not significant over the course of an average day [43].

In a study examining the association between the intake of added sugars (AS) in RTE cereal and five measures of weight or adiposity, Nicklas et al. analyzed NHANES 2003–2006 data and found no significant increases in BMI *z*-scores for age or in other weight-related health measures among study participants, who ranged in age from 6 to 18 years [44]. O'Neil et al. separately concluded that both presweetened and non-presweetened RTE cereals were associated with improved nutrient intake in children and found that presweetened RTE cereal was not associated with increased body weight [45].

Albertson et al.'s analysis of NHANES data from 2001 to 2006 of more than 9,660 study participants further examined the relationship between sugar content in RTE cereal and subsequent health outcomes in children and adolescents. RTE cereals were classified in tertiles according to relative amounts of added sugars

Table 9.5 Mean BMI, BMI-for-age, percent overweight or obese, and waist-to-height ratio (95 % confidence interval) by day-1 cereal classification and subclass of cereal consumed (or consumed no cereal)

Day-1 cereal classification (or no cereal)	Subclass	BMI (kg/mg^2)	BMI-for-age	Percent overweight or obese	Waist-to-height
Ate no cereal (n=5,901)		21.62 (21.31–21.94)	0.564 (0.500–0.628)	35.9 (33.3–38.6)	0.489 (0.484–0.493)
Tertile of sugar classification[a]	Tertile 1 cereal (n=578)	20.07 (19.37–20.76)[b]	0.388 (0.211–0.565)[b]	28.7 (23.9–33.5)[b]	0.480 (0.469–0.491)
	Tertile 2 cereal (n=495)	19.97 (19.34–20.60)[b]	0.303 (0.134–0.472)[b]	24.3 (17.6–31.1)[b]	0.472 (0.459–0.484)[b]
	Tertile 3 cereal (n=1,874)	19.98 (19.51–20.44)[b]	0.414 (0.304–0.523)[b]	30.5 (24.9–36.2)[b]	0.476 (0.469–0.484)[b]

Based on day-1 intakes in NHANES 2001–2006 (3 waves combined)
[a]Cereals in tertile 1 have less than 17 g sugar/100 g, cereals in tertile 2 have 17–33 g sugar/100 g, and cereals in tertile 3 have more than 33 g sugar/100 g
[b]Significantly different from "ate no cereal" (the reference category), $P<0.05$, after adjusting for age group, sex, race/ethnicity, household income, average daily intake of energy, calcium and sugar, and HEI-2005 score
Note. From "Weight indicators and nutrient intake in children and adolescents do not vary by sugar content in ready-to-eat cereal: results from National Health and Nutrition Examination Survey 2001–2006," by Albertson AM, Thompson DR, Franko DL, Holschuh NM. 2011, Nutrition Research, 31, p. 232. Copyright 2011 by Elsevier. Reprinted with permission

(AS). Regardless of sugar classification tertile, the authors concluded from study data that children who consumed cereal regularly had significantly healthier mean BMI levels and BMI *z*-scores, healthier waist-to-height ratios (WHtR), and lower rates of overweight or obesity in comparison to children who ate no cereal.

Cereal eaters also consumed less fat and cholesterol and took in more carbohydrates, whole grains, sugars, and necessary micronutrients than children who did not eat cereal. The mean BMI measures for children who ate low, medium, and high levels of added sugar (AS) cereals did not differ significantly from each other, but all BMI measures were significantly lower than the mean BMI values for children who did not eat cereal at all. Therefore, healthier body weight was associated with RTE cereal consumption, regardless of AS content [46] (see Table 9.5).

RTE Cereal Consumption and Measures of Adiposity

When RTE cereal is eaten regularly at breakfast, micro- and macronutrient intake measures, BMI, and other adiposity markers improve in US children and adolescents. In a study of breakfast consumption patterns, including breakfast skipping, Deshmukh-Taskar et al. looked at measures of adiposity and nutrient intake in a large population of children (9–13 years) and adolescents (14–18 years) who participated in 24-h diet recalls as part of the NHANES study from 1999 to 2006. RTE cereal consumers in both groups had lower intakes of total cholesterol and fat, and higher intakes of total carbohydrates, dietary fiber, and micronutrients, than did breakfast skippers and non-RTE cereal breakfast consumers. Breakfast skippers also had higher rates of obesity (BMI ≥ 95th percentile) than RTE cereal consumers and higher waist circumference measures for their age than RTE cereal and non-RTE cereal consumers. For adolescents only, BMI measures were higher in "Other Breakfast"-type consumers than for those who consistently ate RTE cereal [13].

Breakfast consumption studies document that when breakfast consists of RTE cereal, increased feelings of satiety, increased regulation of body weight [6], and decreased risk for CVD may result. Further analysis of the NHLBI Growth and Health Study (NGHS) looked at whether cereal intake made a substantive difference in the health outcomes of the girls as young adults.

RTE Cereal Consumption, Health Risk Reduction, and Physical Activity Level

Cereal consumption frequency was examined in relation to percent of body fat, waist-to-hip ratio, lipid level, and physical activity level of the girls at 18.6 years. Those who ate cereal on 3 out of 3 days at the five study checkpoints had lower levels of total cholesterol ($P<0.05$) and low-density lipoprotein (LDL) cholesterol ($P<0.05$) when compared to girls who consumed cereal infrequently or not at all. They were also more likely to report higher levels of physical activity and spend lower total hours watching television at the final checkpoint of the study as young adults. No significant effect was found on HDL cholesterol measures. Albertson et al. posit that these associations may have been due to nutrient content of the cereal, to a link between cereal and physical activity level, to lower dietary fat consumption, or to an overall lifestyle that supported healthier eating habits and higher total activity levels [7].

Franko et al. subsequently looked at associations between cereal consumption and CVD risk factors such as waist circumference, height, total cholesterol, and LDL and HDL cholesterol in an examination of similar data from the NGHS. Girls who reported higher levels of RTE cereal had significantly lower waist-to-height ratios (WHtR) ($P<0.005$) than girls who ate no cereal on the 3 days of the study intervals. Recent research indicates that WHtR can successfully detect central obesity, a cardiometabolic risk among both normal and overweight/obese children. This suggests that WHtR is a better predictor of health and disease outcomes than BMI, because adiposity measures are more precise than body weight calculations alone in detecting CVD risk factors [47]. The study controlled for variables of demographics, physical activity levels, and total energy intake. The authors conclude that childhood cereal consumption patterns may predict the presence of CVD risk factors later in adolescence [48].

RTE Cereal Consumption, Nutrient Sufficiency, and Energy Intake

Barton et al. found that the number of days eating cereal was associated with better nutrient intake for the entire day. The study objective in examining 3-day food records of girls enrolled in the NGHS was to examine the changing nature of girls' breakfast and cereal consumption patterns and to look for subsequent changes in BMI measures and nutrient intake. Barton et al. found that the number of days eating breakfast was associated with higher fiber and calcium intake. The number of days eating cereal was predictive of lower BMI and was related to increased consumption of fiber, calcium, iron, folic acid, vitamin C, and zinc and decreased fat and cholesterol intake, all important results for growing children and adolescents. Girls who skipped breakfast or ate non-cereal breakfast tended not to make up missed nutrients at other times of the day in subsequent meals and snacks [2].

Albertson et al. followed with another review of data from the NGHS to determine possible explanations for the positive associations between RTE cereal consumption and health outcomes. Significantly, for weight maintenance and nutrient intake, cereal breakfast facilitated milk consumption, which led to increased calcium intake, and took the place of fats, sweets, quick breads, sodas, and meat and eggs as common breakfast food choices. Girls were more than 5 times as likely to consume milk during cereal breakfast than during non-cereal breakfasts, an important finding because milk consumption decreases as children grow older, yet the calcium derived from milk is essential to bone growth in this developing population. Cereal consumption was also associated with increased carbohydrate and fiber intake and decreased fat consumption throughout the day, linking to greater physical activity levels in girls who participated in the study [49].

In summary, a balanced breakfast provides an energy source for healthy physical activity habits and a foundation for regular meal consumption.

Cereal breakfast has been associated with greater physical activity. Adolescents who consume a healthful breakfast report higher levels of near-daily exercise. In addition, increased physical activity assists with increasing levels of high-density lipoproteins in the blood and decreasing blood cholesterol levels, which in turn favorably influence CVD health factors [50].

Conclusions

US and international studies clearly demonstrate the positive contribution of the breakfast meal to critical dietary nutrients, body weight regulation and maintenance, and overall energy distribution, regardless of geographic locale. When RTE cereal is regularly consumed at the breakfast meal, it provides a nutrient-dense addition to the diet, improves diet quality and overall nutrient profile, produces healthier body weight measures including BMI and WHtR and lower percent of body fat, promotes maintenance of healthy body weight, supports higher levels of physical activity, reduces blood lipid profiles, and decreases risk factors for CVD. It is affordable, convenient, and readily available in many markets and can be tailored to various taste profiles. Added sugars (AS) from RTE cereals do not contribute significantly to overall intake of daily total sugar, and fortification of RTE cereal with essential vitamins and minerals plays an important role in eliminating nutrient deficiencies. Regular RTE cereal consumption, then, is an important determinant of positive diet quality and a healthful lifestyle.

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Fast-Food Consumption: Its Association with Food Prices and Dietary Quality

10

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Key Points

- Fast-food consumption is prevalent in developed countries and has been growing rapidly in some developing countries.
- Fast-food consumption is associated with a poor dietary quality and increased obesity risks.
- Some evidence has supported the association between higher fast-food prices and reduced fast-food consumption as well as with improved dietary quality in terms of overall dietary quality and intake of specific food groups (i.e., fruits, vegetables, and dairy products) and nutrients (i.e., total energy, energy density, dietary fiber, saturated fat, and sodium).
- Currently studies on the association between fast-food consumption, fast-food prices, and dietary quality are predominately conducted in the USA and are based on cross-sectional studies.
- More future research is needed based on better study design (e.g., longitudinal studies), data quality (better measures of food prices and dietary consumption), and in populations other than the USA.

Keywords

Fast food • Dietary quality • Fast-food prices • Fast-food consumption • Obesity risks

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Abbreviations

ACCRA	American chamber of commerce researchers association
Add Health Study	National longitudinal study of adolescent health
aMED	Alternative Mediterranean diet score
BMI	Body Mass Index

V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health, DOI 10.1007/978-1-4614-7315-2_10,

CSFII	Continuing survey of food intakes by individuals
DRIs	Dietary reference intakes
ECLS-K	Early childhood longitudinal study kindergarten cohort
FF	Fast food
FF-C	Fast food consumption
FFPI	Fast Food Price Index
FPL	Federal poverty line
FV	Fruit and vegetable
FVPI	Fruits and Vegetables Price Index
HEI	Healthy Eating Index
MDS	Mediterranean diet score
PIR	Poverty income ratio
SES	Socio-economic status
SSB	Sugar-sweetened beverage

Introduction

As the fast-food (FF) industry continues to increase in many countries worldwide, to study the impact of fast-food consumption (FF-C) on dietary intakes and the risks for obesity and other health outcomes is critical. Related efforts are needed to address the public health implications of such scientific findings and the growing FF industry. In recent years, due to concerns on the growing obesity epidemic in the United States and worldwide and research linking FF-C and obesity risk, it is advocated to increase the prices of unhealthy food including FF as a way to fight the epidemic.

Existing studies examining the relationships between FF-C, food prices, and health risks are predominately conducted in the USA. More research is needed in other populations. FF-C is common among US children and adults and is increasing throughout the world. For example, data from 17,370 US adults and children who participated in the 1994–1996 and 1998 Continuing Survey of Food Intakes by Individuals (CSFII) showed that 37 % of the adults and 42 % of the children reported consumed FF based on two non-consecutive 24-h dietary recalls [1]. FF-C was highly prevalent in both genders, all racial/ethnic groups, and all regions of the country [2].

On a typical day with FF-C, FF provides more than one-third of the total calories, total fat and saturated fat for US adults [3].

FF-C has also been growing rapidly in children in developing countries in recent years. Take China as an example, a recent study in Jiangsu, an economically developed province showed that one in ten boys from high socioeconomic status (SES) families consumed hamburgers on a daily basis [4]. Parallel with its popularity in China especially among high SES groups, the FF industry has been growing tremendously. For example, after the first establishment of Kentucky Fried Chicken in China in 1987, it has been expanding at an accelerating speed in the past decade and opened its 3,000th branch in 2010 [5].

Studies conducted in the USA showed that FF consumers had more unhealthy diet as indicated by a lower overall dietary intake quality score; higher intake of energy, fat, saturated fat, sodium and soft drinks; and lower intake of vitamins A and C, milk, fruits, and vegetables than those who did not reported eating FF [1, 6]. In addition, a growing number of studies showed an association between FF-C and obesity in children and adults [7]. A systematic review [7] examined the association between FF-C and weight gain based on findings from 16 studies (six cross sectional, seven prospective cohort, three experimental) and linked FF-C with obesity risks. The author concluded that sufficient evidence existed for public health recommendations to limit FF-C and facilitate healthier menu selection.

In this chapter, we first discussed how FF prices may affect FF-C, next, the association between FF-C and dietary quality, followed by a discussion on the associations between FF prices and dietary quality. The chapter concluded with some recommendations.

Impact of Food Prices on Fast-Food Consumption

Studies have attempted to examine how food prices may affect FF-C, although a limitation of most existing studies is that they are based on cross-sectional data and have limited details on

FF prices, which affect casual inferences. The demand for FF follows the classic economic model in a free market, i.e., the price of the commodity and related commodities are directly associated with the quantity demanded. The demand function for FF can be formulated as follows [8]: $D_{FF} = f(H, P_{FF,} P_{related\ food}, I, M, O)$, where D_{FF} is individual demand for FF; H is the individual or household demographics; P_{FF} is the FF price; $P_{other\ food}$ are other food prices; I is the income; M are the market demographics; and O represents all other factors that can affect the demand for FF, such as individual taste, quality of the FF, and peer influence.

In the model, the price of FF is a primary parameter in the demand function. In the past 60 years, the real prices (i.e., adjusted for inflation) of FF increased from the year 1950 to 1978 in the USA but declined afterwards [9]. The technology advancement in the FF industry contributed to the reduced real FF prices [10]. Except for the monetary cost of FF, the time cost to obtain FF also needs to be considered. In the USA, with the increasing number of FF restaurants and widespread of them since the 1980s, the time cost of FF-C continuously declined [11]. Therefore, both lowered monetary and non-monetary costs have been stimulating FF-C in many countries.

Food consumption is needed on a daily basis for individuals to meet their biological needs. Other foods can be considered as either a substitute or a complement for FF in one's diet. For example, soft drinks can be treated as a complement food for FF since they are available in most FF restaurants and are often consumed with FF. Lower prices of complement foods could lower the overall cost of dining in FF restaurants, which helps to increase FF-C. Lower prices of soft drinks were blamed for the increasing national trend in soft drinks consumption among American children [12]. Most food consumed at home can be seen as substitutes of FF, i.e., if the cost of food consumed at home is lower, people are more likely to eat at home so the demand for FF is reduced. Compared with FF which has an overwhelming content with fat, many foods prepared at home, such as vegetables, have lower energy density. Previous research suggests a negative relationship between energy density and food costs [13, 14]. Therefore, the relative prices of FF compared to other lower energy-dense foods are continuously declining, which contributes to the increasing expenditure share of FF in household disposable income [13].

Except for the strong theoretical foundation, empirical behavioral studies suggest that the relationship between food prices and FF-C varies by consumers' weight status, i.e., obese individuals may be less responsive to the food price changes due to the seductive nature of FF [15] and by gender. In a cafeteria study, Cinciripini designed a system to change the relative prices by rewarding the consumers with cash if they selected low-energy food (i.e., salads) instead of energy-dense foods (i.e., pizza) [16]. The consumption of energy-dense foods was reduced significantly with the cash rewarding system. The impact was significant in women regardless of their body weight status, but was only significant in non-obese men. In a more controlled lab study with obese and non-obese women, Epstein et al. found that the responsiveness to food price change in high-energy-dense foods was significantly different by body mass index (BMI). Non-obese women were likely to substitute high-energy foods with low-energy foods if high-energy foods became relatively more expensive. However, these substitutions were not significant among obese women [17].

Therefore, although classic economic theory predicts the direct relationship between food prices and FF-C, the real responsiveness to price changes may depend on other factors, such as body weight status and sociodemographic characteristics, which remain to be poorly understood [16, 17]. However, we shall note that one study in children obtained opposite results from those of adults—with overweight children having greater price sensitivity than non-overweight children [18]. More empirical work is needed to understand how food prices affect FF-C and how the effect may vary by population groups.

Association Between Fast-Food Consumption and Dietary Intakes

Substantive evidence has linked FF-C to poor dietary quality in terms of unhealthy dietary pattern (i.e., as indicated by diet quality indices), high intakes of energy, fat, sugar, and sodium and low intakes of dietary fiber, milk, fruits, and vegetables. FF-C thus leads to higher risk of obesity in children and adults [7].

Impact of FF-C on Overall Dietary Quality and Total Energy Intake

Frequent FF-C (≥1 per week) was associated with increased risk of poor dietary quality, as characterized by both the Mediterranean Diet Score (MDS) and Healthy Eating Index (HEI) in a Spanish adult population, and inversely related to meeting the dietary reference intakes (DRIs) for energy [19]. Analysis of cross-sectional data—the CSFII 1994–1996—suggested a higher odds (ranging from 1.26 to 2.14) of not meeting the US federal dietary recommendations for saturated fat, total fat, and added sugars among FF eaters as compared to non-eaters, after adjusting for gender, age, socioeconomic, and demographic factors [3].

Various cross-sectional and cohort studies supported a positive link between FF-C and higher energy intake as well as higher energy density in the diet [2, 3, 7, 19–21]. A systematic review of 16 studies also supported such association [7]. On a typical day of FF-C, FF provided more than one-third of total calories for American adults and 47 % of total calories for American children [1, 3]. FF eaters consumed substantially higher levels of energy (both in terms of absolute values and energy density) than non-eaters, and there was a dose–response relationship. For example, calorie consumption increased with more frequent fast-food intake [20]. The results were similar for children. Results from a national household survey in children suggested that FF eaters consumed 187 more kilocalories (95 % CI: 109–265 kcal) than non-eaters [2]. Moreover, findings from within-subject comparisons were consistent with those from between-subject comparisons. For FF eaters, their energy intake and energy density of diet differed between days when consumed FF vs. not. On average, adults consumed 206 more kilocalories and children consumed 126 more kilocalories on days when consumed FF than on days when not [2, 3].

Impact of FF-C on Specific Food Groups and Nutrients

Fruits and Vegetable Intakes: FF-C was inversely associated with fruits and vegetables intakes in both children and adults. FF eaters consumed substantially less fruits/fruit juices and non-starchy vegetables than non-eaters, and this association became stronger with more frequent FF-C [1–3, 21].

Other Nutrients: FF-C had a positive association with intakes of total fat, saturated fat, sodium, carbohydrates, and protein and had a negative association with intakes of dietary fiber and micronutrient density (including carotene, vitamin A, vitamin C, calcium, and magnesium) [1–3, 20, 21]. For example, a cross-sectional study showed that children who ate FF consumed significantly 9 more grams of total fat, 24 more grams of total carbohydrates, and 1.1 less grams of fiber than those who did not [2]. Nutrient intakes also differed between FF and non-FF days for FF eaters [1–3]. For example, American adults consumed an average of 10 more grams of total fat, 23 more grams of carbohydrates, and 15 more grams of added sugars on days when they consumed FF than on days when they did not [3]. Interestingly, the effect of FF-C was more obvious for White girls as compared to Black girls, with a larger increase in % energy from fat with increased FF intake [20].

Other Food Groups: FF eaters consumed far more sugars and sugar-sweetened beverages (SSB) and much less milk than non-eaters [1, 3, 21]. For example, Fig. 10.1 shows the inverse dose–response relationship between FF-C and milk consumption and a positive relationship between FF-C and SSB consumption. The adjusted average amount of fluid milk intake decreased with frequent FF-C, while that of non-diet

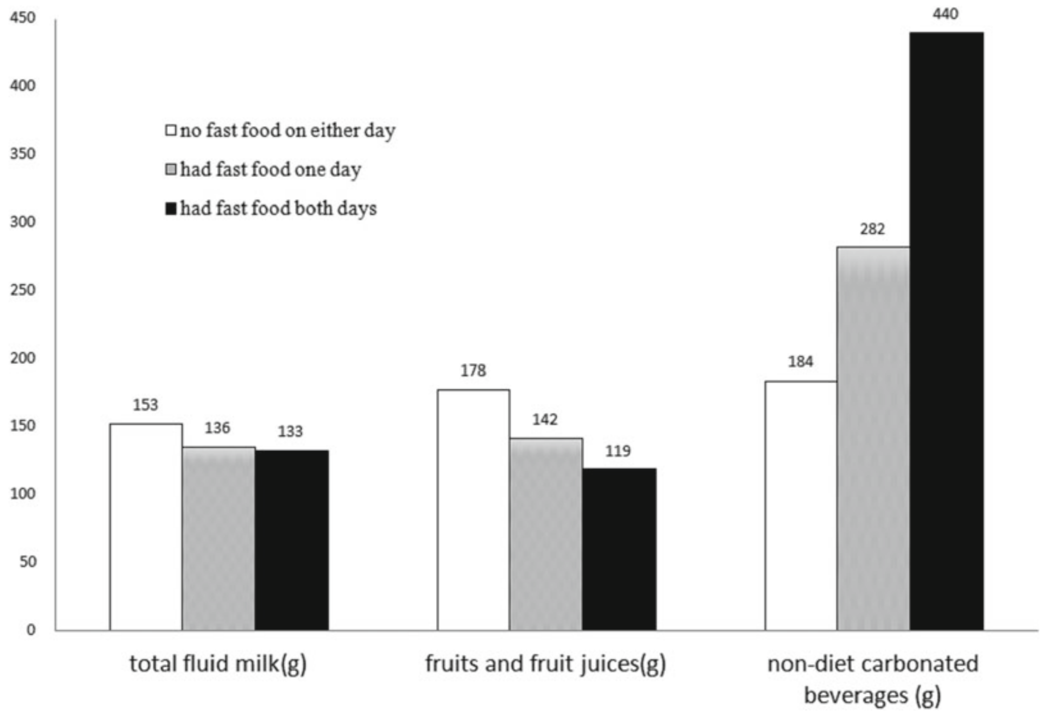


Fig. 10.1 Least squares mean intakes of beverages in US adults (≥20 years), by fast-food intake status, adjusted for age, gender, socioeconomic, and demographic factors: CSFII 199496. Data from Bowman and Vinyard [3]

carbonated beverages increased with more frequent FF-C [3, 21].

In summary, high glycemic index, large portion size, and low dietary fiber that characterize a typical FF meal lead to substantial higher levels of total energy intakes among FF eaters vs. non-eaters as well as on FF-eating days vs. non-eating days. Furthermore, a diet with FF replaces a healthier diet [22–24]. Long-term intakes of unbalanced FF meals would accumulate energy surplus and lead to deficiency in some micronutrients, potentially contributing to the increased risk of obesity and other chronic health conditions.

Association Between Fast-Food Prices and Dietary Intakes

It is speculated that increasing FF prices will reduce FF-C and thus improve dietary intakes. This has drawn more attentions and support in recent years, in particular, in the USA and in some European countries due to concerns on the growing obesity epidemic. Taxation has been advocated to help promote healthy eating. "Fat tax" or taxing on unhealthy FF is recommended to policy makers; however, its actual effect on dietary quality is still under debate [25]. Following we summarized the latest evidence on the relationship between FF prices and dietary quality in terms of overall dietary quality and intakes of energy and selected food groups and nutrients.

Impact of FF Prices on Overall Dietary Quality and Total Energy Intake

In general, FF prices are positively related to overall dietary quality, but the relationships vary by income and measurement of dietary intakes. Due to the collinearity of the prices of numerous FF items, it is necessary to construct consume expenditure-weighted price index to measure the overall

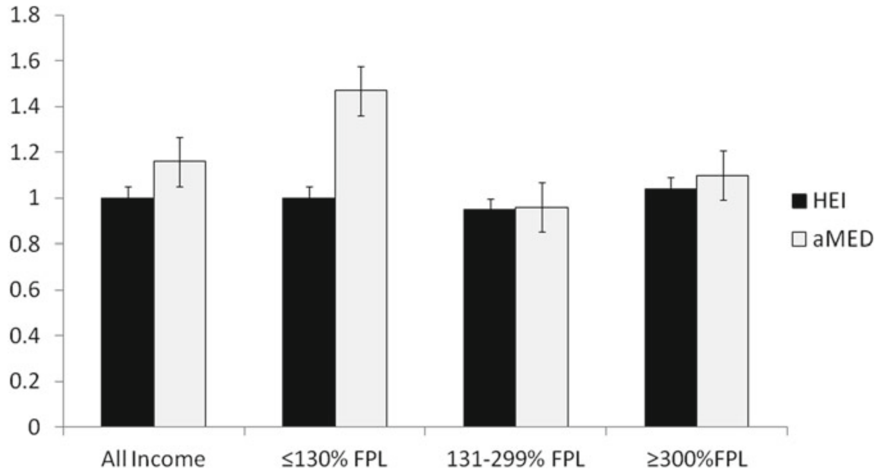


Fig. 10.2 Odds ratio of Fast-Food Price Index on Healthy Eating Index (HEI) and alternative mediterranean diet score (aMED) in American Adults: CSFII 1994–1996. *FPL: federal poverty line. Data from Beydoun et al. [6]

cost of FF in a region. A dataset often used by the researchers is the American Chamber of Commerce Researchers Association (ACCRA) cost of living data, which collects three typical FF items from McDonald's, Pizza Hut/Pizza Inn, or Kentucky Fried Chicken/Church's Fried Chicken.

Using the CSFII 1994–1996 data, we found that a $1 increase in an fast food price index (FFPI) was significantly associated with a 0.49 points (out of 10) increase in American adults' overall dietary quality if measured by the Alternative Mediterranean Diet Score (aMED) although not with the 2005 US Department of Agriculture HEI [6]. As indicated in Fig. 10.2, the impact was more profound among low-income US adults with household income ≤130 % of the federal poverty line (FPL).

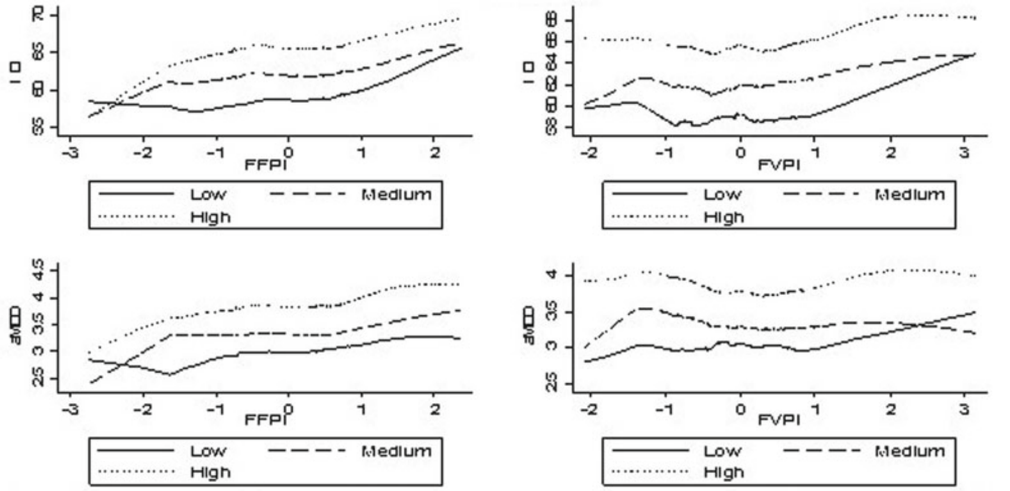
Similar to findings from adults, increase in FFPI is also related to better dietary quality in children and adolescents. Analysis of the CSFII 1994–1998 data indicated that a $1 increase in FFPI was significantly associated with 6.6 and 7.3 points (out of 100) increase in the 2005 HEI among children (2–9 years) and adolescents (10–18 years) [26].

Whether price sensitivity differs by household income remains controversial. Our analysis results based on the CSFII 1994–1996 data linked with food prices data presented in Fig. 10.3 show the association between food price indices and diet quality indices and whether it varied by family income (Poverty Income Ratio (PIR)) in American adults. Diet quality was positively associated with FFPI, but uncorrelated with Fruits and Vegetables Price Index (FVPI), especially for aMED. However, contrary to what was illustrated in Fig. 10.2, the curves in Fig. 10.3 seem to be relatively parallel, indicating no significant differences in price sensitivity by PIR.

In these two studies [6, 26], we did not find a significant association between FF prices and energy intake. However, another 20-year longitudinal study in the USA, the Coronary Artery Risk Development in Young Adults (CARDIA) study, found that a 10 % price increase in pizza led to a 11.5 % reduction in energy from it as well as lower daily energy intake, although the price effect for burgers was insignificant [27].

Impact of FF Prices on Intakes of Selected Food Groups and Nutrients

FF-C: Results of the FF price effect on FF-C seem vary by study design (e.g., longitudinal vs. cross-sectional studies), indicators for FF



Smoothing of the curves was done through locally weighted regression models (LOWESS) with a bandwidth of 0.50. This is a non-parametric analysis that is not adjusted for any other variables. It is expected that FFPI would be directly associated with diet quality while FVPI is inversely associated with these indices. Food prices are expressed as z-scores with "0" being the mean and 1 denoting +1 standard deviation (SD) above the mean and so forth.
Abbreviations: aMED (alternate Mediterranean Diet Score); CSFII (Continuing Survey of Food Intake among Individuals); FFPI (Fast Food Price Index); FVPI (Fruits and Vegetables Price Index); HEI (Healthy Eating Index); PIR (Poverty Income Ratio).
Source: We created the figure based on unpublished results by Beydoun et al.

Fig. 10.3 Association between Food Price Indices (FFPI and FVPI) and Diet Quality Indices (HEI and aMED), stratified by poverty income ratio (PIR): CSFII 1994–1996. Unpublished data from Beydoun et al.

prices, respondents' age, as well as data analysis methods.

Two longitudinal studies tested the impact of FF prices on FF-C in US adults and children, respectively. After adjusting for other economic contextual factors including the zip code-level median household income, FF restaurant density, and prices of food at home, results based on data collected at the fifth and eighth grade in the Early Childhood Longitudinal Study, Kindergarten cohort of 1998–1999 (ECLS-K) reported that the price elasticity for FF was −0.57, which meant a 10 % increase in FF prices being associated with a 5.7 % reduction in weekly FF-C [18]. Table 10.1 shows results from this study that a $1 increase in the price of fast food was associated with a reduction of 0.527 times/week (SE: 0.241) in FF-C. In addition, those being male, White, from lower-income households, frequently watched TV, and were already overweight were more sensitive to changes in FF prices [18]. Another 5-year longitudinal study using data from the National Longitudinal Study of Adolescent Health (the "Add Health Study") without controlling for FF restaurant density found no significant price effect for consumption of burgers [28].

Our two cross-sectional studies based on the CSFII data showed that a $1 increase in FFPI was associated with a significant 0.9 unit (SE: 0.3 count/d) reduction in daily FF-C index (FF-CI) among children (2–9 years), but such negative association was insignificant among adolescents (10–18 years old) or adults [6, 26]. Another cross-sectional study among fifth graders in the ECLS-K cohort found a small and inconsistent own-price effect of FF on FF-C, which might be due to multicollinearity with prices of other food items, such as meat and beverages [29].

Fruit and Vegetable (*FV*) *Consumption*: FF prices have a cross-price effect on FV consumption—higher FF price was positively associated with FV consumption, which is more obvious and consistent in children than in adults. Results from

Table 10.1 Effect of fast-food price ($) on fast-food consumption (times/per week) by sociodemographics, weight status, and TV viewing among US children: ELCS-K grade 5–8[a, b]

	Fast-food price ($)[c]	
	Beta	SE
Full sample	−0.527**	0.241
By gender		
Female	0.070	0.345
Male	−0.190***	0.351
By income		
0–35K	−0.627	0.610
36–75K	−0.407	0.443
75K+	−0.534	0.292
By weight status		
Overweight	−0.787**	0.391
Non-overweight	−0.397	0.332
By race		
White	−0.844***	0.239
African American	0.172	1.389
Hispanic	0.073	0.741
By TV viewing		
≥9 h/wk	−0.595**	0.261
<9 h/wk	1.050	0.617

Source: Data from Khan et al. [18]
$^{**}p<0.05$; $^{***}p<0.01$
[a]ECLS-K, The Early Childhood Longitudinal Study, Kindergarten Class of 1998–1999; longitudinal regression estimates with individual-level random effects; SE was robust and clustered at the home zip code level
[b]Adjusted for price of food at home, zip code-level median household income, availability of fast-food restaurants, mother's education, survey year, urban/suburban/rural residence, days per week eat breakfast and/or lunch with parents
[c]Fast-food price was the weighted average of three common fast-food items reported in the ACCRA Cost of Living Index reports

repeated cross-sectional surveys, the Monitoring the Future Surveys (1997–2003), illustrated a 10 % increase in FF prices associated with a 3.0 % increase in the probability of frequent FV consumption among adolescents [5, 30]. Another cross-sectional survey using the ECLS-K data found that 1 standard deviation increase in FF prices was associated with a 0.13 increase (SE: 0.06 times/week) in the frequency of FV consumption among fifth graders [29]. Cross-sectional data from CSFII also showed a significantly positive relationship among US children, but not in adolescents or adults [6, 26].

Intakes of Other Food Groups and Nutrients: Some evidences suggest that increasing FF prices may improve overall dietary quality and food and nutrient intakes, including reducing FF-C. FF prices have a cross-price effect on dairy products, especially among children and adolescents. CSFII data showed that a $1 increase in FFPI with the mean of $2.80 was associated with higher dairy product consumption (β ± SE: 172.5 ± 36.2 g/d in children and 195.0 ± 63.1 g/d in adolescents) [26] in young people, but the association was not significant among adults [6]. The ECLS-K data showed that one standard deviation increase in FF prices was associated with a 0.24 reduction (SE: 0.08 times/week) in the frequency of meat consumption among fifth graders, although the effect size was small and inconsistent [29]. FF prices were expected to be negatively associated with SSB consumption. Since beverages were usually consumed with FFs, higher FF price limited FF-C and therefore reduced the beverage consumption as well. However, this effect was insignificant in elementary school children [29].

Our two studies reporting analysis of the CSFII data showed that a $1 increase in FF price was associated with significantly higher fiber intake (β ± SE: 2.7 ± 0.7 g/d) and calcium intake (β ± SE: 225.7 ± 52.3 mg/d) in children; higher calcium intake (β ± SE: 309.2 ± 96.8 mg/d) in adolescents; and higher fiber intake (β ± SE: 2.8 ± 1.1 g/d) and lower saturated fat intake (β ± SE: −1.1 ± 0.5 % kcal) in adults [6, 26].

Conclusions

FF-C adversely affects the quality of diet and is linked with increased obesity risks. Higher FF prices are associated with reduced FF-C and improved dietary quality as indicated by the intakes of some food groups such as fruits, vegetables, and dairy products and some nutrients such as fiber, saturated fat, and sodium. However, such findings are predominately based on research conducted in the USA and on cross-sectional studies. More future research is needed based on better study design (e.g., longitudinal studies), data quality (better measures of food prices and dietary consumption), and in populations other than the USA. Efforts are needed to address the health consequences of FF-C in countries where FF-C is common or growing.

Acknowledgements This work is supported in part by research grants from the Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD) and the Office of Behavioral and Social Sciences Research (OBSSR, 1U54 HD070725-01) and the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK, R01DK81335-01A1). Special thanks to Dr. May Beydoun for providing her unpublished results in Fig. 10.3.

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Part III

International Perspectives, Public Health Initiatives

The German Food Pyramid

11

Anne von Ruesten and Helmut Oberritter

Key Points

- The German Nutrition Society (DGE) has the responsibility to issue the official nutrient and food recommendations.
- Therefore, a combination of two graphical representations was established to enable effective dissemination of nutritional knowledge
- First, the Nutrition Circle as a concrete realisation of quantitative food-based dietary guidelines for adults representing the quantity relationships of different food groups in a well-balanced wholesome diet
- Second, the 3D Food Guide Pyramid with four triangle sides to illustrate qualitative recommendations for an adequate food choice within four major food groups: plant foods, animal food, fat and oil, as well as beverages
- These graphical tools may be complemented by other models published in Germany (e.g., food pyramids by the German agency for consumer information [AID] or the food industry [Kelloggs, Nestle]) which are mainly based on the quantitative food recommendations by the DGE.

Keywords

Food pyramid, German, or German Food Pyramid • Three-dimensional Food Guide Pyramid • Nutrition Circle, German, or German Nutrition Circle • German Society of Nutrition • Food-based dietary recommendations, German

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Abbreviations

AID	German agency for consumer information (Allgemeiner Infodienst für Ernährung Landwirtschaft und Verbraucherschutz)
BMELV	Federal Ministry of Food Agriculture and Consumer Protection

V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health,
DOI 10.1007/978-1-4614-7315-2_11, © Springer Science+Business Media New York 2013

	(Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz)
DGE	German Nutrition Society (Deutsche Gesellschaft für Ernährung)
FBDG	Food-based dietary guidelines
n-3	Omega-3
n-6	Omega-6
USDA	US Department of Agriculture

Introduction

Food-based dietary guidelines (FBDG) are used as key instruments in nutritional policy and nutritional education of the public. For that reason, FBDG should:

1. Reflect the national dietary situation
2. Be practicable (foods included in the FBDG should reflect local dietary habits and must be accessible and affordable)
3. Be short and clear to be easily understood and remembered by the general public
4. Be based on scientific evidence [1, 2]

Usually FBDG are communicated by using graphical models in order to facilitate the understanding for the general population. In general, two main pictorial representations of dietary guidelines exist: First, the food circle/plate is used to represent the proportion of specific food groups in total food intake. Second, two-dimensional 'pyramids' (triangles) enable the ranking of foods to illustrate the main messages about a wholesome diet [1]. In Germany, both types of pictorial representation are used: the Nutrition Circle (see section 'Nutrition Circle') and the 3D Food Guide Pyramid (see section 'The 3D Food Guide Pyramid') which represents the officially accepted model issued by the German Nutrition Society. Nowadays, worldwide, approximately 100 different types of food pyramids exist which consider international, national, regional, or target group-specific recommendations (e.g., vegetarians, vegans, athletes) [3]. The pyramidal form of representing FBDG became well known throughout the world after the US Department of Agriculture (USDA) released the 'Food Guide Pyramid' in 1992 with six food groups arranged in four horizontal bars [3]. This pyramid was revised in 2005 (MyPyramid) to consider updates in the dietary guidelines for Americans and to overcome some misperceptions. For example, consumer research revealed that just a few consumers could place the groups into the correct tier of the pyramid graphic. Therefore, in the new graphic symbol, horizontal bars were replaced by vertical ones [4]. Accompanying interactive tools were developed to enable the derivation of individualised dietary recommendations depending on the age, sex, body size and weight, and physical activity of the consumer [5] to facilitate self-assessment and monitoring of nutritional and physical activity status, as well as energy balance [6]. In June 2011, this pyramid was replaced by a circle shape (MyPlate: http://www.choosemyplate.gov/) with four coloured sectors as grossly simplified illustration of the following food groups or nutrients: fruits, vegetables, cereals, and protein. In contrast to MyPyramid, it illustrates quantity relationships of foods and can therefore be considered as an approximation of the German Nutrition Circle.

Besides circles (or plates) and pyramids/triangles, a series of unique other forms that illustrate dietary recommendations exist across countries, e.g. a house in Hungary, stairs in France [1], a pagoda in Korea and China [7], the Canadian rainbow, or a spinning top in Japan [8].

Despite the differences in food groupings (reflecting local dietary habits and food availability) and the shapes of food guide illustrations between countries, the core recommendation is consistent across all of the international food guide illustrations: namely, to consume large amounts of grains, vegetables, and fruits and moderate amounts of meat, milk, and dairy products [7].

Pictorial Representation of Nutritional Knowledge in Germany

The Official Model from the German Nutrition Society

In Germany, a combination of two graphical representations was established by the German

Fig. 11.1 Nutrition Circle from the German Nutrition Society. The Nutrition Circle forms the basis of the three-dimensional food pyramid that has been published by the German Nutrition Society. It translates quantitative recommendations on food intake which are shown in Table 11.1 (DGE-Ernährungskreis®, with permission from German Nutrition Society e.V., Bonn)

Nutrition Society (Deutsche Gesellschaft für Ernährung e.V., DGE).

The Nutrition Circle is a concrete realisation of quantitative FBDG for adults representing the quantity relationships of different food groups in a well-balanced wholesome diet [9]. The Nutrition Circle forms the basis of the 3D Food Guide Pyramid which adds important information on food quality for an adequate food choice [10, 11].

Nutrition Circle

Before pyramids were established as a graphical model in Germany, the circle had been the only form to visualise dietary recommendations for a long time. The basic shape of a nutrition circle was presented for the first time in 1954 by Aldenhoven. In 1956, a modified Nutrition Circle has been published by Spies which is structured in seven segments reflecting seven food groups [12] and, since then, has been continuously improved. The recent Nutrition Circle (see Fig. 11.1) was published in 2004 by the German Nutrition Society (DGE) [9] and is based on the DACH reference values of nutrient intake [13]. *According to the so-called nutritive approach the recommendations for essential nutrients were transferred to food-based dietary recommendations*. Moreover, the 10 Nutritional Guidelines from the DGE [14] as well as the recommendations of the 'five-a-day' campaign [15] to promote consumption of vegetables and fruits are considered for the food-based recommendations of the food circle. The recommendations should also contribute to prevention of diet-related chronic diseases.

The size of each segment represents the relative proportion of seven food groups (cereal products, vegetables, fruits, dairy products, meat/fish/egg, added fat and oil, beverages) in total daily intake. Beverages, however, have a special status because of their physiological importance and the high amount of intake which equates roughly with that of all other food groups taken together. Therefore, beverages are placed in the centre of the Nutrition Circle [16].

Overall, the circle can be considered as a guide to optimal diet rather than a mirror of dietary habits: *therefore*, *it only considers foods with a high nutritional value*. Consequently, food products with a low nutritional value like sweet or fatty snacks as well sugar-sweetened or alcoholic beverages are not included.

To calculate the recommended intake of food groups included into the Nutrition Circle, exemplary daily diet plans using common foods are composed which take age- and sex-specific dietary allowances into account [16]. Calculations were made for four groups: men and women aged 25–51 and ≥65 years, respectively, with a low physical activity level [16] (PAL = 1.4, persons with sedentary work without or with a low level of strenuous leisure-time physical activity, e.g. office workers, precision engineers). The resulting total energy intake ranged from 1,600 (females, ≥65 years, 55 kg body weight) to 2,400 kcal (males, 25–51 years, 74 kg bodyweight) [9]. The goal of these calculations is to cover reference values for all essential nutrients when considering the daily food intake averaged over 7 days [16].

Indeed, *with these exemplary diet plans*, *it is possible to achieve almost all reference values for essential nutrients without use of dietary supplements*. To assure adequate iodine supply, the use of 2 g of iodinated table salt per day is included into the daily plan. An adequate supply of vitamin D intake can be achieved by UVB exposition which catalyses its endogenous synthesis in the skin. Furthermore, women who desire to have children are advised to use folic acid supplements [13, 16].

The food pattern recommended in the Nutrition Circle is characterised by the following relation of macronutrients: 28–31 % of total energy is provided by fat, 52–53 % by carbohydrates, and 16–17 % by protein [16].

Table 11.1 shows the recommended amount of dietary intake of single food groups that refer to intake per day, except meat, fish, and egg, whose recommendations refer to intake per week. The quantities of single food groups are given as a range; thereby, lower values are valid for an energy intake of 1,600 kcal/day, whereas the upper values are adapted to an overall energy intake of 2,400 kcal/day. There are no strict instructions for certain meal compositions, preparation methods, or products. Nevertheless, low-fat and low heat cooking should be preferred.

The Nutrition Circle is valid for healthy adults from the general population and is promoted with the objective to ensure an adequate supply of essential nutrients, fibre, or important secondary plant metabolites as well as maintenance of a healthy weight and to contribute to prevention of diet-related chronic diseases.

To evaluate the achievement of the latter objective, it was investigated among 23,531 participants of the EPIC-Potsdam study whether a high adherence to recommendations of the German Nutrition Circle is actually associated with risk of cardiovascular diseases, type 2 diabetes, and cancer. Therefore, a Healthy Eating Index (HEI) had been calculated to compare actual with recommended intake by scoring the ratio of actual and recommended consumption of relevant food groups. Higher scores indicated better adherence to the recommendations. The so-called HEI-DGE score was inversely related to cardiovascular diseases, type 2 diabetes, and chronic disease risk in men but not in women. No association was observed between the HEI-DGE scores and cancer. Hence, high adherences to German food recommendations probably lower the occurrence of chronic diseases. This associa-

Table 11.1 Food group intake recommended in the Nutrition Circle by the German Nutrition Society (adapted from [9, 25])

Major group	Foods
Plant food	**Cereal products, potatoes** ▪ Bread 200-300 g (4-6 slices) *or* bread 150-250 g (3-5 slices) and 50-60 g cereal flakes ▪ Potatoes 200-250 g (cooked) *or* pasta 200-250 g (cooked) *or* rice 150-180 g (cooked) Prefer whole grain products **Vegetables, salads** ▪ Vegetables: 400 g and more cooked vegetables 300 g + raw vegetables/salad 100 g *or* cooked vegetables 200 g + raw vegetables/salad 200 g **Fruit** ▪ 2-3 servings (250 g) and more
Animal food	**Dairy products** ▪ Milk/yoghurt 200-250 g ▪ Cheese 50-60 g Prefer low-fat products **Meat, sausage, fish and egg** (per week) ▪ Meat and sausage: 300-600 g in total Prefer low-fat products ▪ Fish: sea fish low-fat 80-150 g and sea fish high-fat 70 g ▪ Egg: up to 3 pieces (incl. processed egg)
Fat and oil	▪ Butter, margarine: 15-30 g ▪ Oil (e.g. rapeseed, soy bean, walnut oil): 10-15 g
Beverages	▪ In total at least 1.5 litre, preferable low-energy beverages

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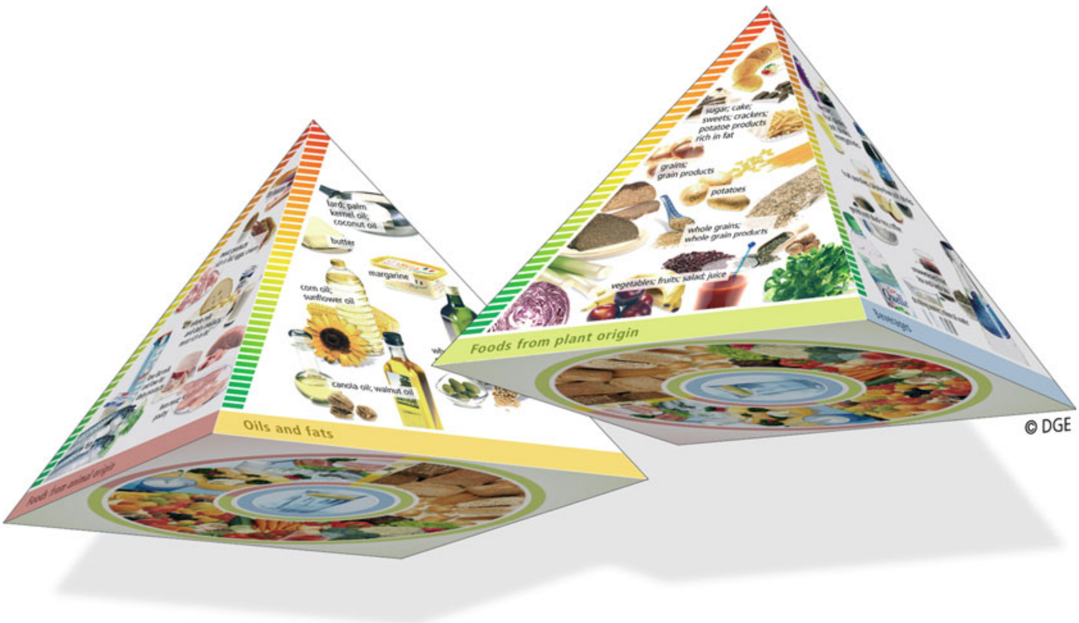

Fig. 11.2 3D Food Pyramid from the German Nutrition Society. Three-dimensional food pyramid (with permission from German Nutrition Society e.V., Bonn)

tion was more pronounced in men than in women in this study [17].

Scientific Basis

The recommendations of the Nutrition Circle are based on recent findings in the field of nutritional science. The advices to consume high amounts of fruits and vegetables [18–20] and especially cereal fibre [20–22], to adequately consume fish [23, 24], and to reduce intake of meat (especially red meat) and processed meat [18, 20, 21, 24] as well as fat intake [20, 24] are confirmed by evidence-based guidelines and systematic reviews. Moreover, a high overall adherence to these recommendations might lower the risk of major chronic non-infectious diseases [17].

The 3D Food Guide Pyramid

The Nutrition Circle that was described in section 'Nutrition Circle' forms the basis of the 3D Food Guide Pyramid (see Fig. 11.2) which had been developed by the German Nutrition Society (DGE), the German agency for consumer information (AID), and the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) [25]. The key innovative feature is the combination of quantitative recommendations (Nutrition Circle in the basis) and information about food quality (visualised in the four pyramid sides) in one model.

Within the four pyramid sides, foods are ranked according to their nutritional value, primarily reflected by the energy and nutrient density. In addition, epidemiological findings of preventive aspects are taken into account ('metabolic approach'). Specific *criteria* for ranking the foods are listed in Table 11.2.

In general, foods with a high nutritional value are placed at the bottom of each pyramid side and are highlighted in green which means that they should be used preferentially. Foods with a medium nutritional value are arranged in the middle of each side and marked in yellow. Finally, foods with a low nutritional value stand at the top of each pyramid side and are highlighted in red to support the interpretation that they should be used sparingly.

Recommendations about quantity are not considered in the sides of the 3D Food Guide Pyramid. Information concerning quantity of

Table 11.2 Criteria for ranking of foods within the sides of the 3D Food Guide Pyramid from the German Nutrition Society (adapted from [11, 16, 25])

Pyramid side	Evaluation criterion
Plant food	Energy density, nutrient density, micronutrients (vitamins, minerals), fibre, phytochemicals and dietary fibre, preventive effects on the prevalence of chronic diseases (e.g., cancer, cardiovascular diseases)
Animal food	Energy density, nutrient density (e.g., calcium, iron, zinc, selenium, and B vitamins), fatty acid composition (saturated fatty acids, n-3 fatty acids), undesirable by-products, preventive aspects from epidemiological studies with respect to chronic degenerative diseases (e.g., cancer, cardiovascular diseases)
Fat and oil	Fatty acid composition (saturated, monounsaturated, and polyunsaturated fatty acids; trans-fatty acids), ratio of n-6:n-3 fatty acids, vitamin E, cholesterol, practical aspects (use of oils/fats in cooking), preventive aspects
Beverages	Energy density (% carbohydrates: medium: <7 % carbohydrates; high: >7 % carbohydrates), vitamins, content of secondary plant metabolites, content of stimulating substances like caffeine, sweeteners

food intake can be inferred only from the Nutrition Circle at the bottom of the 3D Food Pyramid.

In the four sides of the 3D Food Guide Pyramid, foods are summarised to four major groups: 'plant food', 'animal food', 'fat and oil', and 'beverages'.

1. *Plant food*: Vegetables and fruits (including juice) have a high volume and nutrient density but a low energy density and thus may influence satisfaction and regulation of energy intake in a positive way [25]. Hence, they are presented at the basis (see Fig. 11.3). Wholegrain products are still in the green area of foods that should be consumed in high amounts but are arranged above fruit and vegetables because of their higher energy density [25]. Potatoes and white bread or rice are shown above; and sweets as well energy-rich snacks are presented at the top due to their high energy but low nutrient density.
2. *Animal food*. Fish has a marked position at the basis because of its high content of n-3 fatty acids, which does not mean to consume fish in especially high amounts (information concerning quantity can be found in the Nutrition Circle) [25]. Furthermore, lean meat and low-fat dairy products form the basis of this pyramid side and have a higher nutritional quality than high-fat variants of dairy products and meat which are shown in the area above. Eggs, processed meat with a high fat content, and bacon should play a minor role in the daily diet and are therefore placed at the top of the pyramid (Fig. 11.4).
3. *Fat and oil*. Although these foods are consumed in small amounts, they are considered in a separate side of the pyramid due to qualitative recommendation to achieve an optimal fatty acid profile [25]. Plant oils from canola and walnuts have the best fatty acid profile with respect to n3:n6 ratio [25] followed by soy bean, wheat germ, and olive oil (Fig. 11.5). Margarine is shown in the middle, whereas butter, lard, and cooking fat are in the peak because they have the lowest nutritional value.
4. *Beverages*. Beverages are presented on a separate side because they are consumed in high quantities and could provide high amounts of energy in a 'Western diet' and consequently are discussed to be related to obesity [26]. Primarily, beverages should supply our body with water rather than nutrients or energy. For that reason, juices are assigned to 'plant foods' and milk is not presented on this side. Beyond that, alcoholic beverages are not considered due to the risk for abuse [25].

Beverages are ranked according to their energy density and carbohydrate content. Consequently, energy-free beverages like tap/

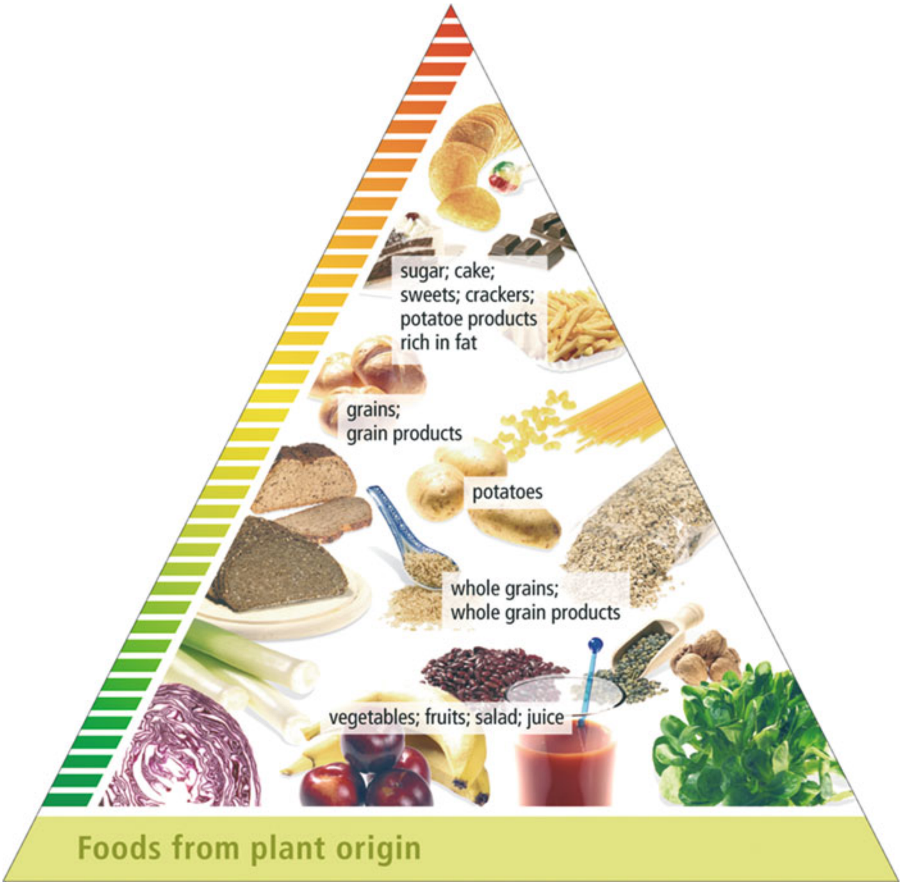

Fig. 11.3 Pyramid side 'plant food'. 'Plant food' is one of the four major food groups represented in the sides of the 3D Food Pyramid from the German Nutrition Society. The foods presented here are ranked based on their nutritional value in which foods with a high nutritional value are presented at the *bottom* and foods with the lowest nutritional quality are placed at the *top*. Specific ranking criteria can be inferred from Table 11.2. The recommendations given here are of qualitative nature; recommendations on the quantity of food intake are not considered (three-dimensional food pyramid, with permission from German Nutrition Society e.V., Bonn)

mineral water or sugar-free fruit and herbal teas are at the bottom, beverages with a carbohydrate concentration of less than 7 % (tea/coffee with added sugar, juices diluted with water, low-energy soft drinks) are in the middle, and beverages with a carbohydrate concentration of more than 7 % (nectar, soft drinks, or energy drinks) are at the top of this pyramid side (Fig. 11.6).

The combination of the circle and the triangle into a 3D model allows transporting more information on food quantity and quality as it is possible compared with 2D graphics.

However, the overall construct is quite complex and not self-explanatory so that some target groups (especially children or young consumers) may not be reached. For the use in nutritional education and advice trained multipliers or dieticians can help to communicate the most important messages.

Other Graphical Models in Germany

Besides the Nutrition Circle and the 3D Food Guide Pyramid also other pictorial representations of nutritional knowledge are used in

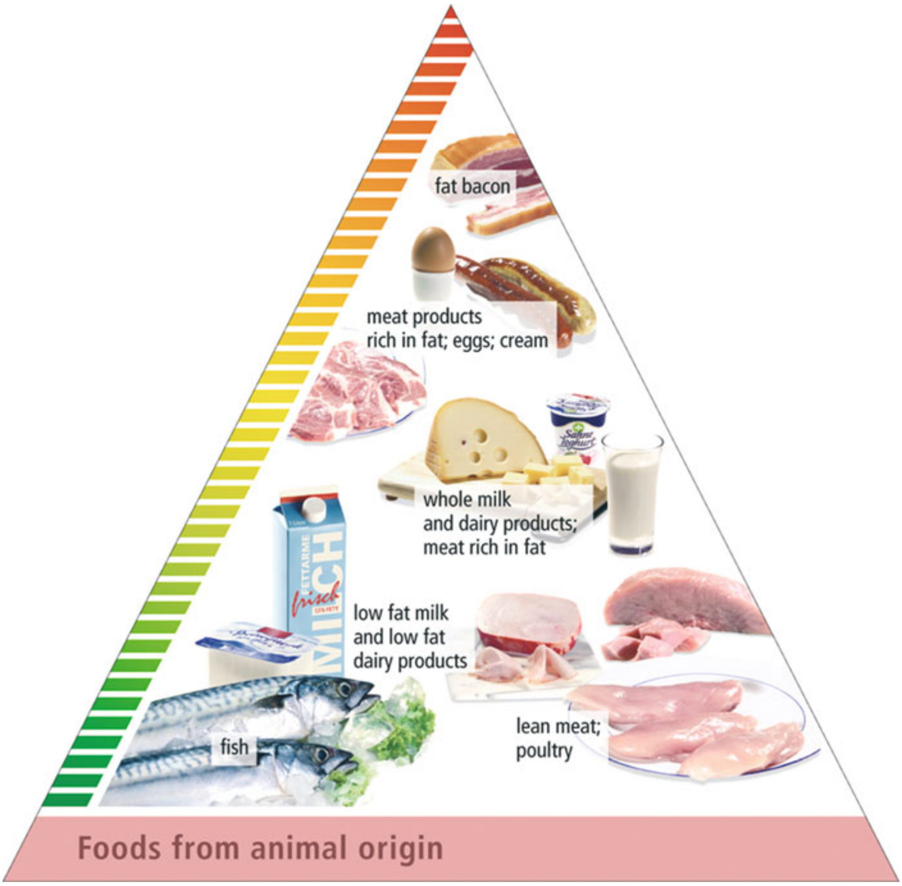

Fig. 11.4 Pyramid side 'animal food'. 'Animal food' is one of the four major food groups represented in the sides of the 3D Food Pyramid from the German Nutrition Society. The foods presented here are ranked based on their nutritional value in which foods with a high nutritional value are presented at the *bottom* and foods with the lowest nutritional quality are placed at the *top*. Specific ranking criteria can be inferred from Table 11.2. The recommendations given here are of qualitative nature; recommendations on the quantity of food intake are not considered (three-dimensional food pyramid, with permission from German Nutrition Society e.V., Bonn)

Germany, best known is the two-dimensional *AID-Food Pyramid* which relies on the recommendations of the German Nutrition Society (DGE) for adults. Thus, the food recommendations of the AID-Food Pyramid are based on the DACH reference values for nutrient intake [13]. Moreover, the AID-Food Pyramid is often used to communicate recommendations on a healthy diet in the nutritional education of children. The quantitative food recommendations for children are based on the optimised mixed diet (OptimiX) released by the Research Institute for Child Nutrition (FKE, Dortmund). Within the AID-Pyramid foods are summarised to eight main groups that are arranged in six different levels. In contrast to the Nutrition Circle of the DGE (see section 'Nutrition Circle'), recommended quantities are given in servings per day, and also foods with a lower nutritional value like sweet and fatty snacks or alcohol are considered to reflect common dietary habits [10]. Analogous with the 3D Food Guide Pyramid of the DGE, foods are evaluated by using traffic light colours. Foods that should be consumed in high amounts are highlighted in green, foods to be consumed moderately are marked in yellow, and foods that should be used sparingly are highlighted in red. Particularly recommended foods are at the bot-

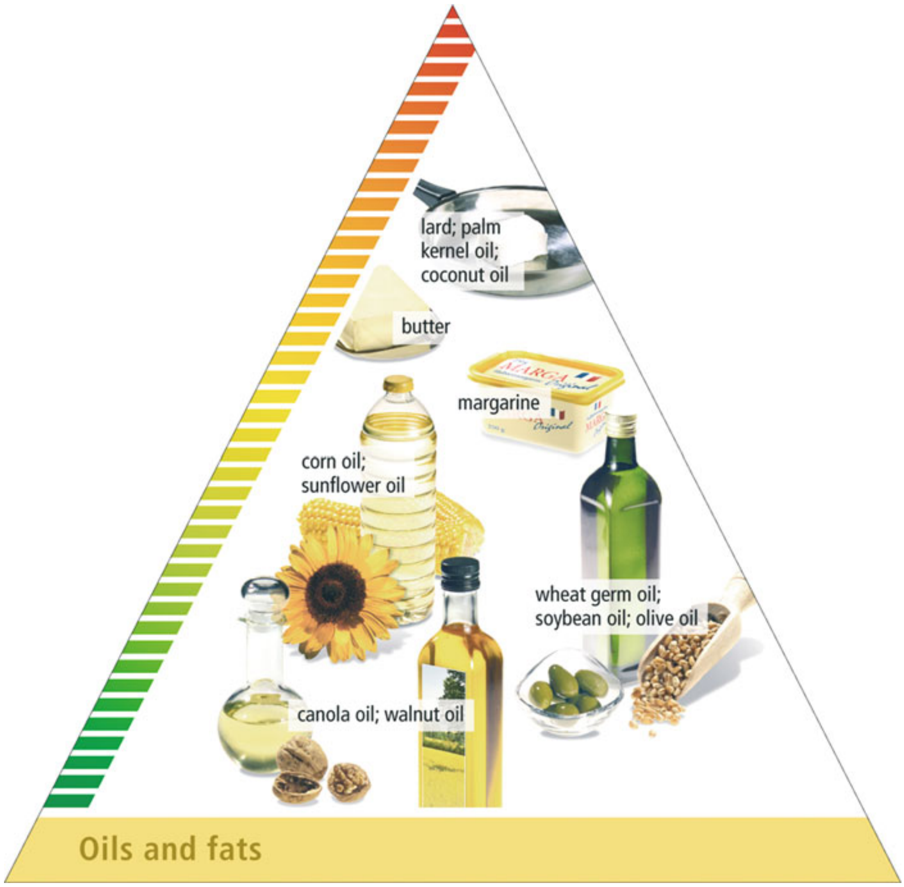

Fig. 11.5 Pyramid side 'fat and oil'. 'Fat and oil' is one of the four major food groups represented in the sides of the 3D Food Pyramid from the German Nutrition Society. The foods presented here are ranked based on their nutritional value in which foods with a high nutritional value are presented at the *bottom* and foods with the lowest nutritional quality are placed at the *top*. Specific ranking criteria can be inferred from Table 11.2. The recommendations given here are of qualitative nature; recommendations on the quantity of food intake are not considered (three-dimensional food pyramid, with permission from German Nutrition Society e.V., Bonn)

tom, whereas less recommendable foods are arranged in the upper levels of the pyramid. Unlike the 3D Food Guide Pyramid, foods are ranked primarily according to recommended quantity; differences in food quality within the eight main food groups are not considered. Hence, beverages and plant foods form the basis, animal food can be found in the middle, and fat or oil as well as sweets, snacks, and alcohol are at the peak. A specific number of daily servings of a defined portion size is allocated to each pyramid level following the 6-5-4-3-2-1 rule that is easy to remember (Fig. 11.7) [27].

An advantage of this didactical model is that it is easy to understand, especially for children. However, this simplification of the DGE model leads to a loss of important information to implement a wholesome diet. For instance, some food groupings are too crude, especially meat, fish and egg, or fat and oils. These foods are combined despite their differing nutritional values. This could be one reason why adherence to recommendations of the AID-Food Pyramid showed no association with risk of chronic diseases (except an inverse association with CVD risk in men) [28] and therewith might be a potentially less effective prevention strategy for chronic diseases. Moreover, the 6-5-4-3-2-1 rule is an inflexible construct as it relies on fixed portion sizes. The consumption

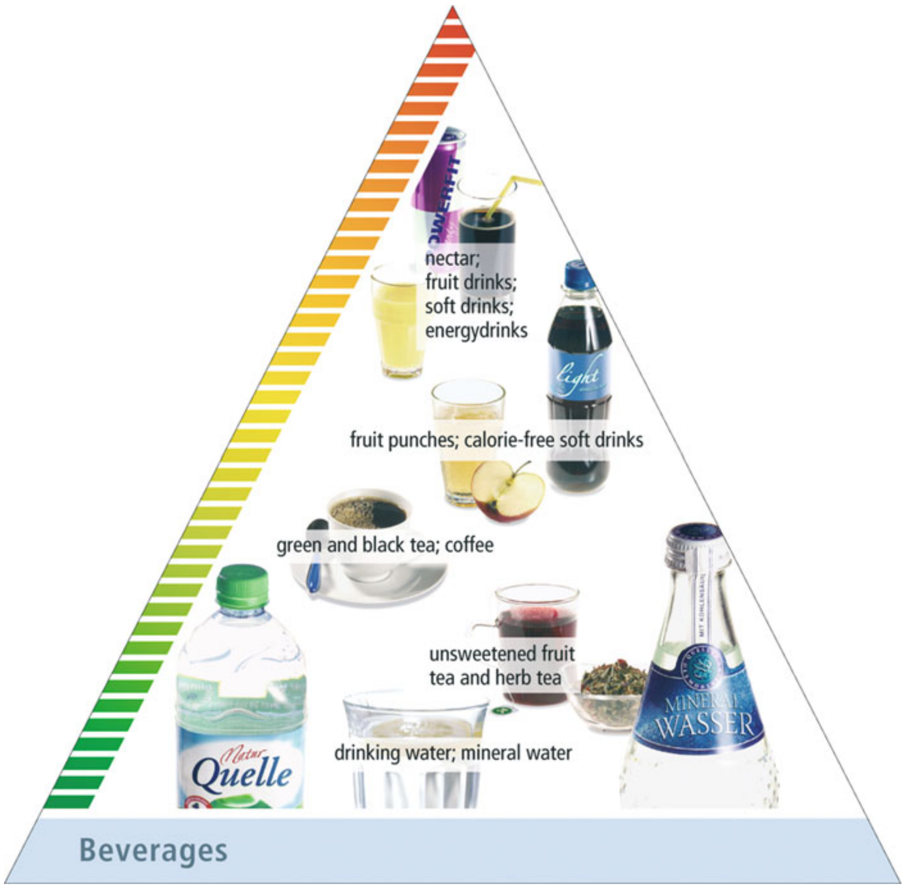

Fig. 11.6 Pyramid side 'beverages'. 'Beverages' is one of the four major food groups represented in the sides of the 3D Food Pyramid from the German Nutrition Society. The foods presented here are ranked based on their nutritional value in which foods with a high nutritional value are presented at the *bottom* and foods with the lowest nutritional quality are placed at the *top*. Specific ranking criteria can be inferred from Table 11.2. The recommendations given here are of qualitative nature; recommendations on the quantity of food intake are not considered (three-dimensional food pyramid, with permission from German Nutrition Society e.V., Bonn)

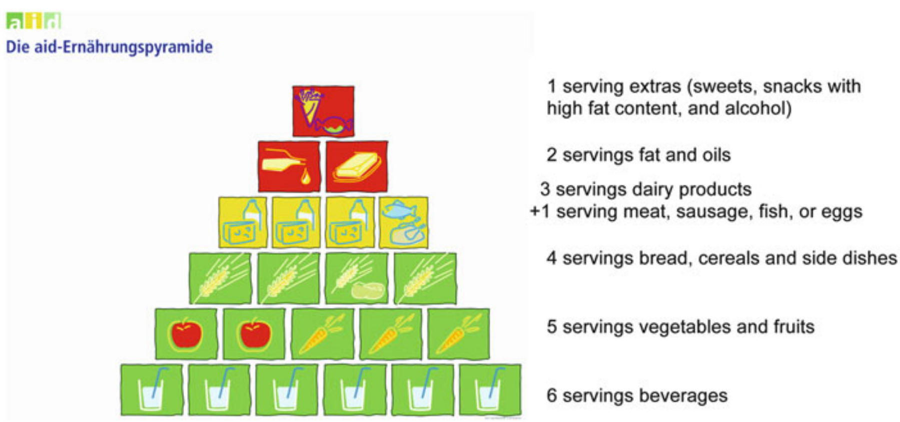

Fig. 11.7 Food pyramid of the AID. The AID-Food pyramid is a complementary graphical representation to the 3D Food Guide Pyramid which is based on the recommendations of the German Nutrition Society. Foods are primarily ranked according to the recommended amount of daily intake; the nutritional quality within food groups is not taken into account. Foods which are advised to be consumed in high amounts are at the *bottom* and highlighted in *green*; foods to be consumed moderately can be found in the *middle* and are marked in *yellow*, whereas foods that should be consumed sparingly are placed at the *top* and are highlighted in *red* (Copyright: aid; idea: S. Mannhardt; AID = Allgemeiner Infodienst für Ernährung, Landwirtschaft und Verbraucherschutz (German agency for consumer information))

of more but smaller servings or less but bigger portions does not seem to be intended.

Examples for further but less widespread pyramids in Germany are given below:

- The three-dimensional Kellogg's pyramid with three sides representing the role of nutrition, physical activity, and relaxation for our health
- The two-dimensional Nestle pyramid
- The food pyramid for vegetarians published by the German Vegetarian Union, registered society (Vegetarierbund Deutschland e.V.)
- Pyramids/triangles used by advisors in the sports and healthcare industry

Conclusions

A wholesome diet should facilitate the maintenance of health and an adequate supply with essential nutrients. To implement these criteria into practice, the 3D Food Guide Pyramid with the Nutrition Circle at its basis is used as the officially accepted model in Germany to transport nutritional knowledge. Recommendations on food quantity can be inferred from the Nutrition Circle, whereas advices concerning food quality are illustrated in the four sides of the 3D Food Guide Pyramid. Adherence to the recommendations of the German Nutrition Society enables adequate supply with nearly all essential nutrients and might lower the risk of chronic diseases.

The three-dimensional model published by the German Nutrition Society is complemented by other graphical illustrations published in Germany (e.g., the AID-Food pyramid, Kellogg's pyramid, or the vegetarian food pyramid) which are often based on the recommendations of the German Nutrition Society.

There is an ongoing discussion about which shape (circle or triangle/pyramid) can more efficiently communicate important messages about a healthy diet. The best solution seems to mainly depend on the target group. Among children and adolescents, many positive effects concerning knowledge and health-related attitudes and intentions are achieved with both forms, but the two-dimensional pyramid (triangle) might be the most effective illustration in this group [29, 30].

In contrast, for adults, the circle is the preferred model [30]. Evaluation studies of the 3D Food Guide Pyramid among target groups like dieticians and other specialised nutritionists or students showed a good rate of acceptance [31, 32].

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12 Diet Quality in the Context of the Nordic Diet

Ulf Risérus

Key Points

- A healthy Nordic diet is a diet accordant with current dietary recommendations.
- The healthy Nordic diet is mainly a plant-based diet, containing small amounts of animal products and processed foods.
- The healthy Nordic diet is high in fatty fish and plant oils, e.g. rapeseed oil, but low in saturated fat.
- The healthy Nordic diet is rich in fibre from whole grains (i.e. rye, oats), fruits, vegetables and legumes.
- The foods are locally produced and therefore an environmentally friendly diet.
- A healthy Nordic diet seems to cause improved cardiometabolic risk profile and weight loss in humans when consumed ad libitum.
- A large cohort study suggests lower mortality risk in subjects with high adherence to a healthy Nordic diet.
- Data on healthy Nordic diet is still very limited, but promising results from clinical and observational studies are emerging.
- For individuals in Northern Europe, a healthy Nordic diet may be a good alternative to the Mediterranean diet.

Keywords

Healthy Nordic diet • Cardiovascular risk factors • Type 2 diabetes • Obesity • Cardiometabolic disease

Introduction

Several different dietary patterns exist in different populations around the world. Dietary patterns are clearly influenced by the cultural surroundings, national traditions, availability of

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V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health, DOI 10.1007/978-1-4614-7315-2_12, © Springer Science+Business Media New York 2013

foods and climate factors. The perhaps most well-described dietary pattern and one of the most established one is the Mediterranean diet. This dietary pattern represents a diet traditionally mainly eaten by populations living in Southern Europe, e.g. Crete. The Mediterranean diet has been extensively investigated in various populations using different types of study designs. The majority of data suggests improved cardiovascular and metabolic health, including reduced risk of coronary heart disease, metabolic syndrome and type 2 diabetes [1]. More recent reports suggest that high adherence to this diet is also associated with decreased risk of cancer and Alzheimer's disease. It has been recently concluded that greater adherence to a Mediterranean diet is associated with significantly better health status and that this diet should be encouraged for primary prevention of the most common chronic diseases [1]. The Mediterranean dietary pattern is characterised by relatively high intakes of vegetables, legumes, fruits, cereals, fish, nuts and olive oil; moderate intakes of dairy products (mainly yoghurt and cheese but very little butter) and wine; and low intakes of red meat and saturated fat.

Since the discovery that the Mediterranean food habits was associated with a lower incidence of chronic diseases, the Mediterranean dietary pattern has been recommended as a healthy diet for many populations in the Western countries including North America and Northern Europe. The Mediterranean dietary pattern has also been a widely promoted diet in the Nordic countries, mostly because of the documented health effects of that diet. However, there are reasons to believe, also as suggested from some studies, that populations living far from the Mediterranean region may not adhere very well to the Mediterranean dietary pattern. Thus, acceptance of the Mediterranean diet may not be easy in other parts of the Western world, including the Nordic countries. This is probably due to difficulties in substantially changing dietary patterns, cultural differences in taste and limited accessibility of various Mediterranean foods. In this region, an appealing alternative to Mediterranean diets are thus a healthy Nordic diet. It should be noted that there are components of the traditional Nordic diet that have been characterised by several unhealthy features including salty dishes including red meats and processed meats, use of butter and high-fat dairy products and low intakes of fruits and vegetables. Thus, negative health impact of several of the food items characterising the modern Nordic "Westernised" diet has been described. The Nordic diet however traditionally also consists of several food items with potentially health-promoting properties. The Nordic climate does not allow very high variation in foods, but plant-derived foods including root vegetables, berries, cabbages, plums, apples, pears, rye, oats, barley and rapeseed oil are readily available, and the Nordic seas, rivers and lakes provide fish that are rich in long-chain n-3 fatty acids. These foods are regarded as traditional Nordic foods with favourable health effects, many that are comparable to the effects shown with Mediterranean food items [2]. For instance, rapeseed oil appears to be one of the most healthy oils with regard to fatty acid profile, e.g. it is more complete than olive oil with higher content of both n-3 and n-6 fatty acids. Indeed, randomised controlled intervention studies have shown that rapeseed oil have at least as favourable effect on blood lipid profile as compared with olive oil [3, 4]. Rapeseed oil may also reduce triglyceride levels as compared with saturated fatty acids from dairy fats, although fish oils have more robust triglyceride-lowering effects [4].

A part from preventing cardiometabolic and obesity-related diseases, it is important that a healthy diet also help maintain nutritional status and improve general health. Health effects should be evaluated based mainly on evidence from randomised controlled trials and prospective cohort studies. In the last few years, there have been a few studies published on healthy Nordic diet as described more in detail below. In these studies, the health effects of a healthy Nordic diet have been investigated, and the food and nutrient composition of such diet has been proposed and evaluated. Table 12.1 summarises the overall healthy Nordic diet including the key food components, as based on the hitherto performed research on the healthy Nordic diet.

Results from Randomised Controlled Studies

The NORDIET Study

The first study to investigate the health effects of a healthy Nordic diet as a whole was the Swedish-controlled study NORDIET [5]. The healthy Nordic diet in this study was based on the existing scientific knowledge within health and nutrition and includes a broad range of foods and nutrients to assure improved nutritional status in subjects following this diet for a long period of time [2]. The selection of foods in the NORDIET study were based on factors including nutritional value, agricultural traditions, seasonal variations as well as habitual use of foods commonly used in the Nordic countries. In addition, all foods used in that study were available at local food stores and supermarkets, and there were no inclusion of any "functional food" in the diet. Foods were based on commonly available specific key nutrients with established favourable effects on individual risk factors, and the included foods in the Nordic diet were inspired by earlier studies and diets [2]. Most of these foods are shown in Table 12.1. For instance, rapeseed oil (also known

Table 12.1 Recommended food composition of a healthy Nordic diet[a]

Nordic foods (consumption pattern[b])	Specifications
Fruits, berries, vegetables, root vegetables (daily)	Includes rose hip, blueberry, lingonberry, apple, pear, prunes, cabbage, cauliflower, Brussels sprouts, broccoli, fennel, spinach, kohlrabi, viper's grass, onion, leek, kale, sugar peas, turnip, carrot, parsnip, beetroot and potatoes (boiled in water)
Fish (frequently)	Herring, cod, Baltic herring, mackerel and salmon
Cereals (daily/frequently)	Wholegrain rye, barley or wheat bread, preferably sourdough with rye. Breakfast porridge made of oat bran, oatmeal or barley flakes or cold cereals of extruded rye, barley and oats, eaten with low-fat milk or yoghurt. Wholegrain pasta was included and pearled barley and oat instead of white rice
Legumes (daily/frequently)	Brown beans, yellow and green peas, kidney beans and lentils
Meat and eggs (sparingly)	Low to moderate amounts of beef, pork, lamb, elk and reindeer. Venison is preferred. Boiled eggs are included as long as the cholesterol intake in the whole diet does not exceed the recommended intake, usually not more than 1 egg per day
Poultry (sparingly/frequently)	Chicken and turkey
Dairy products (frequently)	Moderate amounts of dairy products such as low-fat milk or yoghurt, cheese (preferably low-fat alternatives). Limited use of butter
Nuts and seeds (daily/frequently)	Hazelnuts, sunflower seeds, almonds and other nuts as snacks or with meals or salad
Fats and oils (daily/frequently)	Canola/rapeseed oil and sunflower oil for dressing. Vegetable low-fat spreads (free from *trans*-fatty acids) and vegetable liquid margarines for cooking based on vegetable oils (preferably rapeseed oil)
Spices and herbs (frequently)	Parsley, dill, mustard, horseradish and chive, vinaigrette. Sodium should be used in low to moderate amounts in cooking. Table salt with reduced sodium content may be used
Beverages (daily)	Tap water is the main beverage, but tea and filtered coffee is used on habitual basis. Limited amounts of juice based on apple, berries or vegetables are used
Alcohol	No advice. The subjects' habitual amount of alcoholic beverage

[a]Recommendations are mainly based on Adamsson et al. [2] but also on Refs. [4–7]
[b]*Daily*: food consumed every day, once or several times per day
Frequently: food consumed 2–5 times a week, once or several times a day
Sparingly: food consumed 1–2 times per week or less or in small portions if consumed frequently

as canola oil) rich in oleic, linoleic and α-linolenic acids is the key source of dietary fat used as dressing and in cooking, together with fatty fish. Margarines free of *trans*-fatty acids were recommended in place of butter. Other key natural components of the Nordic diet were low-fat dairy products (milk and yoghurt and cheese for cooking). Wholegrain cereals in general and specific wholegrain cereals based on oat and barley and rye were recommended. Notably, some food items commonly regarded as traditional Nordic foods, such as certain types of meat, butter and hard cheese on the sandwich, were not recommended. Some foods were excluded in this trial because of seasonal availability (e.g. fresh leafy vegetables and berries), logistic and practical reasons (e.g. fresh eggs). Foods known to have adverse effect on a cardiovascular risk factor (e.g. butter on low-density (LDL) cholesterol) were not included in the healthy Nordic diet. As the duration of this study did not span over all seasons, it was not possible to include all types of foods that would have been suitable in a healthy Nordic diet.

Some aspects of cooking was also considered, i.e. low-temperature cooking including baking and boiling were the main preparation methods recommended to ensure optimal effects concerning physical, chemical and nutritional changes in the nutritional value of food products.

The aim of the NORDIET study was to investigate the effects of a healthy Nordic diet on cardiovascular risk factors in men and women with mild hypercholesterolaemia [5]. The study design was randomised controlled with two parallel groups, and study duration was 6 weeks, in which all food was provided to the subjects following the healthy Nordic diet. The results showed that there were significant reductions in several cardiovascular risk factors including LDL cholesterol, systolic blood pressure and fasting insulin concentrations. All these improvements were significant compared with the control group. In Table 12.2, some of the key findings of the study are presented as relative change from baseline. In addition, despite the diet was given ad libitum, the participants lost weight after 6 weeks on the healthy Nordic diet. The results thus indicate that this diet may be useful in the treatment of overweight and/or prevention of obesity. Apart from reducing body fat mass, the improved insulin sensitivity could contribute to reduce the long-term risk of development of type 2 diabetes. The improved insulin action seemed to be mediated by the weight loss induced by the healthy Nordic diet. However, the most clinically relevant results concern cardiovascular risk factors, i.e. reduced LDL cholesterol and blood pressure. The improved cardiovascular risk factor profile could be translated to a reduced risk for coronary heart disease by 15–25 %. Since the diet in this study was to accord with the current dietary Nordic Nutrition Recommendations (NNR), these results also provide proof-of-concept evidence that a mainly plant-based low-fat diet rich in dietary fibres, and low in saturated fat, has a major impact in reducing multiple cardiovascular and metabolic risk factors including reducing adiposity. Long-term studies will however be needed to investigate the cardiovascular long-term effects of this healthy Nordic diet. Indeed, there are promising observational data with hard endpoints indicating that a diet rather similar to the one used in the NORDIET study may also have long-term benefits (see cohort studies below).

Table 12.2 Effects of a healthy Nordic diet on cardiovascular and metabolic risk factors in healthy subjects—the NORDIET study

Risk factor	Absolute and relative reduction from baseline to 6 weeks
Plasma cholesterol	−1.0 (−16 %)
Plasma LDL cholesterol	−0.8 mmol/L (−21 %)
LDL/HDL ratio	−0.42 (−14 %)
ApoB/Apo1 ratio	−0.09 g/L (−1 %)
Systolic blood pressure	−7 mmHg (−5 %)
Plasma insulin	−0.51 mU/L (−9 %)
Body weight	−3 kg (−4 %)

All effects shown for the Nordic diet group ($n=44$) are significantly different from the control group ($n=42$). All values are measured in fasting. Data are adapted from Adamsson et al. J Intern Med 2011 [5].

The Sysdimet Study

In a controlled intervention study conducted in Finland, 131 obese individuals with impaired glucose metabolism and features of the metabolic syndrome were recruited into a 12-week, parallel design, dietary intervention trial [6]. Individuals were randomised to one of three diets: a healthy diet high in the Nordic foods (fatty fish, wholegrains and bilberries), a wholegrain-enriched diet or a control diet.

The primary outcome measure was change in plasma inflammatory markers such as C-reactive protein (CRP) and E-selectin concentrations. Interestingly, there was a reduction in plasma E-selectin only in the healthy diet group, whereas plasma CRP concentrations decreased in the healthy diet and wholegrain-enriched diet groups in participants not using lipid-lowering drugs. A greater increase in plasma concentration of very-long-chain n-3 fatty acids and in the intake of fibre during the study was associated with a greater decrease in plasma E-selectin. The intake of test breads consumed during the healthy diet and wholegrain-enriched diets was inversely associated with the change in CRP levels.

The results from the Sysdimet study suggest that a combination of Nordic foods including fatty fish, bilberries and wholegrain foods may improve endothelial dysfunction and decrease systemic low-grade inflammation in overweight and obese individuals at high risk of developing type 2 diabetes [6].

Cohort Studies: HELGA Project

Although providing less strength of evidence than randomised controlled studies, prospective cohort studies can provide important information on the long-term effects of a healthy Nordic dietary pattern. The Nordic Excellence Programme on Food, Nutrition and Health was created in 2007, supported by the research council NordForsk. The HELGA project was one part of the network that aimed to investigate the associations between healthy Nordic diet and disease outcomes, e.g. cancer mortality. Recently a Danish large cohort study was conducted within that project to investigate the associations between adherence to a healthy Nordic diet index and mortality risk [7]. This study thus aimed to develop a food index based on traditional Nordic food items with expected health-promoting effects and relate this to mortality risk. Detailed information about diet, lifestyle, and anthropometry was provided by more than 57,000 Danes aged 50–64 years. During 12 years of follow-up, there were 4,126 cases of death in the cohort. A healthy Nordic food index, consisting of traditional Nordic food items with expected health-promoting effects (fish, cabbages, rye bread, oatmeal, apples and pears and root vegetables), was analysed and associated with mortality risk. A higher healthy Nordic food index score was associated with a significantly lower mortality risk ratio for both men and women, also significant after adjustment for multiple relevant confounders [7]. When the index components were evaluated separately, wholegrain rye bread intake was the food factor that was most consistently associated with lower mortality in men. Thus, these epidemiological results suggest that a traditional healthy Nordic diet (that was rather similar to the diets used in the NORDIET study described above) is associated with lower mortality among middle-aged Danish subjects, especially among men. This study accords well with the short-term controlled studies and suggests that a healthy Nordic diet could be a useful and health-promoting diet strongly consistent with the current Nordic and European dietary guidelines.

Ongoing and Future Studies

SYSDIET Study

SYSDIET, Systems biology in controlled dietary interventions and cohort studies, is one of the three projects in the Nordic Centre of Excellence (NCoE) Programme on Food, Nutrition and Health, launched by NordForsk in 2007. SYSDIET gathers 12 research groups from Denmark, Finland, Iceland, Norway and Sweden in a coordinated effort to exploiting nutritional systems biology tools in dietary intervention studies. SYSDIET aims to identify novel mechanisms by which Nordic foods and diets could be modified to promote health and prevent metabolic syndrome and related diseases.

A core joint research activity is a multicentre intervention investigating the effects of a healthy Nordic diet in subjects with features of metabolic syndrome, using modern systems biology tools to identify diet-induced changes in physiology. This multicentre intervention will produce mutual publications, first of which may be finalised before end of year 2012.

SYSDIET aims to reveal mechanisms by which Nordic foods and diets could be modified to promote health and prevent insulin resistance, type 2 diabetes and cardiovascular diseases.

To achieve this, nutritional systems biology tools are to be developed and to be used in human randomised controlled dietary interventions as well as experimental studies. A large multicentre randomised controlled isocaloric dietary intervention has been recently conducted to evaluate the clinical metabolic effects and to identify nutrition-related biomarkers for disease pathogenesis and for sensitivity to dietary modifications. The first results from the study showed lower blood lipids and lower levels of certain inflammation markers compared with the control diet [8]. An important distinction in the study design of SYSDIET, as compared with the NORDIET and OPUS study (described below), is the isocaloric study design. Thus, weight loss is not a goal and is inhibited by this design. Thus, it will be difficult to interpret the results concerning metabolic effects from these three controlled studies without also considering effects on body weight. However, the dietary compositions of these three healthy Nordic diets are quite similar and therefore comparable from that point of view.

OPUS Study

A healthy Nordic diet, also called the New Nordic Diet, has also been recently described by Danish investigators who propose that it should consist of a plant-based diet with fewer calories coming from meat and more foods from the sea and lakes and from the wild countryside [9], thus, a healthy Nordic diet similar to that proposed in NORDIET and SYSDIET. The health effects of this diet are currently being investigated in a major research project (OPUS, Optimal well-being, development and health for Danish children through a healthy New Nordic Diet), both including adults and children. Apart from evaluating the clinical effects on body weight control and cardiometabolic risk factors, a key aim of this project is to investigate whether it is possible to develop a healthy New Nordic Diet that is palatable, environmentally friendly and based on foods originating from the Nordic region. This culinary aspect makes the OPUS project rather unique, and the results will be of high interest. Preliminary clinical results from the controlled trial in adults were recently presented at the 19th European Congress on Obesity, in Lyon, France, 9–12 May 2012 [10]. An ad libitum New Nordic Diet, which is similar to the healthy Nordic diets described above, produced clinically relevant and statistically significant reductions in body weight, body fat mass and blood pressure after 6 months in individuals with central obesity. These results were thus in agreement with the short-term effects shown in the NORDIET as described above [5]. Dietary compliance was also considered as good with >80 % completing the trial. Beneficial effects on glucose metabolism and markers of insulin resistance were more pronounced in a subgroup of individuals with prediabetes.

Conclusions

The healthy Nordic diet consists of a combination of healthy foods, mainly a plant-based fibre-rich diet but also including significant amounts of fish. The healthy Nordic diet is fairly low or moderate in total fat with the majority coming from rapeseed oil, sunflower oil and fatty fish. This diet accords with current dietary recommendations around the world, and the dietary and nutrient composition is similar to other European and North American diets with beneficial cardiovascular health effects, e.g. the

Mediterranean diet and DASH diet. Although limited data exist concerning the health effects of the healthy Nordic diet, results from a limited number of studies suggest promising results with regard to prevention of cardiometabolic disease and reduction of mortality risk. The scientific activity concerning health effects of the healthy Nordic diet is currently very high, especially in the Nordic countries. Thus, within a few years, the scientific evidence will be clearly increased regarding the potential health-promoting effects of a Nordic healthy diet.

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13 Dietary Guidelines for Americans: A Brief History

Balagangadhar R. Totapally and Andre Raszynski

Key Points

- Government of the United States of America has been issuing diet and nutrition guidelines and food guides to the American public for over a century.
- The primary focus of initial guidelines was to prevent nutritional deficiencies, and later the focus changed to promote adequate nutrition and to prevent nutrition-related chronic health problems.
- Since1980, the US government has published, every 5 years, the *Dietary Guidelines for Americans*.
- Extensive research into scientific knowledge, consumer behavior, and market conditions are involved in the development of dietary guidelines and food guides.
- Various food guides and the food icons are used to disseminate the information contained in the guidelines to the consumers.
- *Food Guide Pyramid* and *MyPyramid* food icon are the most recognizable food guides worldwide.
- *MyPlate* is the latest food guide introduced in 2011.

Keywords

Dietary guidelines • Food guide • MyPlate • MyPyramid • Pyramid

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V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health,
DOI 10.1007/978-1-4614-7315-2_13,

Abbreviations

DGA	Dietary Guidelines for Americans
DHHS	US Department of Health and Human Services
RDA	Recommended Dietary Allowances
USDA	United States Department of Agriculture

Introduction

Good nutrition is vital to good health and is essential for the healthy growth and development of children and adolescents [1]. A poor diet and lack of exercise can lead to excessive weight or obesity, which have been associated with various diseases and ailments (Tables 13.1 and 13.2). About one-third of US adults and approximately 17 % of children and adolescents aged 2–19 years are obese according to the Center for Disease Control and Prevention [2]. Adequate physical activity and a high-quality diet that does not provide excess calories will together enhance the health of most individuals [1].

Table 13.1 Diseases predisposed due to poor diet

Cardiovascular diseases
Hypertension
Dyslipidemias
Type 2 diabetes
Overweight and obesity
Osteoporosis
Constipation
Diverticular disease
Iron deficiency anemia
Oral diseases
Malnutrition

Table 13.2 Diseases predisposed due to lack of exercise

Cardiovascular diseases
Hypertension
Type 2 diabetes
Overweight and obesity
Osteoporosis

For over a century, the United States Department of Agriculture (USDA) has periodically issued guidelines on food and nutrition [3]. Every 5 years since 1980, the USDA and the US Department of Health and Human Services (DHHS) have jointly issued guidance policy for health promotion and disease prevention—the Dietary Guidelines for Americans (DGA) [4]. These dietary guidelines are published by the DHHS and provide a framework to promote healthier lifestyles. To disseminate the information contained in the guidelines and to educate the public, the USDA and other governmental agencies have published food guides from time to time. These guides have been published as leaflets, pamphlets, or posters with succinct and useful information; food groups were presented graphically on a background of various shapes such as a Food Wheel, Food Pyramid, or MyPlate. The DGA are oriented toward policymakers, nutrition educators, nutritionists, and healthcare providers rather than to the general public, as they contain more technical information, whereas the Food Guides are intended for general public. The main purpose of these food guides is to translate recommendations on nutrition intake into food consumption advice. This chapter describes a brief review of the history of dietary and nutritional guidelines and food guides issued by the US government and its various agencies.

USDA

In 1862 the US Congress established the USDA with a mandate to advise the public about various agricultural topics [5]. The USDA issued its first food guide in 1916 [3, 5]; its goal was to prevent diseases caused or exacerbated by nutritional deficiencies by modifying US dietary practices [5]. Guidelines published by the USDA to solely prevent nutritional deficiencies were last released in 1958 [5]. During the next 2 decades, the scientific community started associating diet with chronic conditions such as coronary heart disease. In 1977, the US Congress published the Dietary Goals for the United States, which primarily focused on the prevention of chronic diseases such as coronary heart disease, cancer, obesity, and stroke. The main focus of subsequent guidelines was to provide nutritional advice to reduce food-related chronic conditions.

Farmers' Bulletins

The first USDA's food guidance was published in 1894 by Dr. Wilbur Olin Atwater in the Farmers' Bulletin as *Foods*: *Nutritive Value and Cost* [6]. Atwater recommended that the diet of American males should be based on protein, carbohydrates, fats, and mineral contents. At that time vitamins and many minerals had not yet been discovered. In his later publication, *Principles of Nutrition and Nutritive Value of Food*, Atwater established the connection between food and health and advocated variety and moderation in the selection of food [6].

Food for Young and How to Select Food (1916–1930s)

Caroline Hunt was the author of the first USDA food guide, *Food for Young*, which was published in 1916. Foods were categorized into five groups: milk and meat, cereals, vegetables and fruits, fats and fatty foods, and sugars and sugary foods [6]. After the release of the food guide, recommendations for food selection based on these five groups were published in 1917 [6]. In 1921, the next guide was published to advise on the quantity of foods to purchase for an average family, using the same five food groups. In 1923, it was modified to include advice for families which differed from an average family of 5 members. The economic problems due to the Great Depression influenced food guidance in the early 1930s. In 1933, the USDA food economist, Hazel Stiebeling, developed food plans at four cost levels to help people shop for food [6].

A Guide to Good Eating: Basic Seven (1940s)

In 1941, the Food and Nutrition Board of the National Academy of Sciences released its first set of recommended dietary allowances (RDAs). These RDAs listed specific recommended intakes for calories and nine essential nutrients, protein, iron, calcium, vitamins A, C, and D, thiamin, riboflavin, and niacin [6]. Several food guides were developed during World War II (early 1940s). These include *Eat Right Food to Help Keep You Fit* (USDA and Bureau of Economics, 1941), the *Yardstick for Good Nutrition* (National Research Council, 1941), and *Good Guide to Eating* (National Dairy Council, 1941) [7]. The number of food groups in each of the food guide ranged from 7 to 10 [7]. As a part of the recommendations, the USDA released the Basic Seven food guide in 1943 as a leaflet: *National Wartime Nutrition Guide* [7]. This guide specified a foundation diet based on the seven food groups. This guide also suggested alternate choices in each food group in cases of limited supplies of certain foods during the war period [7]. However, it lacked the number of servings from each group. After the war, the Basic Seven was revised in 1946 and issued as the *National Food Guide* with suggestions on the number of servings in each food group needed for daily nutrition. However, specific serving sizes were lacking and it was thought be very complex [6, 7].

Food for Fitness: A Daily Food Guide: Basic Four (1956–1970s)

In 1956 the USDA introduced its Basic Four food groups in its recommendation, *Food for Fitness—A Daily Food Guide*. The Basic Four groups included (a) meat, poultry, fish, dry beans and peas, eggs, and nuts; (b) dairy products (milk cheese, and yogurt); (c) grains; and (d) fruits and vegetables. The guide also specified a foundation diet and specified food proportions from each group. Although, this guide did not include advice on appropriate fat, sugar, and calorie intake, it remained popular for the next 2 decades [3, 6, 8].

Dietary Goals for the United States (1977)

In 1977, the Select Committee of US Congress on Nutrition and Human Needs published its first report on dietary goals for the United States [9]. At a press conference announcing the release of these goals, George McGovern, the Chairman of the Select Committee, stressed that US dietary habits had changed radically and had resulted in harmful effects on the health of the nation (Press Conference on 1/14/1977). In his address, he brought attention to the effects of excessive fat, sugar, and salt consumption on the development of heart disease, cancer, stroke, and obesity; furthermore, he pointed out that over the prior 50-year period, the US diet calorie origin had changed from a 40 % to a 20 % plant source. For the first time the focus has shifted from obtaining adequate nutrition to avoiding excess nutrition [6].

In its first report, the Select Committee recommended six main dietary goals [9]:

1. Increasing carbohydrate consumption to account for 55–60 % of the energy intake
2. Reducing fat consumption from 40 to 30 % of the total energy intake
3. Reducing saturated fat consumption to account for about 10 % of total energy intake and balancing that with polyunsaturated and monounsaturated fats, 10 % each
4. Reducing cholesterol consumption to about 300 mg/day
5. Reducing sugar consumption by about 40 % to account for 15 % of total energy intake
6. Reducing salt consumption by about 50–85 %, to approximately 3 g/day

Based on these goals the following changes in food selection and preparation were recommended by the Select Committee [9]:

1. Increase consumption of fruits, vegetables, and whole grains
2. Decrease consumption of meat and increase consumption of poultry and fish
3. Decrease consumption of foods in high fat and partially substitute polyunsaturated fat for saturated fat
4. Substitute nonfat milk for whole milk
5. Decrease consumption of butterfat, eggs, and other high cholesterol sources
6. Decrease consumption of sugar and foods in high sugar content
7. Decrease consumption of salt and foods in high salt content

Hassle-Free Daily Food Guide (1979)

In 1979, the USDA added a fifth group to the Basic Four and emphasized consumption of vegetables, fruits, and grains and highlighted the need for moderate intake of fats, sweets, and alcohol.

For the first time, in 1979, the USDA guidelines added a hierarchical model to present the message of relative importance of various food groups. The *Hassle-Free Daily Food Guide* displayed the groups stacked one above the other with fruits/vegetables at the top, followed in descending order by bread and cereals, milk and cheese, meat, poultry, fish, and beans, and a fifth group at the base of fats, sweets, and alcohol [5].

In 1979, the DHHS released a study by the American Society for Clinical Nutrition on the relationship between dietary practices and health problems [6]. These findings culminated in the release of first DGAs issued jointly by the USDA and the DHHS in 1980 (*Nutrition and Your Health*: *Dietary Guidelines for Americans*, 1980). These guidelines were intended for healthy Americans age 2 and over. The statement of DGA was "eat variety of foods." This statement was included in the guidelines until the fifth edition of DGAs in 2000 [10]. The 1980 DGAs were directional but not quantitative, creating confusion and concerns among consumers, industry, and nutrition scientists [6]. This led to the development of a new food guide, *Food Wheel*: *A Pattern for Daily Food Choices* in 1984, to help consumers implement the guidelines in their daily food consumption. This food guide focused on a total diet, not merely on a foundation diet as described in earlier guides.

Food Wheel: A Pattern for Daily Food Choices (1984)

The food guide, *Food Wheel*: *A Pattern for Daily Food Choices*, was created to address confusion and concerns among consumers, industry, and nutrition scientists and to implement recommendations issued in the first DGAs. This food guide focused on total diet, not merely on a foundation diet as presented in earlier food guides. The food guide emphasized on how to select food for nutrient adequacy as well as moderation of intake of foods related to risk of chronic diseases.

The food guide, *A Pattern for Daily Food Choices*, was first presented to consumers in a food wheel graphic in 1984 by USDA in cooperation with the American National Red Cross [6]. The guide outlined five major food groups and suggested numbers of servings from each food group at three calorie levels. The five groups included bread, cereal, rice, and pasta group; the vegetable group; the fruit group; the dairy (milk, yogurt, and cheese) group; and the meat, poultry, fish, dry beans, eggs, and nuts group. The guide also recommended sparing use of a sixth food group, fats, oils, and sweets [6].

Since the first edition of the DGA released in 1980, the USDA and the DHHS jointly issued the dietary guidelines every 5 years as mandated by the US public law. The second edition of the DGAs was released in 1985 and was similar to the first edition with minimal changes. During the 1980s the USDA developed and distributed a number of publications to help the public use these guidelines. In the third edition of the DGAs published in 1990, the basic tenets of previous editions were kept and promoted enjoyable and healthy eating habits with moderation and variety [6]. For the first time, the guidelines recommended numerical goals for fat and saturated fat of less than 30 % and 10 % of calories, respectively.

Food Guide Pyramid (1992)

The *Basic Four* food guide was a center piece of nutritional education until it was replaced by the new food guide, *A Pattern for Daily Food Choices* in 1980s. The USDA used eight philosophical goals to develop a new food guide (Table 13.3) [7]. Extensive peer-reviewed research was conducted to develop this new food guide. Food consumption and food composition data were also used. Although, the food guide *A Pattern for Daily Food Choices* was used in various publications until it was replaced by the *Food Guide Pyramid* in 1992, it was not well known by the public. The four food groups of the *Basic Four* were popular in teaching about nutrition. However, they put a greater emphasis on meat and dairy products.

In 1988 work began to present the guidelines in a graphic pattern to convey the key concepts of variety, proportionality, and moderation [6]. Consumer studies were completed from 1988 to 1990 on adults with high school education and who had eating patterns similar to general US population [6]. The USDA and Porter Novelli developed, tested, peer-reviewed, and revised the *Pyramid* brochure [5]. The Pyramid brochure

Table 13.3 The USDA's philosophical goals for developing food guide [7]

The food guide should promote overall health, not just prevention of disease
The food guide should be based on up-to-date research on recommended intakes of nutrients and other food substances
The food guide should focus on total diet rather than foundation diet
The food guide should be useful to the target population
The food guide should meet nutritional goals in a realistic manner
The food guide should allow maximum flexibility for consumers to eat in a way that suits their taste and lifestyle while promoting the health
The food guide should demonstrate the practical way to meet nutritional needs
The food guide should be evolutionary, to build on the successes of previous guides

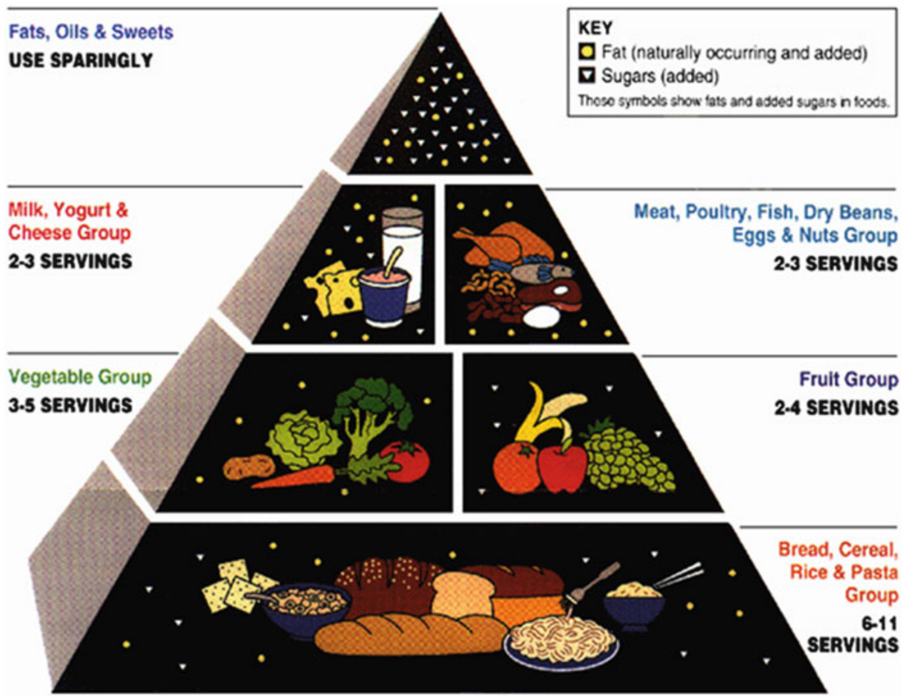

Fig. 13.1 The *Food Guide Pyramid* in 1992 (*Source*: http://www.nal.usda.gov/fnic/Fpyr/pyramid.gif; accessed May 6, 2013)

completed all Federal reviews and clearances and was ready to be released to the public in 1991. However, its publication was postponed because of concerns about need for more research [5]. However, a possible alternate explanation for the delay of the publication was pressure from the milk and meat industry [5]. One year later, in 1992, after completion of additional research, the *Pyramid* brochure was published and released for public as *Food Guide Pyramid*.

The *Food Guide Pyramid* (Fig. 13.1) included five major food groups which would provide nutrients needed for good health. The base of the *Pyramid* was formed by the breads, cereal, rice, and pasta group and the largest servings (6–11 servings daily) were recommended from this group. At the second level were the vegetable group and fruit group, with 3–5 and 2–4 servings each, respectively. The third layer included the milk, yogurt, and cheese group with 2–3 servings and the meat, poultry, fish, dry beans, eggs, and nuts group with 2–3 servings. The tip of the *Pyramid* consisted of fats, oils, and sweets; the recommendation was to use them sparingly. USDA wanted the *Pyramid* to be hierarchical to convey proportionality [5]. Diets low in saturated fats and high in plant source formed the base of the Pyramid and claimed a larger proportion of calories, while diets animal in origin were placed higher in the *Pyramid*.

Research Basis for the *Food Guide Pyramid* [5]

The *Food Guide Pyramid* came to fruition after 11 years of research and testing [5]. Conceptually the USDA scientists met two goals, providing nutrients sufficient to meet the recommended daily allowances and advocating reduced targets for saturated fats, salt, and sugar. The *Pyramid* also conveyed three key concepts, variety, moderation, and proportionality [5]. In her review, Marion Nestle [5] summarized the research conducted for the development and release of the *Food Guide Pyramid* in to three phases. During the first phase, between 1981 and 1984, the USDA developed a *Food Wheel* by selecting nutritional goals, defining food groups, calculating the number of daily servings, and assigning the sizes for each serving. The second phase began with market research by Porter Novelli and ended in 1991 with the graphic design of the *Pyramid*. The third phase began in 1991 after withdrawal of the *Pyramid* due to the concerns mainly from the food and agriculture industry. The USDA evaluated alternate graphic designs with the help of a consulting firm, Bell Associates. Based on focus-group research, two graphic designs, pyramids and bowls, were selected for further testing. Opinion testing indicated both of the designs conveyed the need for variety in food selection, but the *Pyramid* fared better with proportionality and moderation [5].

In 1996, the USDA revised the *Pyramid* brochure to be consistent with the 1995 edition of DGA. From 1980 to 1995 the DGA message remained "eat variety of foods." The statement was changed to "let the Pyramid guide your food choices" in the fifth edition of the DGA in 2000 [10].

MyPyramid Food Guidance System (2005)

In 2005, the USDA updated the *Food Guide Pyramid* and simplified the illustration, added a category for oils and the concept of physical activity by showing a figure ascending stairs on the side of the pyramid (Fig. 13.2). *MyPyramid Food Guide* was consistent with the DGA published in 2005.

Key Recommendations of the *MyPyramid Food Guide* were as follows [1]:

Adequate nutrients within calorie needs

- Consume a variety of nutrient-dense foods and beverages within and among the basic food groups while choosing foods that limit the intake of saturated and *trans* fats, cholesterol, added sugars, salt, and alcohol.
- Meet recommended intakes within energy needs by adopting a balanced eating pattern.

Fig. 13.2 *MyPyramid* graphic in 2006 (*Source*: U.S. Department of Agriculture. MyPlate.gov website. http://www.choosemyplate.gov/print-materials-ordering/graphic-resources.html. Accessed December 22, 2011)

Weight management

- To maintain body weight in a healthy range, balance calories from foods and beverages with calories expended.
- To prevent gradual weight gain over time, make small decreases in food and beverage calories and increase physical activity.

Physical activity

- Engage in regular physical activity and reduce sedentary activities to promote health, psychological well-being, and a healthy body weight.

Food groups to encourage

- Consumption of sufficient amount of fruits and vegetables while providing adequate energy needs. Two cups of fruit and 2½ cups of vegetables per day were recommended for a reference 2,000 cal intake, with higher or lower amounts depending on the calorie level.
- Choice of a variety of fruits and vegetables each day. In particular, selection from all five vegetable subgroups (dark green, orange, legumes, starchy vegetables, and other vegetables) several times a week.
- Consumption of three or more ounce equivalents of whole-grain products per day, with the rest of the recommended grains coming from enriched or whole-grain products. In general, at least half the grains should come from whole grains.
- Consumption of 3 cups per day of fat-free or low-fat milk or equivalent milk products.

Fats

- Consume less than 10 % of calories from saturated fatty acids and less than 300 mg/day of cholesterol, and keep *trans* fatty acid consumption as low as possible.
- Keep total fat intake between 20 and 35 % of calories, with most fats coming from sources of polyunsaturated and monounsaturated fatty acids, such as fish, nuts, and vegetable oils.
- When selecting and preparing meat, poultry, dry beans, and milk or milk products, make choices that are lean, low fat, or fat-free.
- Limit intake of fats and oils high in saturated and/or *trans* fatty acids, and choose products low in such fats and oils.

Carbohydrates

- Choose fiber-rich fruits, vegetables, and whole grains often.
- Choose and prepare foods and beverages with little added sugars or caloric sweeteners, such as amounts suggested by the USDA Food Guide and the DASH Eating Plan.
- Reduce the incidence of dental caries by practicing good oral hygiene and consuming sugar- and starch-containing foods and beverages less frequently.

Sodium and potassium

- Consume less than 2,300 mg (approximately 1 teaspoon of salt) of sodium per day.
- Choose and prepare foods with little salt. At the same time, consume potassium-rich foods, such as fruits and vegetables.

Food safety

- To avoid microbial foodborne illness:
- Clean hands, food contact surfaces, and fruits and vegetables.
  - Separate raw, cooked, and ready-to-eat foods while shopping, preparing, or storing foods.
  - Cook foods at a safe temperature to kill microorganisms.
  - Chill (refrigerate) perishable food promptly and defrost foods properly.
  - Avoid raw (unpasteurized) milk or any products made from unpasteurized milk, raw or partially cooked eggs or foods containing raw eggs, raw or undercooked meat and poultry, unpasteurized juices, and raw sprouts.

MyPlate (2011)

While the *MyPyramid* food graphic was useful as a teaching tool, it was perceived by many as outdated and too complicated. Confusion arose with old and new *Pyramid* graphics [11]. Unfortunately, with familiarity of *MyPyramid*, consumers stopped paying attention to its advice. The report of the White House Childhood Obesity Task Force of 2010 recommended that the Federal government, working with local communities, should disseminate information about the 2010 *Dietary Guidelines for Americans* through simple, easily actionable messages for consumers and a next generation *Food Pyramid* [11, 12]. A plate was identified as a new icon for food guide as it is familiar and is associated with eating and its frequent use in the market place to demonstrate to consumers how to build a healthy meal [11].

The 2010 DGA had two main concepts: (1) maintain caloric balance over time to achieve and sustain a healthy weight and (2) focus on consuming nutrient-dense foods and beverages [11]. These two main messages were presented in the policy document as three consumer messages: (1) how to balance calories to manage weight, (2) which foods and food components to reduce, and (3) which foods and food components to increase [11].

The USDA undertook consumer research to develop consumer messages and test potential new generation food icons [11]. The intent was to build on the best practices and previous experiences, to emphasize 2010 Dietary Guidelines, and to determine the best language and graphic depiction useful to disseminate the Federal policies in the Dietary Guidelines [11]. Formative research used for the development of *MyPlate* icon include one-on-one interviews, media analysis of news articles mentioning “dietary guidelines,” scan of communication programs intended to change consumer behavior, and literature review of articles and reports [11]. Information from various consumer focus groups was utilized in the development of *MyPlate Food Guide* (Fig. 13.3). Diversity among socioeconomic, geographic, and attitudinal groups was achieved during the

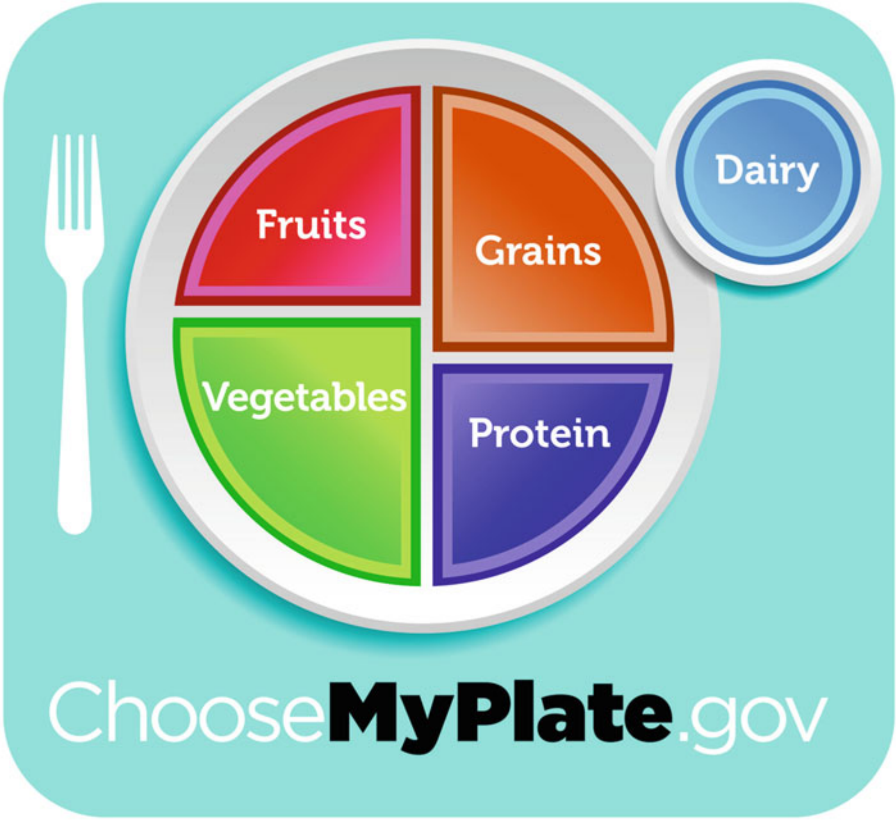

Fig. 13.3 *MyPlate* graphic published in 2011 (*Source*: U.S. Department of Agriculture. MyPlate.gov website. http://www.choosemyplate.gov/print-materials-ordering/graphic-resources.html. Accessed December 22, 2011)

formative research [11]. Finally, a survey of children and adults was conducted in December 2010 through January of 2011 to test the language and graphic images in support of 2010 Dietary Guidelines [11].

MyPlate was initiated as part of larger education initiatives, based on 2010 *Dietary Guidelines for Americans*, to help consumers make better food choices. *MyPlate* illustrated the five food groups, vegetables, fruits, grains, protein, and dairy. It was designed to encourage Americans to eat a healthy diet [13]. Along with the release of *MyPlate Food Guide*, the USDA also released key messages associated with each food group (Table 13.4). Following the publication of the *MyPlate* icon, the *MyPyramid* is still available to interested educators and healthcare professionals. The USDA has used the familiar image of a plate along with actionable messages to bring the 2010 Dietary Guidelines into practice. The messages in the *MyPlate Food Guide* are based on the 2010 DGA policy document and are comprehensive and action oriented [14].

Table 13.4 Food groups and key messages for public from MyPlate Food Guide (*Source*: http://www.choosemyplate.gov/foodgroups/index.html; accessed November 24, 2011)

Food group	Key message
Grains group	Make at least half your grains whole
Vegetable group	Vary your veggies
Fruit group	Focus on fruits
Dairy group	Get your calcium-rich foods
Protein food group	Go lean with protein

Based on consumer surveys and qualitative research, the food groups, "meat and beans" was changed to "protein food" and "milk" was changed to "dairy." The consumer message which emerged as the most effective according to the participants across geographic regions and eating habit segments is "enjoy what you eat, just eat less of it" [11]. Three food icons, abstract pyramid, the plate, and the thought bubble were surveyed during the developmental phase for a new food guide icon. Although no single icon attracted all participants, the plate and the thought bubble attracted more compared to the pyramid. A plate was chosen as the simple icon because it is a familiar eating symbol for consumers [11]. As with *MyPyramid*, it is understood that the simple icon of *MyPlate* will not teach all nutritional concepts nor will by itself change consumer behavior [11]. Several messages are included along with tools and resources for nutritional education for various consumers to supplement the simple food icon, *MyPlate*. For example, the consumer brochure "Let's eat for the health of it" has several simple following messages [15]:

- Build a healthy plate
- Cut back on foods high in solid fats, added sugars, and salt
- Eat the right amount of calories for you
- Be physically active your way

Conclusions

For over a century the government of the United States of America has been issuing diet and nutrition guidelines to the American public. Initially, the primary focus of these guidelines was to pre-

Table 13.5 A brief timeline of diet and nutrition guides and guidelines in the USA

Timeline	Events in the history of diet and nutrition guides and guidelines
1862	Establishment of the USDA
1894	Farmers' Bulletin: *Food*: *Nutrition Values and Cost*
1916–1930s	First Food Guides: *Food for Young* and *How to Select Food*
1941	First Recommended Dietary Allowances (RDA) by the Food and Nutrition of National Academy of Sciences
1940s	*A Guide to Good Eating*: *Basic Seven*
	• *Eat Right Food to Help Keep You Fit* (the USDA and Bureau of Economics, 1941)
	• *Yardstick for Good Nutrition* (National Research Council, 1941)
	• *Guide to Good Eating* (National Dairy Council, 1941)
	• *National Wartime Nutrition Guide* (USDA's Basic Seven leaflet, 1943)
	• *National Food Guide* (the revised Basic Seven by the USDA, 1946)
1956–1970s	*Food for Fitness-A Daily Food Guide*: *Basic Four*
1977	The first report on the Dietary Goals for Americans by the US Congress
1979	*Hassle-Free Daily Food Guide* (Five food groups in a hierarchical model)
1980	The first edition of *Dietary Guidelines for Americans* (DGAs)
1984	*Food Wheel*: *A Pattern for Daily Food Choices* (A food guide based on the first DGAs)
1985	The second edition of DGAs
1990	The third edition of DGAs
	• Fats should be less than 30 % of total calories
	• Saturated fats should be less than 10 % of total calories
1992	The *Food Guide Pyramid*
1995	The fourth edition of DGAs
2000	The fifth edition of DGAs
2005	The sixth edition of DGAs
2005	*MyPyramid*
	• Added steps to the pyramid to represent exercise
2010	The seventh edition of DGAs
2010	The report of White House Childhood Obesity Task Force of 2010
2011	*MyPlate*

vent nutritional deficiencies, but later the focus changed to promote adequate nutrition and to prevent chronic health problems related to nutrition and diet. Every 5 years since1980, the USDA and the DHHS have published the *Dietary Guidelines for Americans* older than 2 years of age. The successive editions are based on the experience of the previous guidelines and interim advances in scientific knowledge and consumer behavior. Extensive research into scientific knowledge, consumer behavior, and market conditions were involved in the development of these guidelines and food guides. The USDA Dietary Guidelines are written mostly in technical terms and are intended for scientists, healthcare professionals, and educators. Various food guides and the food icons are used to disseminate the information contained in the guidelines to the consumers. The *Pyramid Food Guide* and *MyPyramid* food icon are the most recognizable food guides worldwide. *MyPlate* is the latest food guide introduced in 2011. A brief timeline of the development of diet and nutrition advice in the US is summarized in Table 13.5.

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14 Awareness of the United States Federal Dietary Guidance and Its Association with Dietary Quality

Jacqueline D. Wright

Key Points

- Since 1980 the US Federal Government has published advice to the public on consuming a healthy diet in the form of the first Dietary Guidelines for Americans (DGA). The guidelines are reviewed and revised every 5 years and they have become the primary federal guidance to the public on nutrition.
- During the period 2005–2006 over 80 % of US adults 16 years and older had heard of at least one of the three sets of federal dietary guidance with virtually all of them reporting awareness of the Food Guide Pyramid. In contrast only about half of the population had heard of the DGA or the 5 A Day Program.
- Awareness of federal nutrition guidance was higher among women, adolescents 16–19 years old, non-Hispanic whites, and persons with higher education and income levels.
- Differences in awareness of federal dietary guidance efforts by smoking habits, frequency of eating out, and self-assessed diet quality were not significant after adjustment for demographic factors.
- Mean intakes of magnesium, potassium, and fiber were significantly higher in persons aware of the 5 A Day Program than in persons not aware of the program.
- Knowledge and awareness of the components of a healthy diet is a necessary, but not sufficient, component of behavior change.
- Awareness of nutrition guidance is distinct from knowledge of nutrition principles and from "how-to" knowledge of healthy eating. Higher reported use of food labels was associated with more favorable nutrient

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V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health,
DOI 10.1007/978-1-4614-7315-2_14,

intakes among persons with the diagnosed chronic conditions like hypertension, diabetes, and hyperlipidemia.
- Promoting increased importance of preparing and enjoying healthy food and a physically active healthy lifestyle is as important as promoting nutrition guidelines.

Keywords
Dietary guidelines • Awareness • Diet surveys • Dietary habits • Dietary behavior • Nutrition guidelines • Nutrition knowledge

Abbreviations

BMI	Body mass index
CVD	Cardiovascular disease
DASH	Dietary Approaches to Stop Hypertension
DGA	Dietary Guidelines for Americans
FDA	Food and Drug Administration
NHANES	National Health and Nutrition Examination Survey
NSLP	National School Lunch Program
PIR	Poverty income ratio
SNAP	Supplemental Nutrition Assistance Program
USDA	United States Department of Agriculture
US	United States
WIC	Special Supplemental Nutrition Program for Women Infants, and Children

Introduction

Since the early decades of the twentieth century, the US Federal Government has published advice to the public on consuming a healthy diet [1]. In 1980 the first Dietary Guidelines for Americans (DGA) were jointly released by the Department of Health and Human Services and the US Department of Agriculture (USDA) [2]. The DGA are reviewed and revised as necessary every 5 years and have become the primary federal guidance to the public on nutrition and healthy eating habits in the USA. The USDA has developed guides to help consumers incorporate the DGA into their diet, the most recent of which is called MyPlate [3]. In addition to the DGA, other federal dietary guidance is published and promoted, for example, the National Fruit and Vegetable Program (known as "Fruit & Veggies—More Matters") is aimed specifically at increasing fruit and vegetable intake in the general population. The Dietary Approaches to Stop Hypertension (DASH) eating plan was developed as a result of federally funded research on hypertension [4]. A comparison of nutrient values indicated the DASH diet plan was consistent with the MyPyramid, a food guide developed by the USDA that is based on the DGA [5].

Dietary Guidance

Historically the DGA focused on recommendations that ensured adequate intake of important food groups and key nutrient sources. However, since the publication of the 1988 Surgeon General's Report on Nutrition and Health, there has been increasing attention to guidelines focused on preventing chronic disease such as heart disease [6]. Welsh's history of nutrition guidance in the USA up through the development of the DGA and the 5-year revision process details the increasing attention devoted to preventing diseases associated with overconsumption of energy and certain nutrients and increased attention to providing accessible information to consumers on healthy eating [1]. The DGA forms the basis for major federal nutrition programs, such as USDA's Supplemental Nutrition Assistance Program (SNAP, formerly known as the Food Stamp Program), the National School Lunch Program (NSLP), and the Nutrition Services Programs of the Administration on Aging (e.g., Congregate and Home-Delivered Nutrition Services, formerly known as Meals on Wheels) [7, 8]. The Dietary Guidelines are also used in the implementation of the services provided by the Special Supplemental Nutrition Program for Women, Infants, and Children, more commonly known as the WIC program [9].

The Food Guide Pyramid was published in 1992, to provide consumers with a food guide and associated graphic to help incorporate the DGA into healthy eating habits [10]. While there were previous versions of food guides, such as the Basic Seven and the Basic Four, the Food Guide Pyramid was the first guide published since the joint DGA was developed in 1980 [1]. The development process included a needs assessment of nutritionists, pilot testing, and peer review. In 2005 a revised food guide was released, named MyPyramid. The revisions reflected the latest release of the DGA, with changes to the graphic including a figure climbing the side of the pyramid graphic to represent the DGA focus on activity seen in the 2005 revision. Revisions were made based on results of research on its interpretability and ease of understanding by consumers [11, 12].

In 1992 the 5 A Day Program was launched with the objective of promoting increased fruit and vegetable consumption [13]. The program was a partnership between the National Cancer Institute and the Produce for Better Health Foundation, a nonprofit organization consisting of members of the fruit and vegetable industry. The goal of the program was to increase the average per capita consumption of vegetables and fruits to five or more servings daily, with the ultimate aim of reducing incidence of cancer and other chronic diseases through improved diet. The program's goal coincided with the nutrition objectives of the Healthy People 2000 initiative and was consistent with other federal dietary guidance. In 2005 the Centers for Disease Control and Prevention became the lead federal agency for the 5 A Day Program. In 2007 the program was renamed the National Fruit and Vegetable Program and a new initiative was launched, "Fruits & Veggies—More Matters," to reflect the latest recommendations on fruit and vegetable consumption in the 2005 revised DGA [14].

One measure of the success of the DGA would be observed changes in dietary intake in the population reflecting an increased degree of adherence to the guidelines [15]. However, there may be gaps between reported awareness of the DGA and understanding of the specific nutrition recommendations [16]. The DGA committee was asked to focus on the science and not how the guidelines would be communicated. Evaluation of the DGA must consider that awareness of the guidelines is reflective of the implementation of the guidelines and not an evaluation of the scientific integrity. While evaluation of dietary intake, that is, of nutrients and foods or food groups, gives a measure of the ultimate effect of the DGA, measures of behavioral change can give an indication of the consumer's awareness and understanding of the recommendations. The use of measures of diet quality to evaluate the population's dietary intake provides an indication of the extent to which the DGA are incorporated into dietary behaviors at a population level. However, there are many factors besides knowledge and awareness that influence behavior. The latest DGA published at the beginning of 2011 focused on developing recommendations "that would address changes in behavior, the environment, and the food supply" [2, p. 6]. In following the evidence-based approach of this book, this chapter presents studies on population behaviors to assess selected dietary behaviors. Assessment of awareness of guidance is an important aspect of understanding dietary behaviors and why change is occurring, or why not. In this chapter findings on awareness of federal nutrition guidance in the USA from the National Health and Nutrition Examination Survey (NHANES) 2005–2006 are reviewed, including the distribution of awareness of guidance by demographic and health characteristics and the association of awareness with behavioral indicators of diet and diet-related attitudes.

Table 14.1 Estimated age-adjusted[a] and age-specific prevalence of awareness of federal dietary guidance by selected demographic characteristics in persons 16 years and older (National Health and Nutrition Examination Survey 2005–2006, United States)

	Population characteristics % (SE[b])	At least one[c] % (SE)	Dietary guidelines % (SE)	Food guide pyramid % (SE)	5 Day program % (SE)
Age (years)					
16+		83.8 (1.07)	49.2 (1.26)	80.6 (1.24)	51.2 (1.40)
20+		82.0 (1.13)	50.3 (1.29)	79.0 (1.30)	51.4 (1.47)
16–19	7.0 (0.42)	93.1 (0.95**[d])	29.1 (2.03**[d])	92.4 (1.08**[d])	43.7 (2.71)
20–39	35.7 (1.22)	85.2 (1.65)	44.6 (1.55)	83.5 (1.76)	52.6 (1.88)
40–59	36.6 (1.17)	85.4 (1.27)	59.5 (1.75)	81.2 (1.83)	54.9 (2.00)
60+	20.6 (1.80)	71.2 (1.70)	45.2 (1.95)	67.6 (1.99)	43.7 (1.83)
Sex					
Men	48.4 (0.43)	78.5 (1.43**[e])	42.7 (1.67**[e])	74.4 (1.72**[e])	39.4 (1.54**[e])
Women	51.6 (0.43)	88.8 (0.90)	55.3 (1.32)	86.4 (1.13)	62.4 (1.63)
Race-ethnicity					
Non-Hispanic white	71.6 (2.71)	90.3 (0.59**[f,g])	55.1 (1.35**[f,g])	87.8 (0.81**[f,g])	56.4 (1.59**[f,g])
Non-Hispanic black	11.8 (1.93)	70.0 (2.20**[g,h])	35.6 (1.58**[g,h])	63.3 (2.17**[g,h])	40.9 (1.96**[g,h])
Mexican American	7.8 (0.95)	55.1 (2.67**[f,h])	22.7 (2.07**[f,h])	51.2 (2.55**[f,h])	27.8 (2.22**[f,h])
Education					
<High school	20.6 (1.39)	59.6 (3.54**[d])	26.0 (2.08**[d])	54.1 (3.66**[d])	29.8 (2.08**[d])
High school	24.4 (0.76)	81.2 (1.43)	41.6 (1.11)	77.2 (1.59)	46.5 (2.39)
> High school	54.9 (1.85)	92.8 (0.82)	60.0 (1.60)	90.6 (1.02)	60.6 (1.80)
Poverty income ratio[i]					
≤1.300	17.8 (1.17)	69.6 (2.47**[d])	35.1 (2.33**[d])	65.3 (2.69**[d])	40.1 (1.64**[d])
1.301–3.500	38.5 (1.41)	80.8 (2.09)	44.3 (1.94)	76.7 (2.46)	48.8 (1.50)
>3.500	43.8 (2.15)	91.7 (0.66)	58.8 (1.82)	89.7 (0.62)	57.7 (1.96)

Note: Reprinted from Journal of the American Dietetic Association, vol. 111, no. 2, Wright JD, Wang C-Y, Awareness of federal dietary guidance in persons aged 16 years and older: Results from the National Health and Nutrition Examination Survey 2005-2006, p. 295–300, 2011, with permission from Elsevier

$**p<0.01$

[a]Estimates are age adjusted by direct method to 2000 Census population using the following age groups 16–19, 20–39, 40–59, and 60 years and older

[b]*SE* standard error

[c]At least on the of three federal dietary guidance initiatives

[d]Significant linear trend

[e]Significantly different from women

[f]Significantly different from non-Hispanic blacks

[g]Significantly different from Mexican Americans

[h]Significantly different from non-Hispanic whites

[i]Poverty income ratio (PIR) was calculated by dividing family income by poverty guidelines specific for family size

Awareness of Federal Dietary Guidance by Demographic Traits

Awareness of US federal dietary guidance varied by sex, age, race-ethnicity, income, and education [17]. Over 80 % of persons 16 years and older had heard of at least one of the three sets of federal dietary guidance with virtually all of them reporting awareness of the Food Guide Pyramid. In contrast only about half of this population had heard of the DGA or the 5 A Day Program (Table 14.1). Awareness of at least one of the

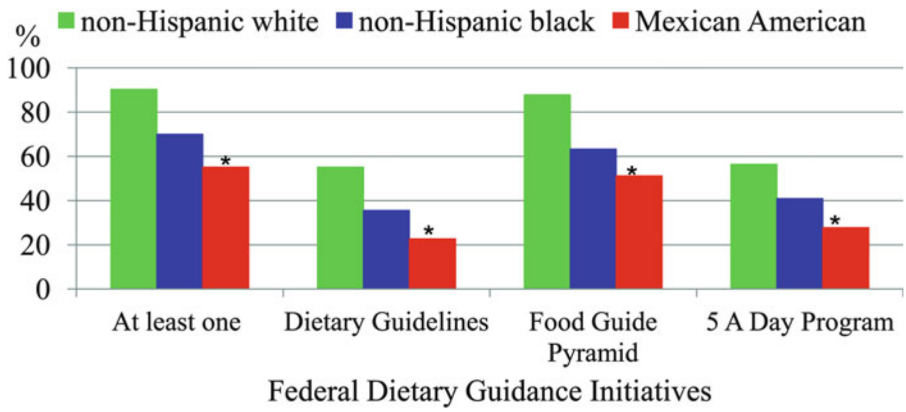

Fig. 14.1 Awareness of federal dietary guidance among persons 16 years and older by race-ethnicity. *Note*: Estimates are age-adjusted by the direct method using 2000 US population with age groups: 16–19 years, 20–39 years, 40–59 years, 60+ years. *p<0.01 for all pairwise race-ethnic differences. (National Health and Nutrition Examination Survey 2005–2006, United States). *Note*: Reprinted from Journal of the American Dietetic Association, vol. 111, no. 2, Wright JD, Wang C-Y, Awareness of federal dietary guidance in persons aged 16 years and older: Results from the National Health and Nutrition Examination Survey 2005–2006, p. 295–300, 2011, with permission from Elsevier

programs was higher in women than men and lower in adults 60 years and older compared with the younger age groups. Ninety percent of non-Hispanic whites had heard of at least one of the three federal guidance efforts, while only 70 % of non-Hispanic blacks were aware, and just over half of Mexican Americans (Fig. 14.1). There was a significant linear trend of increasing awareness with increasing education and a similar significant trend of increasing awareness with increasing income level.

Some trends seen with awareness of any of the three initiatives persisted when examining awareness of the individual dietary guidance initiatives. Awareness was significantly higher in women than in men for each of the three initiatives. Mexican Americans had the lowest levels of awareness followed by non-Hispanic blacks (Fig. 14.1). Non-Hispanic whites had the highest levels of awareness. The linear trends of increasing awareness with increasing education and increasing income persisted when examining each of the initiatives separately. The awareness estimates for the Food Guide Pyramid were higher than for the other two sets of guidance and thus tended to reflect trends in awareness of at least one of the three initiatives. There was a statistically significant trend of decreasing awareness of the Food Guide Pyramid with increasing age, although the difference between 20–39 and 40–59-year-olds was not statistically different. There was a statistically significant linear trend of increasing awareness of the Dietary Guidelines with increasing age up to 40–59 years old; however, comparatively significantly fewer persons 60 years and older had heard of the guidelines than 40–59-year-olds. There was no significant linear trend for awareness of the 5 A Day Program; however, there were significant differences between the two middle-age groups (20–39 and 40–59 years) and the youngest and oldest age groups; the differences were not statistically significant between 20-39 and 40–59-year-olds nor between 16–19-year-olds and persons 60 years and older.

Assessment of Dietary Quality

Diet quality indices that are based on dietary assessment data are subject to all the limitations from sources of measurement error that affect the particular assessment methodology used. For example, 24-h recalls are subject to recall bias and day-to-day variability or intraindividual variation. Waijers and colleagues reviewed diet quality indices and noted key limitations of these indices [18]. The correlations between the various dietary intake factors may not be adequately addressed in the computational algorithms used. In the indices they reviewed, only modest associations with health outcomes were seen and the indices did not predict morbidity and mortality significantly better than the individual dietary factors. These authors questioned whether a dietary score can be constructed that is a significantly better predictor of health outcome than associations with single dietary constituents.

Association of Awareness of Federal Dietary Guidance with Health Measures and Indicators of Diet Quality

Awareness of the three sets of federal dietary guidance was examined by certain health characteristics and indicators of diet quality (Table 14.2). Awareness of at least one of the three dietary guidance initiatives was not statistically different among normal and underweight persons (83.4 %), overweight persons (83.1 %), and obese persons (84.9 %). Adults 20 years and older who never smoked cigarettes were more likely to have heard of at least one of the three programs than persons who currently smoked cigarettes (83.7 % compared with 78.9 %; $p<0.01$, data not shown). After adjusting for demographic traits, this difference was not statistically significant. After adjusting for gender, age, race-ethnicity, education, and income, the linear trend of increasing awareness with increasing self-assessed diet quality was also not significant. Similarly a linear trend of decreasing awareness with fewer meals away from home was not statistically significant after adjustment for demographic factors. These results indicate that apparent differences in awareness by smoking status, self-assessed diet quality, and frequency of eating out were confounded by the association of demographic characteristics with awareness.

A minority of the population reported that they strongly agreed (8.3 %) with the fatalistic statement about body weight (Table 14.2 and Fig. 14.2). More people disagreed (27.9 % somewhat disagreed, 27.0 % strongly disagreed) with the statement "Some people are born to be fat and some thin; there is not much you can do to change this" compared to people who agreed (25.7 % somewhat agreed and 8.3 % strongly agreed). After adjustment for demographic factors, significant linear trends of decreasing awareness of federal dietary guidance with increasing agreement with the statement that people are born to be fat or thin persisted. These trends were driven by significant differences between persons who strongly agreed with the statement and persons who somewhat agreed, somewhat disagreed, and strongly disagreed with the statement. Similar to what was observed for awareness of at least one of the three initiatives, a significant linear trend was seen for awareness of the Food Guide Pyramid and beliefs about body weight, with the lowest level of awareness among persons who strongly agreed with the statement that people are born to be fat or thin (74.2 %).

Mean nutrient intakes, based on 24-h dietary recall interviews, were estimated by awareness of the federal dietary guidance efforts with adjustment for demographic factors, body mass index (BMI), and energy intake (Table 14.3 and Fig. 14.3). Mean intake of sodium was higher in persons who were aware of at least one of the guidance efforts than in persons who were not aware. In persons reporting awareness of the DGA, mean intake of potassium was significantly higher than in persons who were not aware of the DGA. In persons aware of the Food Guide Pyramid, mean sodium intake was higher than in persons who were not aware. In persons reporting awareness of the 5 A Day Program, higher mean intakes were seen for magnesium, potassium, and fiber.

Conclusions

The study findings presented here indicate a higher prevalence of awareness of at least one of the three sets of federal dietary guidance in women, younger age groups, non-Hispanic whites, and persons with higher education and

Table 14.2 Estimated age-adjusted[a] and age-specific prevalence of awareness of federal dietary guidance by selected health characteristics and diet-related attitudes and behaviors in persons 16 years and older (National Health and Nutrition Examination Survey 2005–2006, United States)

	Population characteristics % (SE[b])	At least one[c] % (SE)	Dietary guidelines % (SE)	Food guide pyramid % (SE)	5 A day program % (SE)
Body mass index (kg/M²)					
<25.0	35.9 (1.41)	83.4 (1.44)	48.5 (1.74)	80.0 (1.53)	51.9 (1.34)
25.0–29.9	31.1 (0.79)	83.1 (1.35)	49.5 (1.79)	79.9 (1.45)	50.4 (2.61)
≥30.0	33.0 (1.47)	84.9 (1.21)	51.0 (1.64)	81.7 (1.41)	51.9 (2.11)
Smoking[d]					
Never	51.4 (1.37)	83.1 (1.25)	52.2 (1.37)	80.2 (1.43)	52.5 (1.92)
Former	24.9 (1.09)	83.5 (1.57)	51.1(2.13)	79.3 (1.77)	53.1 (2.27)
Current	23.7 (1.28)	82.8 (1.55)	49.0 (1.78)	78.9 (1.78)	49.9 (1.34)
How healthy is your diet?					
Excellent	8.8 (0.54)	82.7 (1.55)	54.5 (2.15)	80.0 (1.88)	54.8 (2.68**[e])
Very good	23.0 (0.96)	84.3 (1.42)	51.9 (2.40)	81.9 (1.49)	55.6 (1.63)
Good	40.4 (0.78)	84.7 (1.25)	49.7 (2.11)	81.2 (1.72)	51.9 (2.26)
Fair	21.5 (1.08)	82.4 (1.61)	46.3 (2.86)	78.7 (1.65)	46.7 (2.20)
Poor	6.3 (0.44)	83.6 (1.87)	46.4 (2.69)	79.1 (2.11)	45.0 (3.47)
Some people are born to be fat and some thin; there is not much you can do to change this					
Strongly agree	8.3 (0.52)	77.7 (1.98**[e])	47.6 (2.65)	74.2 (2.07**[e])	49.5 (3.66)
Somewhat agree	25.7 (0.84)	85.4 (1.57)	50.1 (1.81)	81.8 (1.72)	54.1 (2.23)
Neither agree nor disagree	11.0 (0.48)	82.0 (1.58)	46.0 (2.07)	78.8 (1.75)	48.3 (2.23)
Somewhat disagree	27.9 (0.94)	85.0 (1.17)	50.0 (1.98)	81.6 (1.10)	51.5 (1.43)
Strongly disagree	27.0 (1.21)	85.0 (1.59)	51.1 (2.44)	81.9 (1.79)	50.8 (1.98)
How often do you eat meals away from home?					
Never or <1/week	16.8 (1.00)	83.6 (1.61)	45.7 (1.39)	80.6 (1.83)	50.2 (1.83)
1/week	17.6 (1.09)	84.1 (1.51)	51.3 (2.03)	81.5 (1.79)	55.4 (2.08)
2/week	15.8 (0.70)	84.3 (0.86)	51.7 (2.44)	80.2 (1.19)	53.1 (1.94)
3/week	11.1 (0.40)	84.1 (1.17)	47.6 (2.52)	79.9 (1.59)	52.9 (1.88)
4–7/week	26.6 (1.24)	82.8 (1.95)	48.5 (2.24)	79.5 (2.29)	48.1 (2.46)
8+/week	12.0 (0.81)	85.6 (1.34)	54.2 (2.23)	82.3 (1.56)	51.0 (2.33)

Note: Reprinted from Journal of the American Dietetic Association, vol. 111, no. 2, Wright JD, Wang C-Y, Awareness of federal dietary guidance in persons aged 16 years and older: Results from the National Health and Nutrition Examination Survey 2005-2006, p. 295–300, 2011, with permission from Elsevier

**$p < 0.01$

[a]Estimates are adjusted for sex, age, race-ethnicity, education, and poverty income ratio (PIR) using logistic regression

[b]*SE* standard error

[c]At least one the of three federal dietary guidance initiatives

[d]Results by smoking status are presented for persons 20 years and older because comparable data were not collected for 16–19-year-olds

[e]Significant linear trend

income levels. Differences by smoking habits, frequency of eating out, and self-assessed diet quality were not significant after adjustment for demographic factors. High levels of awareness in some population subgroups suggest that education messages may have reached these groups. For example, the high awareness of the Food Guide Pyramid in 16–19-year-olds may reflect successful education programs in schools. The low levels of awareness of all of the federal dietary guidance efforts among Mexican Americans suggest that efforts to reach this group should be strengthened. Awareness of the Food Guide Pyramid was higher than awareness of the

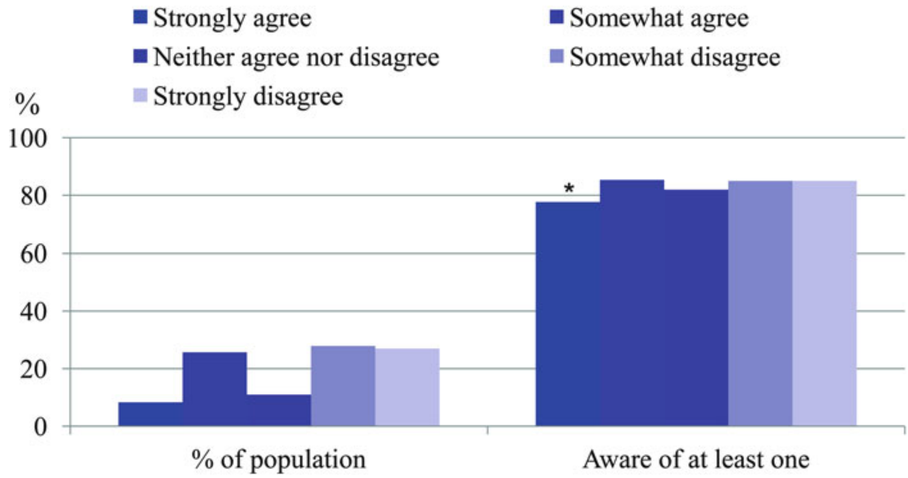

Fig. 14.2 Population distribution and awareness of federal dietary guidance by agreement with fatalistic statement on body weight. *Note*: Estimates are adjusted for sex, age, race-ethnicity, education, and poverty income ratio (PIR), by logistic regression. Survey participants were asked whether they agreed with the following statement: Some people are born to be fat and some thin; there is not much you can do to change this. (National Health and Nutrition Examination Survey 2005–2006, United States). $*p<0.01$ for linear trend of lower awareness with increasing agreement with statement

Table 14.3 Estimated mean (standard error of mean) nutrient intakes by awareness of federal dietary guidance in persons 16 years and older (National Health and Nutrition Examination Survey 2005–2006, United States)

	At least one[a]		Dietary guidelines		Food guide pyramid		5 A Day Program	
Nutrient	Aware	Not aware	Aware	Not aware	Aware	Not aware	Aware	Not aware
Total energy (kcal)[b]	2,271 (27.0)*	2,116 (58.6)	2,224 (34.8)	2,270 (31.9)	2,278 (28.4)*	2,112 (49.5)	2,250 (28.4)	2,244 (46.7)
Protein (%kcal)[b]	15.8 (0.11)	15.2 (0.28)	15.9 (0.15)	15.5 (0.10)	15.7 (0.11)	15.5 (0.24)	16.0 (0.16)*	15.4 (0.10)
Carbohydrate (%kcal)[b]	48.4 (0.32)	49.4 (0.64)	48.4 (0.37)	48.7 (0.34)	48.4 (0.35)	49.0 (0.54)	48.5 (0.43)	48.6 (0.35)
Total fat (%kcal)[b]	33.9 (0.26)	33.0 (0.47)	33.9 (0.27)	33.6 (0.30)	34.0 (0.26)*	32.8 (0.44)	33.9 (0.50)	33.6 (0.31)
Saturated fat (%kcal)[b]	11.3 (0.12)	11.1 (0.20)	11.3 (0.13)	11.2 (0.11)	11.3 (0.12)	11.1 (0.17)	11.2 (0.14)	11.4 (0.13)
Cholesterol (mg)[c]	298 (4.3)	291 (7.3)	304 (5.1)*	290 (5.0)	297 (4.7)	297 (5.7)	301 (4.3)	293 (7.3)
Sodium (mg)[c]	3,633 (45.9)*	3,432 (57.5)	3,640 (49.6)	3,564 (51.1)	3,636 (46.5)*	3,454 (56.8)	3,605 (42.7)	3,598 (56.2)
Calcium (mg)[c]	973 (18.7)	913 (28.5)	978 (22.2)	950 (17.8)	976 (18.7)*	912 (23.2)	976 (21.1)	951 (17.0)
Magnesium (mg)[c]	305 (3.7)*	286 (4.5)	307 (3.4)*	297 (3.8)	305 (3.7)*	287 (4.3)	310 (3.8)*	293 (3.4)
Potassium (mg)[c]	2,746 (29.7)*	2,570 (55.6)	2,770 (26.4)*	2,666 (32.7)	2,745 (28.9)*	2,603 (51.6)	2,774 (31.0)*	2,658 (33.2)
Fiber (g)[c]	15.8 (0.21)	14.9 (0.51)	16.1 (0.24)*	15.2 (0.25)	15.8 (0.21)*	14.8 (0.42)	16.2 (0.23)*	15.1 (0.27)

Note: Unpublished table
$*p<0.002$ difference between aware and not aware
[a]At least on the of three federal dietary guidance initiatives
[b]Estimates are adjusted for sex, age, race-ethnicity, education, PIR, and BMI using linear regression
[c]Estimates are adjusted for sex, age, race-ethnicity, education, PIR, BMI, and total energy using linear regression

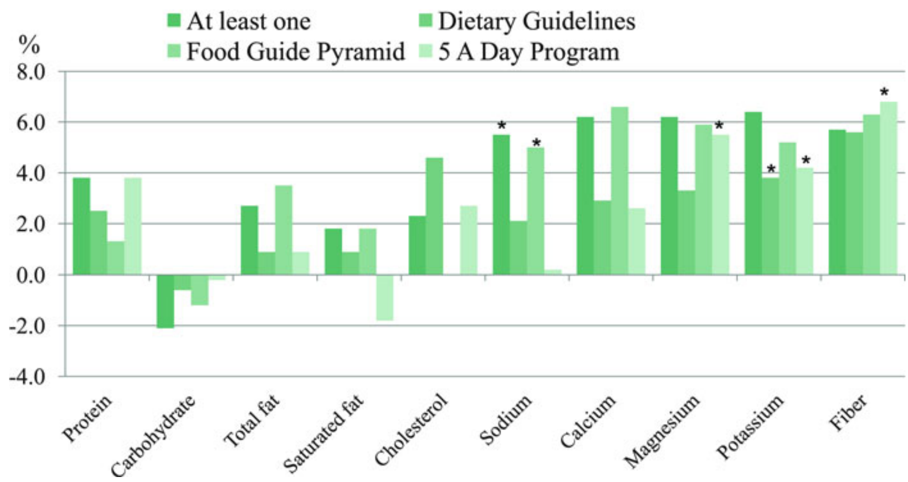

Fig. 14.3 Percent difference in mean nutrient intake by awareness of federal dietary guidance (National Health and Nutrition Examination Survey 2005–2006, United States) *Note*: % difference = [(aware-not aware/aware)*100]. Estimates for protein, carbohydrate, total fat, and saturated fat are adjusted for sex, age, race-ethnicity, education, PIR, and BMI using linear regression. Estimates for cholesterol, sodium, calcium, magnesium, potassium, and fiber are further adjusted for total energy. *$p<0.002$

other two guidance efforts. There were some differences in nutrient intakes associated with awareness of dietary guidance. Mean intakes of magnesium, potassium, and fiber were significantly higher in persons aware of the 5 A Day Program than in persons not aware of the program. This suggests some beneficial differences in nutrient intake with higher levels of awareness. However, higher mean sodium intakes were estimated in persons reporting awareness of the Food Guide Pyramid.

The 2005 FDA's Health and Diet Study reported similar findings with 48 % of adults reporting that they had heard of the Dietary Guidelines and that younger persons, women, and persons with more education were more likely to report awareness [19]. Awareness of the other two programs was lower than in the results presented here with only 49 % of adults having heard of the Food Guide Pyramid and only 38 % of adults having heard of the 5 A Day Program. A 1995 FDA survey found that more adults were aware of the Food Guide Pyramid (43 %) than the Dietary Guidelines (30 %) or the 5 A Day Program (24 %) [20]. Similar to the results presented here, the 1994–1996 Diet and Health Knowledge Survey of meal preparers reported the smallest percentage of adults strongly agreed with the statement that people are born to be fat or thin (13.7 %) [21]. In the NHANES 2005–2006, the differences in awareness seen with beliefs about body weight indicate that the small proportion (8.3 %) of the population who strongly agree with the fatalistic statement on body weight are somehow different from the proportion who believe body weight can be changed.

These study findings are subject to some limitations. The estimated nutrient intakes are subject to recall bias and increased intraindividual variations associated with 24-h recall methodology. The increased intraindividual variation may have attenuated some of the differences in estimated nutrient intakes. It is possible that social desirability has influenced response to the questions on awareness of dietary guidance [22–24]. Another possible limitation is that respondents may have been thinking of the newer version of the USDA food guide, MyPyramid, when answering the question on having heard of "the Food Guide Pyramid." MyPyramid received substantial media attention when it was released in April 2005 which was during the data collection period for the NHANES 2005–2006. The other two federal dietary guidance efforts examined were released earlier; the 5 A Day for Better Health Program was initiated in 1991, while the last edition of the Dietary Guidelines was published in January 2005 [25–27]. The higher estimated awareness for the Food Guide Pyramid than for the other two programs may in part reflect the more recent publicity this program received.

Models of behavioral change specify that knowledge is a necessary, although not sufficient, requirement for successful behavior change [28]. Awareness of DGA can be quite high and still not translate into changed eating behaviors; once awareness is improved and education has increased nutrition knowledge, this does not automatically lead to improved diet quality. Wansink's research on mindless eating identified many factors other than awareness of healthy diets affect eating behavior [29].

An important aspect to understanding the observed differences between awareness of nutrition guidance and dietary behaviors in adherence of DGA is the concept of health literacy. Awareness is modified by health literacy level, and nutrition literacy can be measured using "Newest Vital Sign" [30]. Health literacy can be assessed using instruments such as the Test of Functional Health Literacy in Adults. Population-wide education efforts should take into account the varying health literacy levels in the population. Additional effort to translate the guidelines into interpretable and understandable advice may be required. A better understanding is needed of how health literacy affects the awareness and understanding of federal dietary guidance and the adoption of dietary recommendations.

There is a distinction between awareness and knowledge. Guthrie and coauthors proposed that awareness of DGA is distinct from knowledge of nutrition principles and from "how-to" knowledge [31]. Awareness of nutrition guidelines might stimulate interest in acquiring "how-to" knowledge that would result in dietary behaviors adhering to the DGA. Post and coauthors examined reported use of food labels among persons who reported being diagnosed with chronic conditions including type 2 diabetes, hypertension, or hyperlipidemia in comparison with persons not reporting these diagnoses [32]. They found higher reported use of food labels and more favorable nutrient intakes among persons with the diagnosed chronic conditions. Specifically, among persons diagnosed with the selected chronic conditions, those reporting use of food labels had lower dietary intakes of total energy, saturated fat, carbohydrates, and sugar and higher intakes of fiber than among those who did not report use of food labels. Noting the gap between knowledge and behavior, Folta and Nelson described techniques aimed at bridging the gap between awareness and behavioral change, specifically motivational interviewing and evidence-based community programs for reducing cardiovascular disease (CVD) risk [33].

Awareness of healthy eating habits is an important piece of the puzzle of affecting dietary change in the US population. But it is only one piece of the puzzle. The conclusion of the 2010 edition of the DGA directs that "We must value preparing and enjoying healthy food and the practices of good nutrition, physical activity, and a healthy lifestyle" [2]. This is more than simply promoting awareness of nutrition guidelines but encouraging a shift in values with a focus on food preparation and enjoyment of healthy food.

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Food Choices and Healthy Eating in Hispanic Adults

15

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Key Points

- Hispanics comprise the largest minority group in the United States.
- Hispanics face greater risks of diet-related health problems such as food insecurity obesity, and chronic diseases.
- Dietary acculturation is when an individual from a minority group adopts the eating patterns or food choices of the host country.
- Differences in diet patterns and food choices are observed within Hispanic subgroups and among Hispanics and other ethnic groups.
- Traditional Hispanic foods which are fresh and rich in complex carbohydrates, micronutrients, fiber, and phytochemicals, are being replaced by highly processed foods with higher amounts of salt, sugar, and fat.
- Food acculturation may not change the percentage of the contribution that a specific food group has in the total calorie intake but it can have an impact on the kind of foods that are selected.

Keywords

Hispanics • Adults • Food choices • Healthy eating • Food acculturation

Abbreviations

AA	Anglo-American
CA	Central American
BMI	Body mass index
LIH	Low-income Hispanics
MA	Mexican American
ME	Mexican
NHANES	National Health and Nutrition Examination Survey
PR	Puerto Rican
RDA	Recommended dietary allowances
SA	South American
US	United States

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V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health,
DOI 10.1007/978-1-4614-7315-2_15,

Introduction

Hispanics comprise the largest minority group in the United States (US); it is estimated that by 2050, they will represent about 25 % of the US population [1]. The US Office of Management and Budget defines the terms "Hispanic," "Latino," and "of Spanish origin" as a "person of Cuban, Mexican (ME), Puerto Rican (PR), Central American (CA) or South American (SA), or other Spanish culture origin, regardless of race" [2]. Sometimes the terms "Latino" and "Hispanic" are used interchangeably; however, these terms are not used in Hispanic American countries; people from these countries prefer to refer themselves with national terms like "Colombians," "Costa Ricans," "Mexicans," or "Dominicans." Although, most of the Hispanics share a language (Spanish) and some cultural values, they should not be considered a homogenous group; Hispanics came from different sociocultural contexts [3]. Studies have demonstrated that Hispanics have differences in several socioeconomic indicators, health outcomes, lifestyle behaviors, and cultural characteristics [4, 5]. This chapter focuses on one of the main differences found within the Hispanic population—food-related practices.

The Hispanic Population in the United States

Even though the majority of Hispanics are located in Hispanic America, a large number of them live in the US. In fact, according to the US Census Bureau, in 2010, there were 50.5 million Hispanics living in this country (16 % of the population), and by 2050, they will represent 17 % of the elderly population [6, 7]. The distribution of Hispanics in the USA is shown in Fig. 15.1. MEs represent the largest US Hispanic group (63 %), followed by PRs (9.2 %), CAs (7.9 %), SAs (5.5 %), and Cubans (3.5 %). Currently, the majority of Hispanics live in the Western US [8]. Yet, between 2000 and 2010, the Hispanic population grew most significantly in the South and

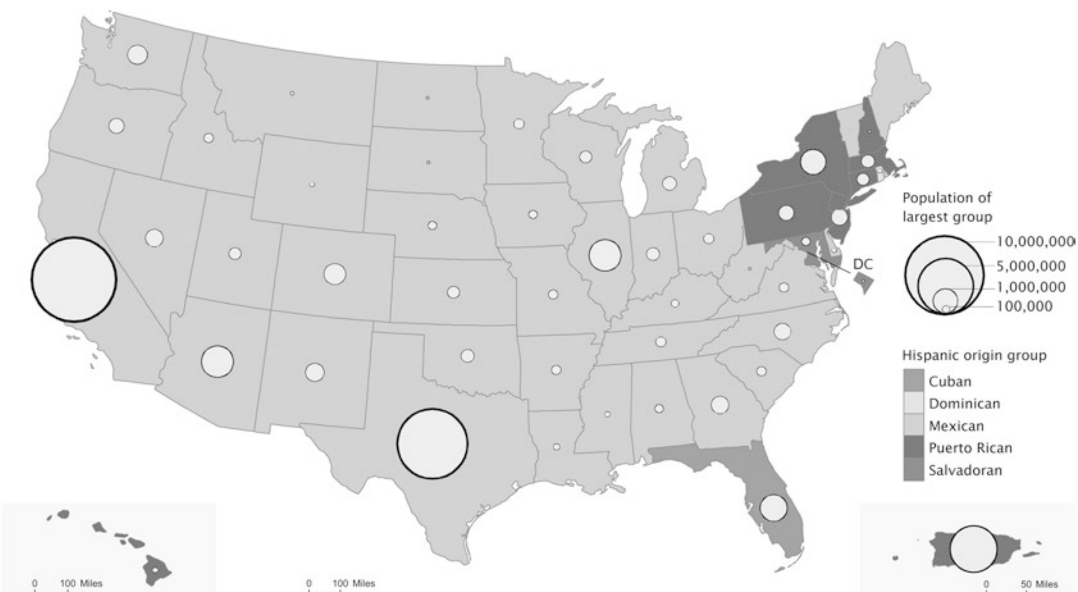

Fig. 15.1 Distribution of largest Hispanic origin group in the United States by state. The area of each *circle* symbol is proportional to the population of the largest Hispanic origin group in a state. *Source*: US Census Bureau, 2010 Census. The Hispanic population: 2010. Copyrighted by US Census Bureau with permission from reference [8]. With rare exceptions, US Census Bureau materials are entirely in the public domain (items that include copyrighted material indicate what is copyrighted). The Census Bureau does ask that you cite it as the source of any material you republish, however

Midwest [8]. In the US, Hispanics represent a minimum of 20 Latin American and Caribbean countries, and 40 % of them were born outside of the US [9].

Hispanic Health Disparities

Despite living in relatively poor social or economic conditions, Hispanics have often shown better health/mortality outcomes compared to non-Hispanic Whites—a phenomenon referred to as "The Hispanic Paradox" [10]. However, several epidemiological studies have belied this paradox by showing that Hispanics face greater risks of diet-related health problems such as food insecurity, obesity, and chronic diseases [11].

Data from the 2009 National Food Security Survey (NHANES) (n=46,000 households) showed that children living in Hispanic households had the highest prevalence of food insecurity (18.7 %) compared to children living in White non-Hispanic (7 %) and Black non-Hispanic households (17.2 %) [12]. And according to the 2007–2008 NHANES (n=5,555), the prevalence of being overweight was higher in Hispanics (76.9 %) than in Whites (67.5 %) and Blacks (73.7 %) [13]. Meanwhile, both Hispanic women and men had higher triglycerides, body mass index (BMI), and blood pressure and lower high-density lipoprotein cholesterol than non-Hispanic Whites [14]. Other studies have found that Hispanics tend to also have a higher prevalence of metabolic syndrome and diabetes mellitus than other race/ethnic groups [15, 16].

Acculturation

It is methodologically challenging to fully comprehend Hispanics' health disparities and modifiable risk factors (i.e., food and physical activity behaviors), as these differences vary in function of acculturation [4]. Acculturation takes place when an individual (from a minority group) is repeatedly exposed to the influences of a new culture and adapts his or her behavior accordingly [17], then the assimilation to a new culture could occur at different rate. Individuals coming from countries with cultures that are similar to the host country's culture will adapt more rapidly than individuals with cultures completely different from the host country's culture. On the other hand, acculturation may be facilitated or hindered by several factors such as an individual's level of education, age at emigration, and voluntary vs. nonvoluntary migration [11].

Dietary Acculturation

Specifically, when an individual of a minority group adopts the eating patterns or food choices of the host country is known as *dietary acculturation* [17]. Although Hispanic immigrants bring their own cultural and food-related traditions with them, they also learn new ways to use traditional foods, exclude other traditional foods, and/or consume "new" ones. Figure 15.2 shows a model of dietary acculturation that was proposed by Satia-Abouta et al. [11]; the model shows a complex and dynamic relationship between socioeconomic, demographic, and cultural factors. During the acculturation process, all these factors interact with the host culture, predicting the degree to which new immigrants may modify their attitudes and beliefs about food, taste preferences, and food selection and preparation. Finally, a change of dietary intake patterns occurs [11].

Traditional Hispanic Diet

The current practices of Hispanics in the host country are also highly predisposed by the traditional foods and meal patterns from the country where they come from and from the place/region where they grew up in their home countries [3]. As it was mentioned previously [18], Hispanics in the USA are people or descendants of people who come from Cuba, Mexico, Puerto Rico, and other Spanish-speaking countries in Central America (Costa Rica, Guatemala, Honduras, El Salvador, Nicaragua, or Panama), South America (Argentina, Bolivia, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, or Venezuela), or in the Caribbean (the

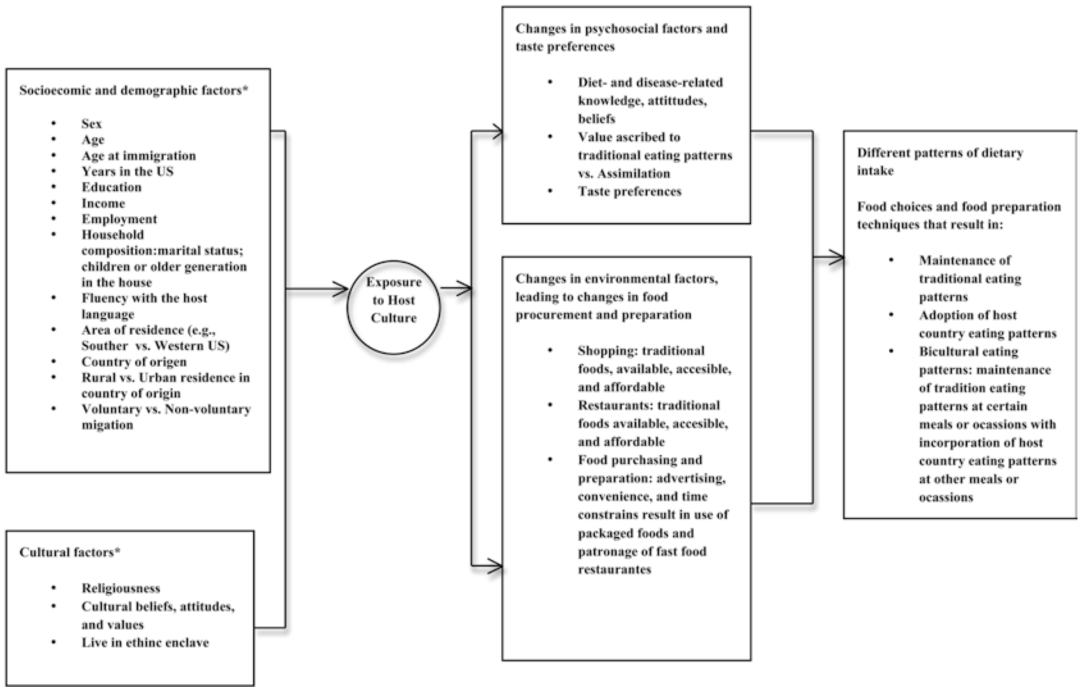

Fig. 15.2 Model of dietary acculturation. Relationship between socioeconomic, demographic, and cultural factors that occur during the acculturation process. *Asterisk* Some of these factors may also be influenced by exposure to host country. Copyrighted by Elsevier. Reprinted with permission from reference [11]

Dominican Republic). These Hispanic American countries generally share most of the foods that are traditionally consumed (i.e., grains, beans, fresh fruits, and vegetables). However, the ingredients, the preparation techniques, the inclusion of culinary marinades and seasonings, and even the names of similar foods and dishes are different for each country and can also vary from one region to another within the same country (see Table 15.1). These differences can be explained by regional characteristics specific of each country such as type of ancestral cuisine, cultural traditions, climate, geography, farming practices, types of holidays, dietary guidelines, and level of adoption of a “Western diet” [19].

Ancestral Cuisine

Hispanic cuisine is derived mainly from the combination of cooking styles, foods, and ingredients

Table 15.1 Understanding the Hispanic culture: traditional Hispanic foods and different ways to name them in Hispanic America

English term	Terms used in Hispanic America
Avocado	Aguacate, cura, palta
Banana	Banano, platano, guineo
Beans	Frijoles, fríjoles porotos, habichuelas
Beet	Remolacha, betabel, betarraga
Brown sugar sugarloaf	Tapa de dulce, panela, piloncillo, chancaca
Corn	Elote, maíz, choclo, chicha, cochlo
Cilantro	Culantro, cilantro
Bell peppers	Chile morrón, chile dulce, pimentón, morrón
Rice and beans	Gallo pinto, casamiento, calentado
Sour cream	Crema, natilla
Strawberries	Fresas, frutilla
Sweet potato	Camote, patata
Tomato	Tomate, jitomate

Comparison of how traditional foods are called differently depending of the country where it is consumed
Previously unpublished data

of the Spanish colonies and native Indians [19]. Nevertheless, there are also some traditional Hispanic dishes (i.e., Argentinean pastas and pizzas) that come from countries/regions influenced by other Europeans colonies (i.e., Italians) and Africans ancestry.

Daily Meal Patterns

The traditional Hispanic meal pattern consisted of *desayuno* (breakfast), *almuerzo* (lunch), and *cena* (dinner) with snacks in between (i.e., coffee, tea, hot chocolate, or *maté* with sweet bread, pastry, or fresh baguette bread) [19]. *Almuerzo* (known as *comida* in Mexico) is generally the main and largest meal of the day, while *cena* (known as *comida* in Colombia) is a smaller meal that often includes lunch leftovers and is eaten late in the afternoon (after 7 pm). Depending on the country, breakfast could be a quick light meal or a full breakfast. For example, a typical ME or SA breakfast includes coffee with some bread (toast or *pan dulce*, sweet bread). Occasionally, in some SA countries, they also have fresh fruits, ham or cheese, and tea instead of coffee [19]. On the other hand, a CA breakfast often include eggs, fresh cheese, sausage, beans, corn tortillas, bread, fresh fruits, fresh orange juice, and coffee. A traditional daily breakfast dish from Costa Rica and Nicaragua is the *gallo pinto* (spotted roster), in which rice and beans are cooked together with natural spices (peppers, onions, and cilantro). In these countries, *gallo pinto* is served with scrambled or fried eggs, bread or tortillas, fried plantains, *salchichón* (sausage), and *natilla* (sour cream). A similar dish is found in Panama and in El Salvador, but it is called *casamiento*. See Table 15.2 to identify traditional lunch foods/meals in specific Hispanic American countries.

Traditional Major Foods

In Mexico, the traditional diet is primarily vegetarian and is based on beans, maize, and *calabacitas* (a type of squash). It also includes a variety of other foods such as nopales (tender cactus leaves), *agave*, *verdolaga*, and *quelites* (greens) as well as *chiles* (peppers) and *tomatillo*. Nowadays, tortillas (corn and flour), hot peppers, tomato, onion, rice, and frijoles are the staples of the MEs diet. Similarly, corn (eaten mostly as handmade tortillas in the south of Mexico), beans, and rice are the staples of CAs daily diet and are usually served at lunch and dinner with some sort of meat, poultry, or fish; local vegetables; and agua fresca (water, sugar, and fresh-squeezed fruit juice).

Table 15.2 Traditional lunch menus of specific Hispanic American countries

Mexican	Costa Rican "casado"	Colombian "corrientazo"	Ecuadorian
Fried rice cooked with tomato and onions	Rice cooked with sliced red bell peppers and onions	"Principio": soup	"Locro" (potato soup, prepared with milk and cheese and served with avocado)
Beans	Beans	"Seco" which includes beans, fried eggs, and/or meat	Rice
Steak, pork or chicken sautéed with tomato, onions, and peppers	Steak, pork or chicken sautéed with onions	Salad prepared with cabbage and carrots	Salad prepared with beet and tomato
Corn tortillas	Fried plantains	"Patacones": fried green plantains	"Menestra": beans or lentils
"Agua fresca": fresh fruit blended with water and sugar (i.e., cantaloupe)	Handmade corn tortillas Salad prepared with cabbage, tomato, and lemon juice "Fresco": fresh fruit juice (i.e., cas, starfruit, tamarind)	"Jugo": fresh fruit juice (i.e., guava, lulo)	"Seco de pollo": stewed chicken

Foods and dishes included in a traditional meal of different Hispanic groups
Previously unpublished data

The staple foods of Puerto Rico, Cuba, and the Dominican Republic are rice and beans. Beans in all of these Caribbean countries are prepared similarly—fried with lard and salt. However, PRs prefer pink and red kidney beans, Cubans prefer black beans, and Dominicans prefer Roman beans [20]. Other Caribbean traditional foods include plantains, *viandas* (root vegetables), *cassava* (yucca), *ropa vieja* (shredded beef), fried meats (mostly chicken), *café con leche* (espresso coffee with hot steamed milk), coconut, and limejuice for seasoning meats and fish.

The SA diet has more variation compared to the Hispanic American regions mentioned above. In general, SA diets are essentially based on corn, chile peppers, tomatoes, beef, rice, onions, olive oil, stuffed foods (*empanadas*, turnovers), potatoes (especially in Peru and Ecuador), beans, and tropical/temperate fruits and vegetables such as strawberries, guava, and cassava [19].

Changes of Traditional Dietary Patterns

Nowadays, with globalization, many Hispanic American countries (especially in urban areas) are replacing traditional dietary patterns with Western diets. Therefore, traditional Hispanic foods, which are fresh and rich in complex carbohydrates, micronutrients, fiber, and phytochemicals, are being replaced by highly processed foods with higher amounts of salt, sugar, and fat [21].

Acculturation and Dietary Quality

Several studies have looked at the effects of acculturation on diet among Hispanics. In general, the majority of studies that have explored acculturation have shown a statistically significant association between the level of acculturation and diet. However, results varied depending on how acculturation was measured [3, 4]. As a whole, negative effects between level of acculturation and dietary intake were observed, such as a decrease of bean consumption [22, 23] and an increase in the consumption of meat (mainly as hamburgers from fast-food restaurants) [23] and foods high in added sugars such as ready-to-eat cereals and soft drinks [22–26]. At the same time, both less- and more-acculturated Hispanics infrequently chose skim milk at fast-food restaurants [27].

In relation to fruit and vegetable consumption, among less-acculturated Hispanics, it increased moderately with immigration; however, consumption of fruit-base beverages diminished. In their home countries, Hispanics usually drink *aguas de sabor*, a mix of water, sugar, and fresh fruit (such as watermelon, *guayaba*, cantaloupe); these types of beverages are prepared because they are cheaper than soft drinks. After migration, Hispanics consume more soft drinks because fresh fruit becomes more expensive to purchase. More-acculturated Hispanics eat fewer portions of fruit and vegetables per day ($p \leq 0.02$) [27]. Place of birth also has a large influence on the consumption of fruits and vegetables, as Hispanics not born in the United States eat more fruit and vegetables than do their US-born counterparts [27]. No significant differences have been found in the consumption of fruits and vegetables among Hispanics subgroups ($n = 7,954$; $p = 0.86$ for women; $p = 0.24$ for men), and although their reported intake is greater compared to other ethnic groups, they do not meet recommendations [28].

Food acculturation may not change the percentage of contribution that a specific food group has in the total calorie intake, but it can have an impact on the kind of foods that are selected; for example, after immigration, MAs consume less lard and Mexican cream but more salad dressing and mayonnaise [23]. Some studies have produced contradictory results related to fat intake; research conducted among MAs found that those born in Mexico or who were less acculturated (i.e., were Spanish speaking) had diets lower in fat and higher in dietary fiber [29, 30], while others found an inverse association [31]. In some cases, positive and negatives change have been observed, included cooking with less fat, baking more frequently than frying, and using vegetable oil instead of lard as a positive food behavior and eating a greater quantity of meat, skipping meals, and eating more fast food than they did in their native country as negative food behavior, although the causes of these changes were not reported as negative [23].

Studies on the consumption of sugar and acculturation have shown more consistent findings. More-acculturated Hispanics consume more sugar than their less-acculturated counterparts [23, 25].

The association of dietary patterns and acculturation, particularly among Hispanics, is only somewhat understood; more research is needed in order to increase understanding of how acculturation influences food selection. Studies need to consider the social, economic, and built environment context in which the process of acculturation takes place.

Food Choices and Practices of Hispanics

People's decisions on what and when to eat are influenced by the interaction of cultural, personal, behavioral, social, and environmental factors. The literature reports that food preference is the main reason people make food choices. Other influencing factors on individuals' food choices include habits, ethnic heritage, social interactions, availability, convenience, economy, emotional comfort, values, positive and negative associations toward determined food, body weight and image, and the nutritional content and health benefits of foods [32]. Because of these factors, differences in diet pattern and food choices are observed within Hispanic subgroups and among Hispanics and other ethnic groups.

The dietary guidelines for the US population establish five principal food groups: grains, fruits, vegetables, dairy, and protein foods [33]; differences in the distribution of servings within these major food groups are observed among Whites, Blacks, and Mexican Americans ($n=431$) [34]. Blacks and MAs obtain higher percentages of all nutrients from the meat group (read meat, fish, poultry, and eggs) than Whites. Milk and milk products were the main contributors of calcium for all ethnic groups, and dried and fluid milk was the major contributor to calories and protein, in all ethnic groups, as well as the major contributor of carbohydrates, total and saturated fat, and cholesterol for Blacks and MAs; while the cream and ice cream subgroup was the main provider of these nutrients for Whites. Meanwhile, MAs consumed the greatest percentage of calories, carbohydrates, and proteins and the least amount of dietary fiber from grains. Vegetables were the greatest contributors of fiber for Whites, while for MAs, it was legumes, and for Blacks, it was grains. Whites consumed a greater percentage of calories from high-fat foods than the other ethnic groups, and Blacks consumed the greatest consumption of fried foods.

Other study reported similar findings [35]; the mean calorie intake was higher among Whites (2,023 ± 991.0), followed by MAs (1,902 ± 971.7) and Blacks (1,730 ± 815.6). MAs had the highest intakes of carbohydrates (119 ± 31.1 g/1,000 kcal, $p<0.05$) and the lowest total fat intake (39 ± 12.2g/1,000 kcal, $p<0.05$). Even though intakes of saturated fat and cholesterol were not statistically significant among the three ethnic groups, Blacks had the highest cholesterol intakes (206.1 ± 207.4 mg/1,000 kcal), and Black males had the highest intakes of saturated fat (13.2 ± 6.2 g/1,000 kcal). Meanwhile, no significant differences were observed in the intakes of vitamin A, expressed in retinol equivalents (RE), and vitamin C; but Blacks had the highest intake of these nutrients (888.6 ± 1450.4RE/1,000 kcal and 60.9 ± 70.6 mg/1,000 kcal, respectively). Mean intakes of calcium and phosphorus were significantly higher for Whites compared with those for Blacks and MAs (330.8 ± 194.6 mg/1,000 kcal, 262.7 ± 159.6 mg/1,000 kcal, 255.2 ± 176.9 mg/1,000 kcal; $p<0.05$). And finally, Blacks had the lower mean intake of fiber (7.2 ± 6.2 g/1,000 kcal, $p<0.05$).

A study conducted among Anglo-Americans (AA) ($n=916$) and MAs ($n=1{,}254$) in the USA [36] found no differences in energy intake between AA and MA men (2,415 ± 46 vs. 2,414 ± 40, $p=0.985$), but MA females consumed more calories than AA females (1,646 ± 25 vs. 1,590 ± 29, $p=0.008$). In addition, MAs, both male and female, consumed less protein (as a percentage from total calories). Carbohydrates consumption was higher among MAs (42.4 ± 0.5 and 43.7 ± 0.4 for men and women, respectively).

No differences were found in total fat consumption, but MA males had a higher consumption of saturated fat than AA males (14.3 ± 0.2 vs. 13.6 ± 9.2, $p = 0.027$).

Additional research conducted among African Americans ($n = 31{,}902$); Hispanics born in Mexico, Central America, and South America ($n = 21{,}083$); and Hispanics born in the USA ($n = 21{,}868$) [37] found that Hispanics born in Mexico or Central and South America had the largest mean energy intake (2,716 ± 1,401 and 2,316 ± 1,238 for men and women, respectively) compared with African Americans (2,194 ± 1,166 and 1,879 ± 993 for men and women, respectively) and US-born Hispanics (2,468 ± 1,261 and 2,056 ± 1,104 for men and women, respectively). Also, this group reported the highest mean intake of all food groups. All ethnic groups exceeded the recommended intake of meats and other sources of protein. None of the ethnic groups met the recommended intake of dairy products; however, Hispanics born in Mexico or Central and South America reported the highest mean intake (1.9 ± 1.4 and 1.8 ± 1.4 for men and women, respectively) and African Americans, the smallest (1.1 ± 1.0 and 1.1 ± 0.9 for men and women, respectively). Contrary, in another study [38], MAs had lower mean intakes of calcium.

A regional study conducted with Hispanic migrant workers ($n = 401$) [39] found that a considerable number of participants did not meet the recommended intake levels of food groups and/or certain nutrients. In fact, a large number of participants reported consuming no fruit, vegetables, or dairy products, and more than half of the female participants were below the suggested number of servings for all food groups. These findings are consistent with those of other studies [27, 40].

Siega-Riz et al. examined breakfast food patterns in adults ($n = 15{,}641$) [41]; results showed that Hispanics were more likely to consume a bread- or egg-based breakfast (24.2 % and 17.9 %, respectively), while non-Hispanic Whites were more likely to consume a bread- or ready-to-eat-cereal-based breakfast (22.5 % and 19.6 %, respectively). However, Hispanics were more likely to eat a fruit-based breakfast than were non-Hispanic Whites (6.3 % vs. 5.5 %), but they were also slightly more likely to skip breakfast (17 % vs. 16.2 %).

Although some generalizations can be made, studies have found some differences in the dietary patterns within the Hispanic population [42, 43]. Table 15.3 shows the differences in the food intake of MEs ($n = 153$), CAs ($n = 45$), and SAs ($n = 76$) [43]; ME men had the largest mean intakes of grains (10.2 ± 5.16) and meats and beans (7.5 ± 5.5). The diet of CA men had the largest mean intake of vegetables (2.3 ± 2.8), while the biggest mean intakes for SA men were fruits (2.5 ± 2.4), dairy (2.4 ± 1.9), and oils (2.34 ± 2.6). For ME woman, their greatest mean intake was grains (6.65 ± 3.25), while their CA counterparts reported a large mean intake of fruits (2.15 ± 1.74), and meat and beans (5.19 ± 3.34). SA women reported the greatest mean intake of vegetables (2.20 ± 1.79), dairy (1.82 ± 1.65), and oils (2.53 ± 3.08).

In another study among MAs ($n = 3{,}239$), Puerto Ricans ($n = 1{,}180$), and Cuban ($n = 852$) adults [42], Puerto Rican men had higher usage of whole milk (2.5 times) compared to MAs men. Also, differences were found in the consumption of the combined protein-rich food group, eggs, legumes, organ meats, and mixed dishes. About 50 % of MAs consumed more than one portion a day of protein-rich foods. This percent was higher than that of Cuban and Puerto Rican men and of Cuban women. Meanwhile, nearly three out of four Cuban or Puerto Rican individuals reported not having consumed eggs in the 3 months before the interview, compared with one in ten MAs. In addition, the percentage of MAs consuming more than one portion of legumes a day was higher than that of Cuban and Puerto Ricans. However, the consumption of saturated fat and monounsaturated fat was greater among MA men than among Puerto Rican men, and MA women had a higher mean intake of cholesterol than did Puerto Rican women. Additionally, intakes of dietary fiber were greater for MAs than for the other ethnic groups. In summary, most of the differences found in the eating patterns between Puerto Ricans, MAs, and Cubans were not unpredicted due to the traditional eating patterns of each ethnic group.

Table 15.3 MyPyramid serving's intake per day for Mexicans, Central Americans, and South Americans (*n* = 274)

MyPyramid serving[a]	Mean ± SE ME men ± (*n* = 73)	CA men (*n* = 24)	SA men (*n* = 21)	ME women (*n* = 80)	CA Women (*n* = 21)	SA women (*n* = 55)
Total grain	10.2 ± 5.16	9.5 ± 4.39	5.3 ± 3.15	6.65 ± 3.25	4.31 ±2.90	4.64 ±2.47
Whole grain	4.0 ± 3.34	5.7 ± 3.66	5.0 ±3.32	2.93 ± 2.87	1.48 ± 1.88	0.18 ± 0.60
Refined grain	6.2 ± 4.71	3.8 ± 4.59	0.3 ± 4.8	3.72 ± 2.68	2.83 ±2.51	4.46 ± 2.42
Total vegetables	2.1 ± 1.8	2.3 ± 2.8	2.2 ± 2.0	1.95 ± 2.01	1.94 ±1.72	2.20 ± 1.79
Dark green	0.07 ± 0.3	0.1 ± 0.6	0.1 ± 0.39	0.08 ± 0.33	0.03 ± 0.15	0.15 ± 0.46
Deep yellow	0.08 ± 0.3	0.03 ± 0.1	0.1 ± 0.15	0.09 ± 0.29	0.13 ± 0.37	0.12 ± 0.18
Tomato	0.7 ± 0.8	0.4 ± 1.0	0.2 ± 0.21	0.47 ± 0.51	0.25 ± 0.40	0.40 ± 0.53
Potato	0.4 ± 0.7	0.9 ± 1.1	0.5 ± 0.8	0.26 ± 0.64	0.55 ± 1.03	0.65 ± 1.08
Other starchy	0.04 ± 0.08	0.1 ± 0.6	0.1 ± 0.2	0.06 ± 0.15	0.08 ± 0.27	0.11 ± 0.31
Other vegetables	0.8 ± 0.9	0.6 ± 1.2	1.2 ± 1.5	0.99 ± 1.46	0.90 ± 1.20	0.77 ± 0.80
Total fruits	1.7 ± 2.4	1.5 ± 2.1	2.5 ± 2.4	2.02 ± 2.13	2.15 ± 1.74	2.00 ± 2.09
Fruit juices	0.8 ± 1.5	1.0 ± 1.9	1.0 ± 1.5	0.58 ± 1.22	0.86 ± 1.41	0.76 ± 1.39
Whole fruits	0.8 ± 1.8	0.3 ± 0.57	0.8 ± 0.7	1.22 ± 1.53	1.16 ± 1.20	0.95 ± 1.24
Other fruits	0.02 ± 0.1	0.2 ± 0.6	0.7 ± 1.5	0.22 ± 0.87	0.13 ± 0.62	0.29 ± 0.72
Total dairy	1.3 ± 1.6	1.2 ± 1.5	2.4 ± 1.9	1.71 ± 1.55	1.14 ± 1.51	1.82 ± 1.65
Milk	0.7 ± 1.0	0.5 ± 0.7	1.3 ± 1.2	1.01 ±0.93	0.60 ±0.85	0.79 ± 0.98
Cheese	0.5 ± 1.1	0.5 ± 0.8	0.7 ± 0.8	0.58 ± 1.18	0.31 ± 0.68	0.72 ± 0.71
Yogurt	0.03 ± 0.1	0.0 ± 0.0	0.03 ± 0.15	0.03 ± 0.13	0.14 ± 0.45	0.04 ± 0.16
Other dairy	0.06 ± 0.4	0.2 ± 0.5	0.4 ± 0.7	0.09 ± 0.29	0.09 ± 0.43	0.27 ± 0.67
Total meats and beans	7.5 ± 5.5	5.6 ± 3.0	6.9 ± 3.9	4.32 ± 3.10	5.19 ± 3.34	4.68 ± 2.87
Legumes	0.6 ± 0.8	0.5 ± 0.9	0.4 ± 0.6	0.32 ± 0.65	0.80 ± 1.15	0.25 ± 0.59
Beef	1.9 ± 3.7	2.4 ± 2.7	3.3 ± 3.4	1.39 ± 2.25	1.9 ± 2.59	1.48 ± 1.960
Poultry	2.2 ± 3.3	1.5 ± 2.6	1.6 ± 2.6	0.92 ± 1.53	0.90 ± 1.59	1.43 ± 2.51
Pork	0.6 ± 1.6	0.3 ± 0.6	0.6 ± 1.5	0.35 ± 1.26	0.24 ± 0.70	0.25 ± 0.80
Fish	0.6 ± 2.4	0.1 ± 0.7	0.06 ± 0.3	0.19 ± 0.96	0.19 ± 0.87	0.36 ± 1.48
Shellfish	0.3 ± 1.7	0.0 ± 0.0	0.1 ± 0.3	0.05 ± 0.25	0.03 ± .003	0.05 ± 0.39
Eggs	0.7 ± 1.1	0.3 ± 0.6	0.5 ± 0.8	0.43 ± 1.00	0.39 ± 0.65	0.31 ± 0.53
Organ meats	0.0 ± 0.0	0.2 ± 0.8	0.0 ± 0.0	0.16 ± 1.13	0.31 ± 0.98	0.0 ± 0.0
Oils	1.35 ± 1.93	1.39 ± 2.08	2.34 ± 2.6	1.42 ± 2.79	.92 ± 1.20	2.53 ± 3.08

Comparison of food portions eaten by three different Hispanic subgroups
[a]MyPyramid recommendations are based on daily energy intake and have 12 different categories

Essential Nutrients

In reference to essential nutrients, reported findings [38] found that MAs, both male and female, had a lower dietary intake of calcium, vitamin A, vitamin C, niacin, and phosphorus than their AA counterparts. Calcium intake between both MA and AA women were markedly low, with intakes of 55 and 67 % of the recommended dietary allowances (RDA), respectively. The intake of vitamin A was also moderately low in both groups. MA males and females had intakes ranging from 61 to 52 % of the RDA, respectively, and those ranged from 75 to 73 % for AA males and females, respectively. In general, iron intake surpassed the RDA in males of both ethnic groups, while iron intake in females of both ethnic groups averaged 71 % of the RDA. In addition, dietary intakes of B vitamins and phosphorus met or went above the RDA. Finally, MAs had a significantly greater dietary intake of riboflavin than AAs.

According to studies conducted among Hispanics [29, 37, 44–46], nutrients that are at highest risk for deficiency in both males and females are calcium, vitamin A, vitamin C, vitamin B_6, vitamin E, folate, potassium, and magnesium.

Table 15.4 Nutrients at risk of deficiency among Hispanics

Nutrient	Recommended foods
Calcium	Low-fat milk and low-fat dairy products
	Sardines with bones
	Tortillas (maize)
Vitamin A	Sweet potatoes, low-fat dairy products, carrots, broccoli (dark-green/yellow vegetables)
Vitamin C	Red and green bell pepper, kiwi, broccoli, tomato juice, oranges, strawberries, watermelon
Vitamin B_6	Fortified grain products, whole grains, bananas, green leafy vegetables, watermelon, chicken breast, tuna (canned in water), prune juice, pinto beans
Vitamin E	Vegetables oils, whole-grain cereals, seeds and nuts
Folate	Lentils, asparagus, pinto beans, flour tortilla, fortified grain products, broccoli, tomato juice, oranges
Potassium	Broccoli, carrots, potatoes, bananas, tomato juice, watermelon, low-fat milk and yogurt, cottage cheese, pinto beans, tuna (canned in water), chicken breast and ground beef (lean), whole grains
Magnesium	Whole-grain cereals, green vegetables, nuts, pinto beans, potatoes, low-fat milk and yogurt
Fiber	Fruits, vegetables, and whole grains
Iron	Lean meats, tortilla (flour), broccoli, potatoes, tomato juice, pinto beans, green leafy vegetables

Nutrients at risk of deficiency among Hispanics and the foods recommended to satisfy those deficiencies
Previously unpublished data

For Hispanic women, fiber and iron are also at risk for deficiency [29, 37, 44–47]. Table 15.4 displays nutrients at risk of deficiency among Hispanics and the foods recommended to fulfill those deficiencies. On the other hand, the nutrients found to be in excess were sodium, cholesterol, percent of carbohydrates, percent of total fat, percent of saturated fatty acids, sugars, and added sugars.

Fat-Related Behaviors

A study conducted among Blacks ($n=561$), Whites ($n=7{,}817$), and Hispanics ($n=1{,}425$) to examine baseline fat-related dietary behaviors [48] found that the six fat factors measured (replace with fruit and vegetables, avoid fat as flavoring, replace meat, substitute lower-fat products, modify meats, and avoid frying) were significantly different by all ethnic groups (Wilk's Lambda = 0.84, $p<0.0001$). Whites and Blacks were less likely to eat salads without dressing, while Hispanics were less likely to eat low-fat frozen desserts. Meanwhile, White participants were more likely to use margarine instead of butter and to drink or use nonfat milk instead of whole milk. Hispanic participants were more likely to add milk to coffee instead of cream and to eat smaller portions of meats; they were also less likely to cook without fat or oil. Black participants were more likely to use margarine instead of butter and eat fish or chicken in substitution of red meats; they were also were less likely to eat low-fat cakes and cookies. In addition, differences in the consumption of fats between Hispanic subgroups have been observed [39, 43].

Barriers and Positive Factors to Healthy Eating

Research has found that some of the main barriers to dietary change among low-income Hispanics (LIH) are income and educational level; attitudes, traditions, and beliefs; time constraints; lack of family support; lack of awareness and knowledge about healthy eating; and lack of skills for cooking healthy meals [49, 50]. On the other hand, factors promoting healthy eating included having family support, having to be a good role model for children, feeling better, the desire to lose weight, diagnosis of a disease (i.e., diabetes or cardiovascular disease), and stress release [49, 50].

Most nutrition educational programs, mainly those available for Spanish-speaking audiences, have relied in large part on written educational and informational materials. LIH, who are those most likely to need nutrition education, are on average at a low level of literacy, and most of the materials for Hispanics have comparatively high reading levels, representing another barrier to healthy eating.

Nutrition Education for Hispanics

Nutrition education is defined as "any combination of educational strategies, accompanied by environmental supports, designed to facilitate voluntary adoption of food choices and other food and nutrition-related behaviors conducive to health and well-being" [51]. Researchers have found a need for nutrition education interventions and have pointed out the need for nutrition education materials targeted to minority groups in the United States [22, 29, 40, 47]. In addition, studies have shown that nutrition interventions help to reduce weight and to change behaviors, leading to better health [52].

Literature cites specific recommendations for developing dietary interventions for Hispanics, who comprise a mixture of people with different cultural backgrounds and variations in socioeconomic status, culture, and language [3]. Therefore, some important factors when developing nutrition education materials for Hispanic audiences are to identify and to understand the group that will be served and to consider their different cultural values, beliefs, and traditions.

Only a few nutrition educational materials and programs have taken the Hispanic culture into account in their development. However, effective educational programs must be culturally appropriate in order to be successful. For example, dry beans, which are a staple food among Hispanics, are called *frijoles* by Mexicans and *habichuelas* by Puerto Ricans. Adequate terminology is a key factor in avoiding misunderstanding and increasing chances for success.

Hispanics' nutrition education needs are related to food choices, meal planning, and food preparation; Hispanics should be encouraged to eat more specific foods, such as whole grains, beans, and cereals as well as fruit and vegetables, low-fat dairy products, and a variety of foods that are good sources of calcium [22, 23, 29, 40, 47]. Research has also suggested that since macronutrients and micronutrients vary among Hispanic groups, nutrition interventions should be targeted to each group individually [43]. Among the most significant modifiable risk factors for Hispanics are dietary patterns and physical activity, both of which are associated with the development of obesity [53, 54]. Other studies have found that Hispanics want information about how to get kids to eat healthier foods, healthy snacks for kids, ways to involve children in food preparation, and low-fat recipes and information on food preparation techniques that are quick, easy, nutritious, and inexpensive [50].

While there are many educational materials focused on different topics related to nutrition, only a few of these have been developed specifically for Hispanic audiences; most are materials that were developed for the general public and translated into Spanish, leaving a gap in educational material geared specifically to Hispanics.

Conclusions

The high prevalence of diet-related diseases among Hispanics clearly suggests a need for changes in their dietary patterns. Consequently, there is a need for nutrition education materials developed specifically for Hispanic audiences that would employ comprehensive strategies targeting patterns of food purchase, preparation and consumption, and the interrelationships of nutrition, health, and physical activity. As is true for all populations, these strategies should be culturally sensitive, economically appropriate, and integrated into family and community structures.

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16 Puerto Rican Guidelines on Food and Diet Quality

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Key Points

- Current Puerto Rican diet and food guidelines are mainly based on translation and adaptations from the United States.
- The Puerto Rican Food Guide Pyramid and the Puerto Rican Food Guide Pyramid for Children were adapted and adopted from the United States which were acculturated, particularly to account in differences in vegetables and carbohydrates.
- The United States Dietary Guidelines 2010 were adopted and adapted for Puerto Ricans with emphasis given to the translation of colloquial local phrases and these are used as the basis for Federal food and nutrition education programs in Puerto Rico.
- The United States Myplate campaign is currently under revision for its adaptation for Puerto Ricans.
- The Puerto Rico Department of Health has launched several campaigns for reducing the high rates of overweight and obesity in Puerto Rico by promoting changes in behaviors and lifestyles such as "Health Recommends you" and "Health promotes".
- Other interagency programs have been developed for implementing the dietary guidelines in Puerto Rico such as NutriActiva Playing for your health, Puerto Rico Move!, and a law for prohibiting the use of trans fats.

Keywords

Puerto Rico • US adaptations • Diet guidelines • Food guide pyramid • Myplate • Department of Health

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V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health, DOI 10.1007/978-1-4614-7315-2_16, © Springer Science+Business Media New York 2013

Abbreviations

USDA United States Department of Agriculture
WIC Women Infant and child program for supplementary feeding

Introduction

Puerto Rico, an island located in the northeastern Caribbean, is a commonwealth and a territory of the United States (USA). Puerto Ricans' dietary guidelines, especially for federal nutrition-food programs, are mainly based on adaptations from the USA. Some of the US dietary guidelines that have been adapted for Puerto Ricans are the Puerto Rican Food Guide Pyramid, the Puerto Rican Food Guide Pyramid for Children, and the recent Myplate for Puerto Ricans and US Dietary Guidelines 2010. However, there are some island-based guidelines and initiatives directed for promoting diet quality, independently of the USA, managed mainly by the Puerto Rico Department of Health.

There are also several US Food Assistance Programs available to help the population achieve these dietary guidelines that have also been implemented in Puerto Rico. These are the Women, Infant and Child Program for Supplementary Feeding (WIC) managed by the Puerto Rico Department of Health; the School Lunch and Breakfast Programs, the Summer Food Service Program, the Child and Adult Care Food Program, the Milk for Children Program, and the Education and Skills in Nutrition Program managed by the Department of Education; Head Start managed by different Puerto Rican public or private institutions; and the Supplemental Nutrition Assistance Program managed by the Administration of Family Socioeconomic Development. In addition, the Puerto Rico Department of Health has participated in the Healthy People, an initiative from the US Department of Health and Human Services for improving the quality of the population's health by producing a 10-year framework for public health prevention priorities and actions. The Commonwealth of Puerto Rico is developing their strategic plan for the Healthy People 2020. Included in the objectives of Healthy People 2020 is the implementation of the dietary guidelines at different levels. Furthermore, Puerto Rico has approved several laws to help promote these dietary guidelines, such as the law for prohibiting the use of trans fat in prepared foods for purchase.

Earlier Dietary Guidelines in Puerto Rico

Since 1946 several food-nutrition guides have been developed in Puerto Rico. These guides, developed as educational tools, capture nutrition advice based on local food preferences and nutritional recommendations.

Based on the studies performed by Dr. Lydia Roberts in 1946 on the living conditions in Puerto Rican families, including the "typical diet" [1], the earlier dietary guidelines were developed in Puerto Rico. The first food guide developed in the island was the "Protective foods for Puerto Rico" (*Alimentos Protectores para Puerto Rico*). This guide, developed by the Puerto Rico Department of Health, identified the foods usually consumed and the foods needed to improve the health and nutrition status of the Puerto Rican community (Fig. 16.1).

In 1966, an island-wide nutrition survey was carried out in a representative stratified sample of the Puerto Rican population [2]. The survey included data on socioeconomic, dietary patterns, and clinical and biochemical data, such as serum analysis (hemoglobin, hematocrit, plasma values of total proteins, albumin, carotene, vitamin A, and vitamin C) and urine and stool analyses. Eight hundred and seventy-seven families were interviewed at their homes. This study showed that average intake of milk in all age groups was at least two or more cups daily, with daily meat and legume consumption and high use of lard for food preparation, while fruits were consumed only about once per week. With respect to clinical findings, the main nutritional deficiencies were vitamin A, riboflavin, and

Fig. 16.1 Protective foods for Puerto Rico (*Alimentos Protectores para Puerto Rico*). Legend: first food guide developed in Puerto Rico by the Puerto Rico Department of Health and the Nutrition Committee of Puerto Rico in 1949 (with permission from the Food and Nutrition Commission of Puerto Rico, Puerto Rico Department of Health)

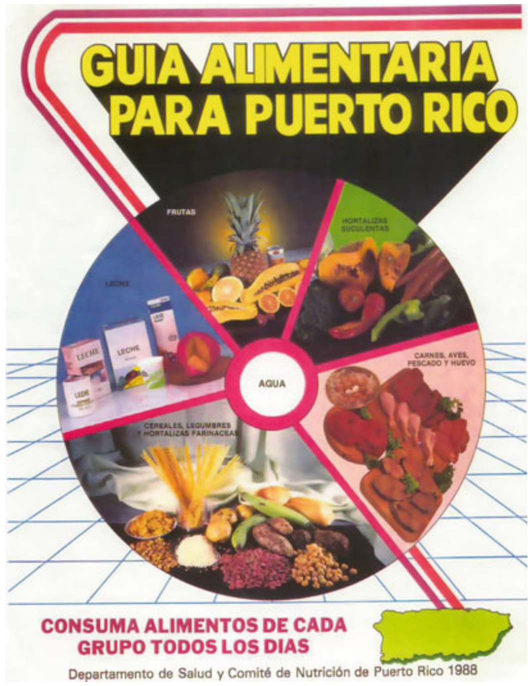

Fig. 16.2 Puerto Rican Dietary Guidelines ("Guía Alimentaria para Puerto Rico"). Legend: these subsequent guidelines were developed for Puerto Ricans by the Puerto Rico Department of Health and the Nutrition Committee of Puerto Rico in 1988 (with permission from the Food and Nutrition Commission of Puerto Rico, Puerto Rico Department of Health)

niacin, with the most alarming result being the obesity problem, particularly in children. Therefore, this study was one of the first to document a shift in the main morbidity causes in the island, from infectious diseases to chronic conditions, especially obesity. The results and recommendations generated from this important study promoted the development of the Puerto Rican Dietary Guidelines ("Guía Alimentaria para Puerto Rico") in 1988 by the Puerto Rico Department of Health and the Nutrition Committee of Puerto Rico. This guide changed dramatically the educational tool for use in the island. With the leadership of the Nutrition Committee of Puerto Rico, the graphic representation changed to represent a variety of food groups to be consumed daily (Fig. 16.2).

Puerto Rican Food Guide Pyramid and the Puerto Rican Food Guide Pyramid for Children

During the first decade of this century, an interagency committee adapted and adopted the Food Guide Pyramid for Puerto Rico (Fig. 16.3) [3]. In response to acculturation, several differences exist between the US and the Puerto Rican Pyramid. The main difference is the establishment of foods in food groups as vegetables and carbohydrates. Examples are the addition of specific starchy roots (i.e., yams) as carbohydrates as well as adding beans in the vegetables and beans groups, since these are Puerto Rican staples. Another difference is the recognition and inclusion of water as an essential element in the Food Pyramid. In general, the Food Pyramid for Puerto Rico has nine components: physical activity,

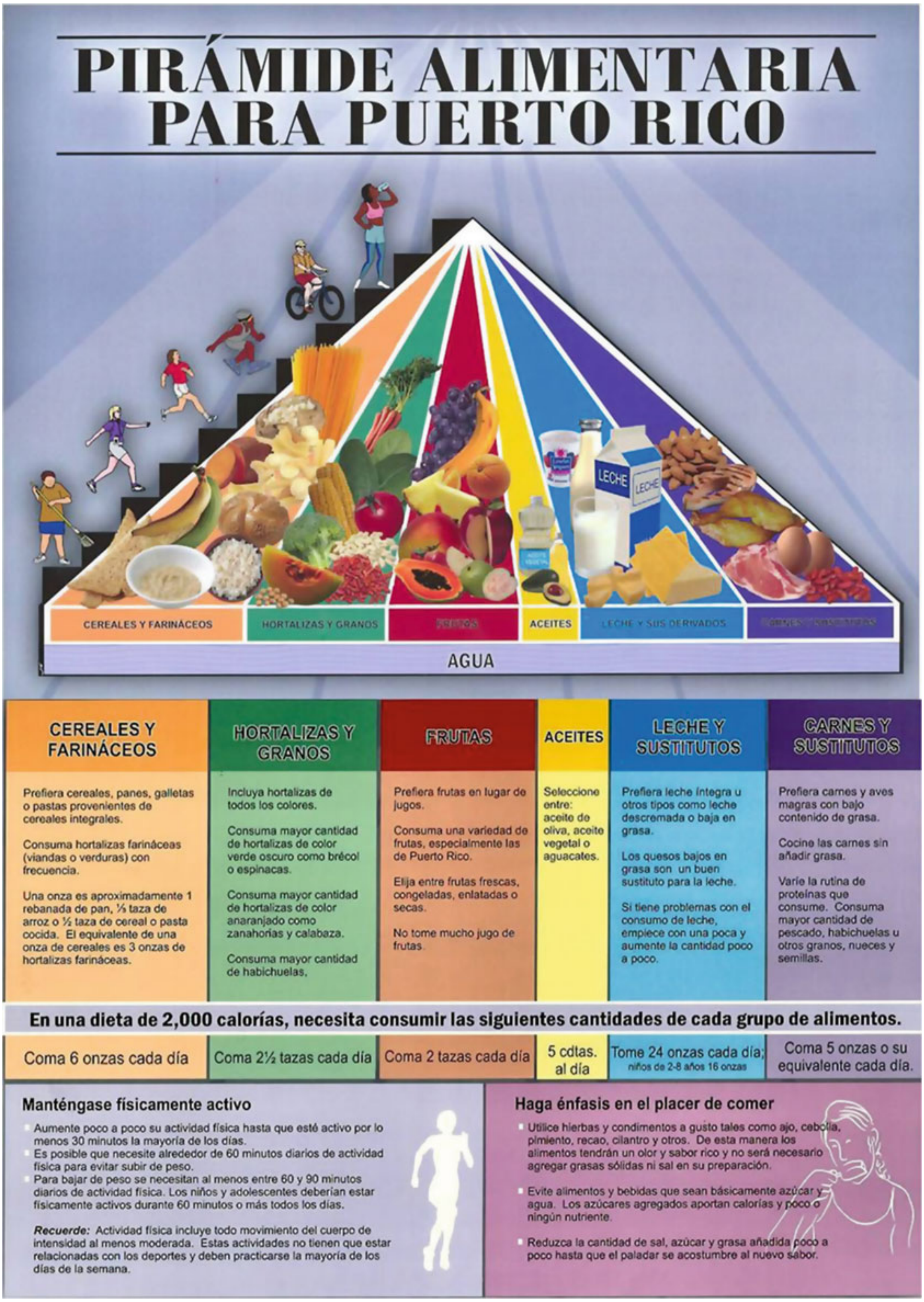

Fig. 16.3 Puerto Rican Food Guide Pyramid. Legend: this pyramid was an adaptation of the US Food Guide Pyramid by the Nutrition Committee for Puerto Rico, Food and Nutrition Commission of Puerto Rico, and the Agriculture Extension Services of the College of Agricultural Sciences [3] (with permission from the Food and Nutrition Commission of Puerto Rico, Puerto Rico Department of Health)

starchy group, vegetables, fruits, oils, dairy products, meats and beans, water, and general recommendations. It provides specific recommended portions for each food group for a 2,000 kcal diet. These recommendations are:

1. *Physical activity*: It is represented by different activities performed by several individuals on the steps of the pyramid. Physical activity includes any body movement that is at least of moderate intensity. These activities are not necessarily related to sports and are recommended most of the days in the week. The guide also recommends increasing physical activity gradually for at least 30 min almost every day, increasing to about 60 min to avoid weight gain, and increasing to 60–90 min daily for weight loss. For children and adolescents, it recommends at least 60 min daily.
2. *Starchy group*: It is recommended that individuals consume 6 oz daily, from which at least half should be as whole grains. It is also recommended that starchy vegetables (yucca, plantain, etc.) be consumed frequently.
3. Vegetables: It is recommended that individuals consume 2 1/2 cups daily of all color vegetables, with emphasis on dark-green vegetables, orange vegetables, and beans.
4. Fruits: It is recommended that individuals consume 2 cups daily of diverse whole fruits, particularly local fruits, avoiding fruit juice.
5. Oils: It is recommended that individuals use olive oil, vegetable oil, and avocados, emphasizing on fish, nut, and vegetables sources and limiting solid fats (margarine, shortening, and pork fat). It is also recommended to read food labels to avoid saturated fat, trans fat, and sodium.
6. Milk *and related products*: It is recommended that individuals consume 24 oz daily (children 2–8 years should consume 16 oz daily) as whole or low-fat milk and cheese. In case individuals have problems with milk, it is recommended to consume a little first and then gradually increase intake.
7. Meat *and* substitutes: It is recommended that individuals consume 5 oz daily from lower-fat meats and poultry, without fat addition when cooking. The guide also recommends varying the protein sources, with emphasis on fish, beans, nuts, and seeds.
8. *Water*: It emphasizes the importance of water in the body and the water sources: fruits and vegetables, milk and beverages, and water.
9. *General recommendations*: The guide recommends the use of herbs and spices, such as garlic, onions, pepper, coriander (cilantro), and cilantro (recao), which will help reduce the need for fat and salt addition when cooking. It also recommends limiting sugar and sugary beverages and reducing gradually the use of sugar, salt, and fat.

Afterwards, another interagency committee adapted and identified the Puerto Rican Food Guide Pyramid for Children (Fig. 16.4) [3]. The Pyramid presented a visual form of the nutrition recommendations, particularly for a young Puerto Rican population, taking into consideration the local staples. The Pyramid emphasizes on physical activity, depicting children playing games, sports, and being outside and on water ingestion. It also gives specific recommendations for each food group based on a 1,800 kcal diet, providing information on the importance of each group and examples of serving sizes:

1. *Starchy group*: It recommends the consumption of seven servings daily, with emphasis on whole grains and non sugary products.
2. Vegetables: It recommends the consumption of three servings daily of different colors (red, green, orange, violet, and white).
3. Fruits: It recommends the consumption of five servings daily, preferably whole fruits, local fresh fruits, canned in its own fruit juice, and 100 % fruit juice.
4. Oils: It recommends the consumption of four servings daily from oils or vegetable fat.
5. Milk *and related products*: It recommends the consumption of three servings daily from milk or low-fat dairy products.
6. Meat *and* substitutes: It recommends the consumption of five servings daily from moderate and low-fat sources.

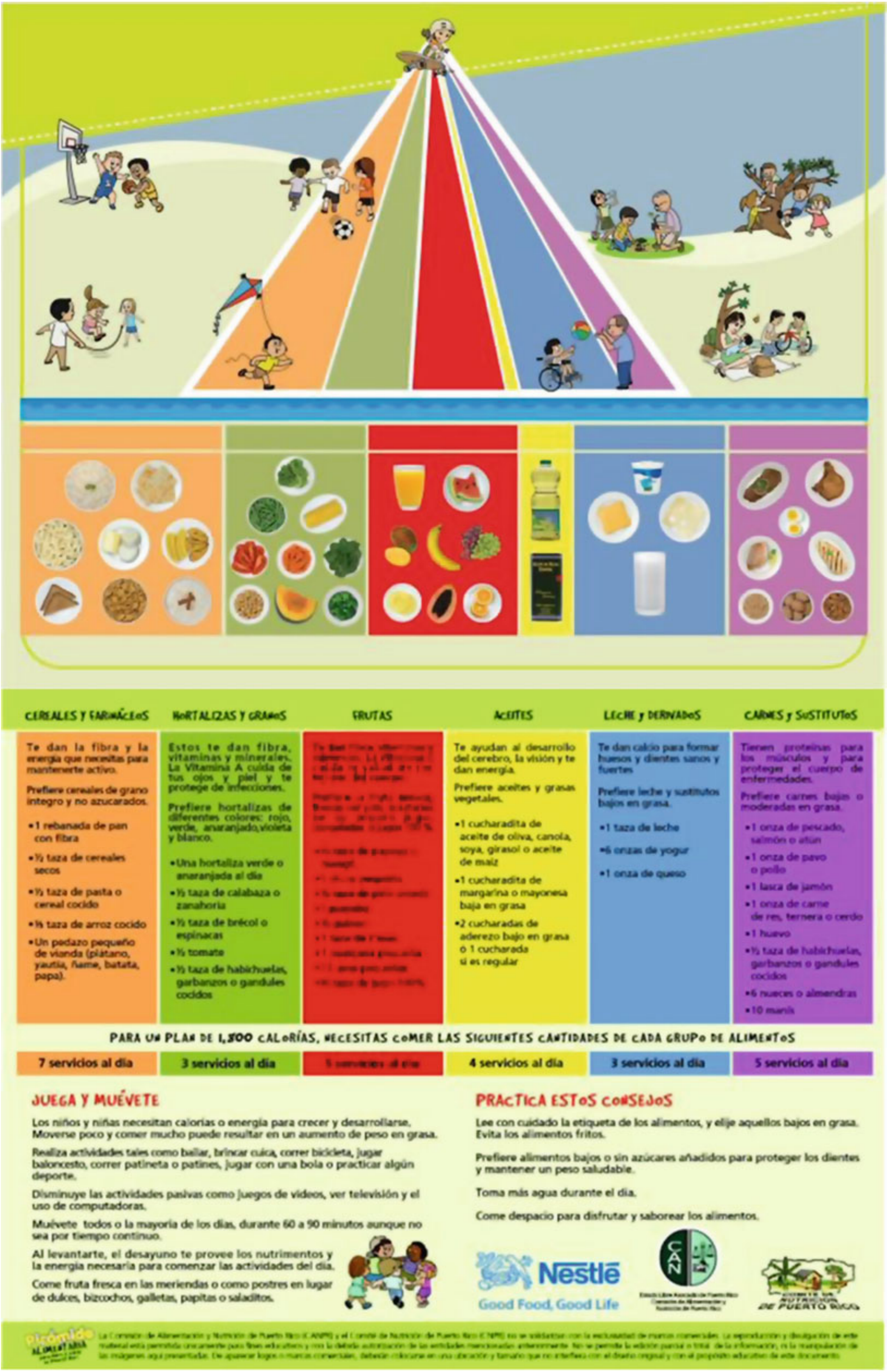

Fig. 16.4 Puerto Rican Food Guide Pyramid for Children. Legend: this pyramid was an adaptation of the US Food Guide Pyramid by the Nutrition Committee for Puerto Rico, Food and Nutrition Commission for Puerto Rico, and the Agriculture Extension Services of the College of Agricultural Sciences [3] (with permission from the Food and Nutrition Commission of Puerto Rico, Puerto Rico Department of Health)

US Dietary Guidelines 2010

The US Department of Health and Human Services and the United States Department of Agriculture (USDA) jointly publish the Dietary Guidelines every 5 years since 1980 with the *Dietary Guidelines for Americans 2010*, released on January 31 of 2011, the last in the series. These guidelines provide evidence-based nutrition information and advice for people age 2 and older, leading to healthier diets, improving health, and reversing obesity and chronic diet-related diseases [4].

The *Dietary Guidelines for Americans 2010* consists of six chapters. The first chapter introduces the document and provides information on background and purpose. The next five chapters correspond to major themes that emerged from the 2010 Dietary Guidelines Advisory Committee's review of the evidence, and Chaps. 2 through 5 provide recommendations with supporting evidence and explanations. These recommendations are based on a preponderance of the scientific evidence for nutritional factors that are important for promoting health and lowering risk of diet-related chronic disease. Quantitative recommendations always refer to individual intake or amount rather than population average intake, unless otherwise noted.

The *Dietary Guidelines for Americans 2010* emphasizes three major goals for Americans [4]:

- Balancing calories with physical activity: The guidelines provide recommendations for preventing and/or reducing body weight by controlling total calorie intake, increasing physical activity, and reducing sedentary activities through the life cycle.
- Increasing the consumption of certain foods: The guidelines emphasize increasing the consumption of fruits, vegetables, whole grains, fat-free and low-fat dairy products, seafood, lean meat and poultry, eggs, beans and peas, soy products, unsalted nuts and seeds, and vegetable oils.
- Reducing the consumption of certain foods or nutrients: The guidelines emphasize reducing the consumption of foods high in sodium, saturated and trans fats, cholesterol, added sugars, and refined grains. It also provides guidelines on the consumption of alcohol.

These major goals are detailed in the guidelines through 23 key recommendations for the general population [4]. An additional 6 key recommendations are provided for specific population groups, such as women capable of becoming pregnant, pregnant women, and lactating women, providing guidelines for increasing iron and folic acid intake while limiting mercury from seafood, and for individuals 50 years and older, providing specific guidelines for increasing vitamin B12 consumption.

The information provided by these guidelines was adopted and adapted for Puerto Ricans by the Food and Nutrition Commission of Puerto Rico. Emphasis was given to the Spanish translation of colloquial phrases utilized in Puerto Rico, especially words that may be used by other Hispanics, not Puerto Ricans. Words like "grains" convey for Puerto Ricans staple foods, like beans or legumes, while for other Hispanics, like Mexicans, include starchy vegetables and rice. They serve as the basis for Federal food and nutrition education programs in Puerto Rico.

Myplate for Puerto Ricans

By mid-2011, the icon MyPlate was published by the USDA and has been used as a nutrition education tool thereafter substituting the Food Pyramid [5]. MyPlate is based on 2010 Dietary Guidelines for Americans to help consumers make better food choices for eating healthfully but also includes much of the information from the Food Guide Pyramid. It is part of a larger campaign; therefore, it is not intended to change consumer behavior alone. MyPlate illustrates in a simple visual form the five food groups using a place setting (Fig. 16.5) [5].

In Puerto Rico, the Food and Nutrition Commission of Puerto Rico has the responsibility to adopt and adapt the icon for Puerto Ricans. The development of nutrition education materials for the Puerto Rican community, using MyPlate as a model, has been sparkled with

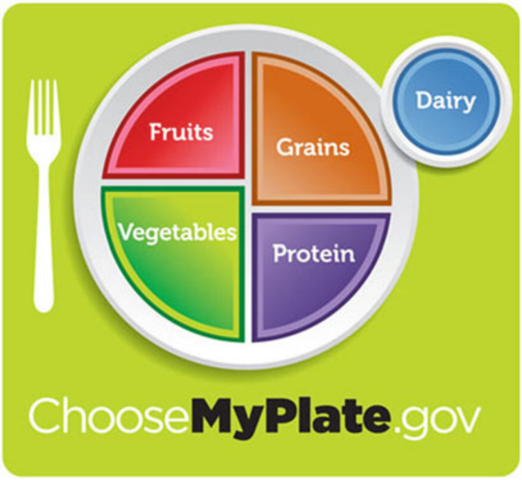

Fig. 16.5 Myplate. Legend: current US nutrition educational tool based on the 2010 Dietary Guidelines for Americans, from the US Department of Agriculture [5] (not copyright)

6. *Switch to fat-free or low-fat (1 %) milk*: Information is provided on the benefits of low-fat dairy products.
7. *Make at least half your grains whole grains*: Examples of whole grains products are provided and on how to substituting refined products.
8. *Foods to eat less often*: Recommendations are given for limiting foods high in solid fats, added sugars, and salt, and examples are provided.
9. *Compare sodium in foods*: Information is provided on the use of the Nutrition Facts label for choosing lower sodium versions of certain high salty prepared and canned foods.
10. *Drink water instead of sugary drinks*: Recommendations are provided for substituting sugary drinks with water or unsweetened beverages.

translation concerns. The USDA "official" translation is mainly for Mexicans, therefore not necessary tailored for Puerto Rico. Currently the official translation for Puerto Rico of MyPlate is under revision.

In general, the MyPlate campaign focuses in the following selected messages (Fig. 16.6; [5]):

1. *Balance calories*: Recommendations are given on individual's calorie level depending on weight and on physical activity to achieve this.
2. *Enjoy your food, but eat less*: Recommendations are provided for avoiding eating too fast and paying attention to consumption, hunger, and fullness to avoid overeating.
3. *Avoid oversized portions*: Recommendations are given for the use of smaller eating utensils and portion sizes.
4. *Foods to eat more often*: Recommendations are provided from increasing the consumption of vegetables, fruits, whole grains, and fat-free or 1 % milk and dairy products.
5. *Make half your plate fruits and vegetables*: Recommendations are provided for choosing red, orange, and dark-green vegetables and eating fruits as part of meals or desserts.

Puerto Rico Department of Health Campaigns

The Puerto Rico Department of Health launched in 2008 the program "Health Recommends you" (*Salud Te Recomienda*) in response to the high rates of overweight and obesity in the Puerto Rico's population, estimated in >60 % [7], with higher rates of mortality and morbidity from most chronic diseases compared to the USA [7]. The main goal of this program is to promote changes in behaviors and lifestyles in the Puerto Rican population that will lead to better health, reducing the overwhelming consequences of obesity and lack of physical activity among Puerto Ricans [8]. The campaign uses obesity-related public health intervention based on a socio-ecological model and social marketing techniques. It provides useful and practical information about proper nutritional habits and patterns at the community level but also operates through the proper labeling of products evaluated and recommended by a panel of nutritionists from the Department of Health. All nutritional recommendations were based using published guidelines from the American Heart Association, the American Diabetes Association, and the

10 tips
Nutrition Education Series

choose MyPlate

10 tips to a great plate

ChooseMyPlate.gov

Making food choices for a healthy lifestyle can be as simple as using these 10 Tips.
Use the ideas in this list to *balance your calories*, to choose foods to *eat more often*, and to cut back on foods to *eat less often*.

1 balance calories
Find out how many calories YOU need for a day as a first step in managing your weight. Go to www.ChooseMyPlate.gov to find your calorie level. Being physically active also helps you balance calories.

2 enjoy your food, but eat less
Take the time to fully enjoy your food as you eat it. Eating too fast or when your attention is elsewhere may lead to eating too many calories. Pay attention to hunger and fullness cues before, during, and after meals. Use them to recognize when to eat and when you've had enough.

3 avoid oversized portions
Use a smaller plate, bowl, and glass. Portion out foods before you eat. When eating out, choose a smaller size option, share a dish, or take home part of your meal.

4 foods to eat more often
Eat more vegetables, fruits, whole grains, and fat-free or 1% milk and dairy products. These foods have the nutrients you need for health—including potassium, calcium, vitamin D, and fiber. Make them the basis for meals and snacks.

5 make half your plate fruits and vegetables
Choose red, orange, and dark-green vegetables like tomatoes, sweet potatoes, and broccoli, along with other vegetables for your meals. Add fruit to meals as part of main or side dishes or as dessert.

6 switch to fat-free or low-fat (1%) milk
They have the same amount of calcium and other essential nutrients as whole milk, but fewer calories and less saturated fat.

7 make half your grains whole grains
To eat more whole grains, substitute a whole-grain product for a refined product—such as eating whole-wheat bread instead of white bread or brown rice instead of white rice.

8 foods to eat less often
Cut back on foods high in solid fats, added sugars, and salt. They include cakes, cookies, ice cream, candies, sweetened drinks, pizza, and fatty meats like ribs, sausages, bacon, and hot dogs. Use these foods as occasional treats, not everyday foods.

9 compare sodium in foods
Use the Nutrition Facts label to choose lower sodium versions of foods like soup, bread, and frozen meals. Select canned foods labeled "low sodium," "reduced sodium," or "no salt added."

10 drink water instead of sugary drinks
Cut calories by drinking water or unsweetened beverages. Soda, energy drinks, and sports drinks are a major source of added sugar, and calories, in American diets.

USDA Center for Nutrition Policy and Promotion

Go to www.ChooseMyPlate.gov for more information.

DG TipSheet No. 1
June 2011
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Fig. 16.6 The ten Tips Nutrition Education Series. Legend: summary tip from the 2010 Dietary Guidelines for Americans, from the US Department of Agriculture [6] (not copyright)

American Cancer Association. By partnering with grocery stores and fast-food chains, the Department of Health identified healthy foods and menus with the campaign logo (Fig. 16.7; [7, 8]) to promote their consumption. It also impacted the food distributors by promoting the incorporation of new products to the market. It also impacted the general public with educational and public service announcements in the media on behavioral and lifestyle changes to improve health. Preliminary results in change in food purchases in grocery stores are shown in Fig. 16.8 [9]. In addition, an average increase of 6 % in the sale of both foods and menu recommended by the program was observed in fast-food restaurants.

Fig. 16.7 Symbol for "Health Recommends you" (*Salud Te Recomienda*). Legend: this symbol was used for identifying foods, menus, announcements, etc., in the campaign "Health Recommends you" (*Salud Te Recomienda*) from the Puerto Rico Department of Health [8] (with permission from the Puerto Rico Department of Health)

More recently, this program was slightly changed to "Health promotes" ("Salud Promueve"), which is directed specifically to identify healthy foods using a logo designed by the Department of health in accordance with the dietary guidelines of the American Heart Association, the American Diabetes Association, the American Cancer Association, US Dietary guidelines, and Food and Nutrition Commission of Puerto Rico [10]. This program was also in response to the high rates of overweight (38.1 %) and obesity (27.5 %) in Puerto Rico's population [7]. It will emphasize in the consumption of dairy products low in fat; local fruits and vegetables; lean proteins; carbohydrates high in fiber and from whole grains;

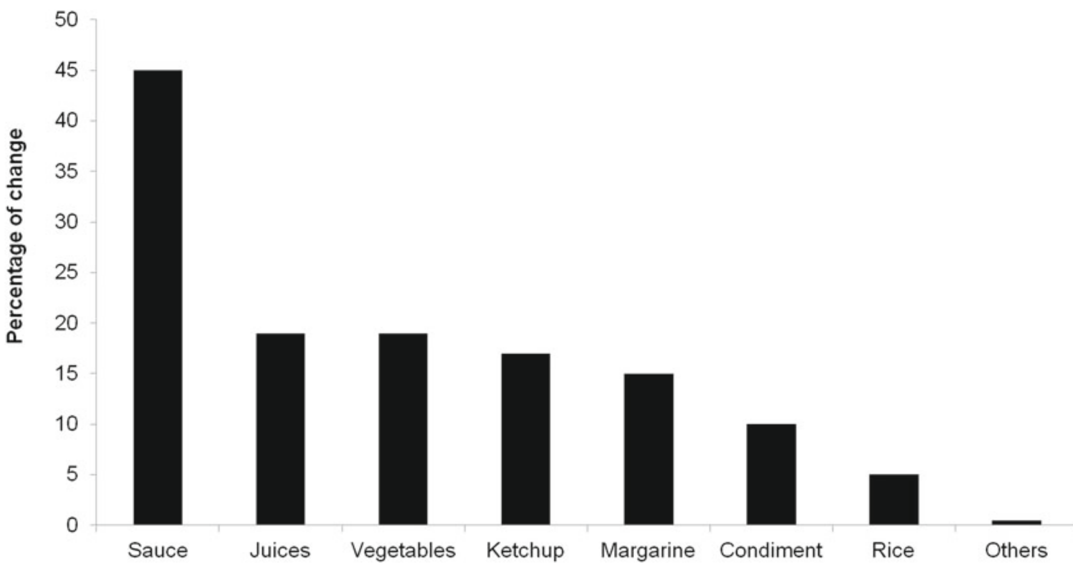

Fig. 16.8 Change of food purchases in grocery stores. Legend: preliminary data from the Campaign "Health Recommends you" (*Salud Te Recomienda*) [9] (with permission from the Puerto Rico Department of Health)

Fig. 16.9 Symbol for "Health promotes" (*Salud Promueve*). Legend: this symbol is used for identifying foods, menus, announcements, etc., in the current campaign "Health promotes" (*Salud Promueve*) from the Puerto Rico Department of Health [10] (with permission from the Puerto Rico Department of Health)

foods low in fat, cholesterol, salt, and sugar; and physical activity. The campaign started in 2011 with the promotion of low-fat dairy products, for which the Puerto Rico Department of Health partners with the major dairy producers to identify such products with the logo, a check mark (Fig. 16.9, [10]). The campaign will be followed by the promotion of local fruits and vegetables.

Other Programs

NutriActiva is a collaborative program between the Puerto Rico Departments of Health and Housing (DV) for the prevention and treatment of diabetes by promoting healthy lifestyles among employees of public and private agencies [11]. The initiative seeks to change the statistics in Puerto Rico, where 67.4 % of adults do not exercise, while 65 % have problems of obesity and overweight [7]. The Health and Wellness Program from the Puerto Rico Department of Health makes regular visits to several public and private agencies, where it develops a plan that includes 16 intensive physical activity and eight nutrition interventions for 2 months. The program started with a pilot project with the employees of the DV program.

Playing for your health (*Jugando por tu Salud*) is a recreational program for children and adolescents between 7 and 12 years with deficiencies related to obesity, poor eating habits, and physical activity and other emotional factors [12]. This program combines sports with education, with teams for basketball, soccer, and volleyball at the region level with competitions. The sports part is run by the Puerto Rico Department of Health and Sports and Recreation Department, while the education in nutrition is managed by the Department of Health.

Puerto Rico, *Move*! (*Puerto Rico ¡MUÉVETE*!) is an initiative for promoting healthier lifestyles by increasing physical activity and promoting healthy eating habits by several public and private organizations [13]. It promotes increasing physical activity in the population in their daily lives using parks and designated walking areas. It is a strategic integration of three projects, the global Initiative from the World Health Organization "1,000 cities, 1,000 lives," the program "Let's Move" launched by the US First Lady Michelle Obama, and the Recreational Ciclovia by Americas Ciclovias Network. In 2011, the Commonwealth of Puerto Rico declared the second week of November of each year as the "Week for Puerto Rico Move!" [14].

Trans fat use law is a law approved in September of 2007 by the senate of Puerto Rico to prohibit selling foods with hydrogenated vegetable fat in food establishments in Puerto Rico, school cafeterias, preschool centers, and elderly centers [15]. The mobile establishments must have food labels accessible for all foods sold. The typical food and small artisan's establishments are exempt from this law, although an announcement with the use of these fats has to be posted when used.

Conclusions

In conclusion, Puerto Rican guidelines on food and diet quality were originally based on local studies. However, the current guidelines are based on US adaptations, taking into consideration local food preferences, Spanish translation of colloquial phrases utilized in Puerto Rico, and other acculturation factors.

Due to the very high rates of overweight, obesity, and diabetes in the island, several agencies have develop island-based initiatives for translating these guidelines into practices that leads to improvements in healthy behaviors, such as campaigns for identifying healthy foods, nutrition education, and increasing physical activity by promoting recreational physical activity in the population in their daily lives using parks and designated walking areas.

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17 Dietary Acculturation and Diet Quality Among the Arab Minority Population in Israel

Kathleen Abu-Saad, Nuha Younis-Zeidan, Havi Murad, Laurence Freedman, Iris Shai, Vered Kaufman-Shriqui, Drora Fraser, and Ofra Kalter-Leibovici

Key Points

- Dietary acculturation has been associated with changes in diet quality and increased prevalence of chronic diseases.
- Subsequent to changes in lifestyle, the indigenous Arab minority population in Israel suffers from higher rates of chronic disease morbidity and mortality than the majority population and has direct exposure to Western dietary influences.
- Among traditionally seminomadic Bedouin Arabs, the transition away from whole wheat bread to white bread as the main dietary staple was associated with markers of Westernization.
- Bedouin consuming predominately white bread had higher saturated fat intake, poorer micronutrient diet quality, and higher chronic disease prevalence.
- In dietary pattern analysis among historically agrarian Arabs who have undergone urbanization, the most dominant pattern was the fast foods, sweets, and snacks pattern.
- Younger age, non-health-related dietary change, and higher energy, fat, and sugar intakes were associated with the fast foods, sweets, and snacks pattern.
- Dietary acculturation among Arabs in Israel may negatively affect their diet quality and may place them at higher risk for the development of chronic diseases.
- Longitudinal studies are needed to document the process of dietary acculturation in this minority population and its impact on diet quality and health.

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V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health,
DOI 10.1007/978-1-4614-7315-2_17,

Keywords
Dietary acculturation • Diet quality • Nutrition transition • Arabs • Israel

Abbreviations

AI	Adequate Intake
AMDR	Acceptable Macronutrient Distribution Range
BMI	Body mass Index
CHD	Coronary heart disease
CI	Confidence interval
DRI	Dietary Reference Intakes
MUFA	Monounsaturated fatty acids
OR	Odds ratio
PUFA	Polyunsaturated fatty acids
RDA	Recommended Daily Allowance
SFA	Saturated fatty acids

Introduction

Dietary acculturation occurs in a society when members of a minority group adopt the food choices/dietary patterns of the majority group. Evidence suggests that this is a complex, multidimensional process ranging from using traditional foods in new ways and/or using new ingredients to make traditional foods/meals to replacing traditional foods with new foods [1]. The process is affected by socioeconomic, demographic, and cultural factors, as well as by the extent of exposure to mainstream culture.

Dietary acculturation has been studied among non-Western immigrants to Western countries and has been associated with changes in diet quality (generally, but not necessarily, negative) and increased prevalence of chronic diseases [1, 2]. This phenomenon has also been found among indigenous peoples in countries in which European immigrant populations have become the dominant majority (e.g., USA, Canada, Australia) and have introduced a Western diet higher in animal fat, processed foods, and sugar/simple carbohydrates than was present in traditional indigenous diets [3, 4]. There is also evidence from developing countries generally, and Middle Eastern countries specifically [5–7], of a nutrition transition from traditional diets to more Westernized diets. Reports on this transition in the Middle East, however, have not included the Arab population in Israel, which is an indigenous minority that has undergone major lifestyle transitions [8–10]. At the same time, they have exposure to the food culture of the country's multiethnic Jewish majority population, which includes substantial European/Western dietary influences.

The Arab minority in Israel (over 82 % of which is Muslim) makes up a relatively large percentage (20 %) of the total population [11]. This group differs from the Jewish majority population in terms of language and other demographic and cultural traits and is characterized by a lower socioeconomic level [11, 12] and poorer health status (e.g., higher infant mortality and chronic disease morbidity and mortality and lower life expectancy) [13, 14].

In this chapter, we review existing evidence of dietary acculturation and its associations with diet quality and health among two communities of the indigenous Arab population in different regions of the country: a historically seminomadic community in the southern Negev desert and a rural community in the centrally located Wadi 'Ara. Findings from two recent cross-sectional studies in these subpopulations will be reviewed, the Bedouin Nutritional Study [9, 15, 16] and the Hadera District Study [10, 17]. Data from food-based assessments [18] were used to explore dietary acculturation and its associations with diet quality and health.

Bedouin Arabs in the Southern Negev Desert

Background and Dietary Traditions

The Arabs living in the Negev Desert in southern Israel make of 13 % of the total Arab minority [11]. Historically, they were seminomadic agro-pastoralists (known as "Bedouin") [19], and as such they differed in dietary and other characteristics from the rest of the Arab population, most of whom were rural villagers. The Bedouin's lifestyle entailed a high level of physical activity. The primary crop they raised was wheat, from which their traditional dietary staple of whole wheat flour bread was made [19]. After Israel's establishment in 1948, Bedouin mobility was restricted, and they lost access to the majority of their land. While non-mechanized agropastoralism remained the mainstay of their economy into the mid-1960s, the changes in mobility and access to land led to a process of sedentarization and other socioeconomic and lifestyle changes [20].

Dietary data from the 1960s indicate that bread made from locally ground whole wheat flour comprised approximately 60 % of their total energy intake. In addition, the Bedouin produced and consumed legumes, and to a lesser extent dairy and meat products from their herds, and seasonal vegetables [19]. Anthropometric and clinical data on Bedouin adults from this same period indicated that the mean body mass index (BMI) for men and women was approximately 21 kg/m^2 [19] and that rates of hypertension and diabetes among those aged ≥30 were 3.2 % and 2.5 %, respectively [21].

Since the 1970s, the Israeli government began establishing nonagricultural, urban-style towns for the Negev Bedouin [22]. By mid-2000, approximately 60 % of the population lived in these towns, while the remainder continued to live more traditionally in unrecognized villages not connected to modern service infrastructures [22]. As a consequence of these changes, the Bedouin became integrated to varying extents into the Israeli labor market, and their access to markets and modern amenities (e.g., motor vehicles and for the urbanized, electricity, refrigeration) increased [14, 23]. The socioeconomic status of the Bedouin, as measured by education and income levels, remains the lowest of any population group in Israel, including other sectors of the Arab minority [11]. According to recently published data from the medical records of the health management organization serving over 85 % of the Bedouin population, rates of diagnosed hypertension and diabetes have reached 21.0 % and 16.9 %, respectively, among those aged ≥40 [24, 25].

The Bedouin Nutritional Study

The Bedouin Nutritional Study (n=451), conducted from 2001 to 2003, was based upon a convenience sample that included a broad cross-section of urban and rural Negev Bedouin adults (65 % and 35 % of the sample, respectively) [9, 14, 15]. The median age of participants was 31 years (range, 19–82). Mean ± SD BMI values for men and women were 25.0 ± 4.0 and 26.4 ± 4.9 kg/m^2, respectively, and 86 % reported sedentary/light activity physical activity levels [9, 14]. Employment rates were 57 % among men and 6 % among women, with only 4 % reporting engaging in herding activities.

Dietary data collected using a modified USDA 24-h recall questionnaire provided evidence of dietary acculturation in the form of a traditional food (bread) being made with new ingredients (white flour) [9, 14]. Given the major contribution of bread to the diet historically, the Bedouin Nutritional Study data were used to explore associations between bread type (traditional whole wheat flour vs. white flour bread) and sociodemographic characteristics, lifestyle, diet quality, and health status in multivariate regression analyses [9]. The sample was divided into two mutually exclusive and exhaustive bread type intake groups: (1) those with a predominantly whole wheat bread (hereafter "whole wheat bread") intake pattern, who ate most of their meals (two or more) with whole wheat bread, and (2) those

Table 17.1 Results from a multivariate logistic regression analysis of the characteristics associated with predominantly white bread intake vs. predominantly whole wheat bread intake pattern among Bedouin Nutrition Study participants[a] ($n=451$)

Variables in the model	Adjusted OR	95 % CI	*P*
Female vs. male	1.45	0.66–3.16	0.353
Urban vs. rural residence	2.79	1.70–4.58	<0.001
Age ≥40 vs. <40 y	0.85	0.47–1.51	0.574
Employed vs. unemployed	2.03	0.93–4.43	0.077
Smoker vs. nonsmoker	0.48	0.22–1.05	0.068
Store-bought bread eaten at one or more meals vs. no store-bought bread eaten	8.18	4.34–15.41	<0.001
Currently dieting vs. not dieting	4.67	1.28–17.11	0.020
BMI (reference: <25.0 kg/m^2)			
25.0–29.9	0.45	0.26–0.78	0.004
≥30.0	0.43	0.21–0.88	0.020
Physical activity level: moderate vs. sedentary/light activity level	0.83	0.37–1.82	0.635
Total energy from bread: ≥median% (33 %+) vs. <median% (0–32 %)	0.48	0.29–0.80	0.004

Characteristics of Bedouin eating primarily white bread

[a]Predominantly white bread coded 1, predominantly whole wheat bread, coded 0

with a predominantly white bread (hereafter "white bread") intake pattern, who ate white bread or other refined carbohydrates (e.g., white rice) with most of their meals (two or more).

Mean total bread intake in the Bedouin Nutritional Study sample accounted for 32.7 % of the energy intake, less than half of which was from whole wheat bread (13.7 % of total energy). Most respondents (72.5 %) reported a white bread intake pattern. In multivariate logistic analysis, white bread consumption was characterized by a more Westernized lifestyle than whole wheat bread consumption (Table 17.1).

Urban vs. rural residence was associated with a 2.8-fold higher odds of being in the white bread group, while dieters vs. non-dieters and those eating store-bought vs. homemade bread had 4.7- and 8.2-fold higher odds of being in the white bread group, respectively. Whole wheat bread intake patterns were associated with deriving a higher percentage of total energy from bread and also with having a higher BMI.

The mean intake of selected nutrients by bread group, adjusted for age, sex, energy intake, and other possible confounders, is presented in Table 17.2, along with the mean percentages of the Dietary Reference Intakes (DRIs) reached. While in the whole wheat bread group the daily total energy and macronutrient intakes were significantly higher than in the white bread group ($P<0.001$), the groups did not differ in percentages of total energy from protein, carbohydrates, and fat. The mean intakes of both groups were within the Acceptable Macronutrient Distribution Range (AMDR) for all macronutrients. Less than 20 % of respondents exceeded the upper end of the AMDR for fat (35 %), while approximately one-third exceeded the upper end of the AMDR for carbohydrates (65 %). Most of the fat intake (~75 %) came from monounsaturated fatty acids (MUFA) or polyunsaturated fatty acids (PUFA); however, the percentage of total fat from SFA was significantly lower in the whole wheat than the white bread group ($P=0.013$). The mean dietary fiber intake of whole wheat bread consumers exceeded the Adequate Intake (AI), while that of white bread consumers fell below the AI.

There were also significant differences between the whole wheat and white bread groups in mean daily intakes of most micronutrients (Table 17.2). Calcium, potassium, vitamin A, vitamin E, and folate intakes were below the Recommended Daily Allowance (RDA)/AI for all respondents, yet the intakes of most of these nutrients were significantly higher in the whole

Table 17.2 Daily nutrient intake by bread intake groups defined as predominantly whole wheat bread ($n=124$) and predominantly white bread ($n=327$) intake patterns in the Bedouin Nutrition Study[a]

Nutrients	Whole wheat bread Mean ± SE	White bread Mean ± SE	*P* value	% of DRI[b] Whole wheat bread	% of DRI[b] White bread
Total energy (kJ/d)	11459 ± 276	8223 ± 167	<0.001		
Protein (g/d)	78.9 ± 2.7	64.1 ± 1.6	<0.001		
% energy from protein	13.9 ± 0.4	13.6 ± 0.2	0.528	*0.0*	*0.0*
Fat (g/d)	72.6 ± 3.0	56.6 ± 1.8	<0.001		
% energy from fat	27.6 ± 0.8	26.2 ± 0.5	0.144	*16.1*	*13.3*
% of total fat from SFA	24.6 ± 0.8	26.9 ± 0.5	0.013		
% of total fat from MUFA	39.9 ± 1.0	38.8 ± 0.6	0.326		
% of total fat from PUFA	27.8 ± 1.1	27.4 ± 0.7	0.762		
Cholesterol	194.1 ± 17.2	190.3 ± 10.3	0.671		
Carbohydrates (g/d)	373.6 ± 10.2	308.6 ± 6.2	<0.001		
% energy from carbohydrates	62.7 ± 0.9	61.9 ± 0.5	0.566	*31.5*	*39.1*
Dietary fiber (g/d)	41.8 ± 1.0	23.3 ± 0.6	<0.001	*140.5*	*79.1*
Calcium (mg/d)	428.7 ± 20.8	391.5 ± 12.5	0.081	*41.8*	*38.4*
Iron (mg/d)	16.7 ± 0.4	11.0 ± 0.3	<0.001	*130.2*	*87.0*
Magnesium (mg/d)	490.3 ± 9.8	262.2 ± 5.9	<0.001	*139.2*	*75.3*
Potassium (g/d)	3.0 ± 0.1	2.3 ± 0.0	<0.001	*63.1*	*49.0*
Zinc (mg/d)	11.6 ± 0.3	8.1 ± 0.2	<0.001	*113.8*	*79.2*
Vitamin A (RAE, mcg/d)	453.2 ± 288.8	677.4 ± 172.9	0.743	*54.7*	*82.2*
Vitamin E (mg/d)	8.6 ± 0.3	6.5 ± 0.2	<0.001	*57.2*	*43.1*
Vitamin C (mg/d)	92.3 ± 6.9	88.0 ± 4.1	0.237	*106.6*	*101.2*
Thiamin (mg/d)	1.35 ± 0.03	0.88 ± 0.02	<0.001	*109.1*	*71.3*
Vitamin B2 (mg/d)	1.43 ± 0.06	1.21 ± 0.04	<0.001	*109.5*	*92.6*
Niacin (mg/d)	22.0 ± 0.6	15.3 ± 0.4	<0.001	*138.0*	*96.2*
Vitamin B6 (mg/d)	1.80 ± 0.05	1.34 ± 0.03	<0.001	*118.8*	*89.3*
Folate (mcg/d)	290.2 ± 13.4	275.5 ± 8.0	0.144	*63.2*	*60.5*

Comparison of nutrient intakes of Bedouin who eat primarily whole wheat to those eating primarily white bread
DRI Dietary Reference Intake, *RAE* retinol activity equivalent

[a]Each result is obtained using a Generalized Linear Model analysis, adjusted for age, sex, rural/urban status, and physical activity level; each micronutrient result is also adjusted for total energy intake
[b]Value for macronutrients represents % above AMDR; value for micronutrients represents % of RDA/AI

wheat than the white bread group. Whole wheat bread consumers had higher intakes of iron, magnesium, zinc, thiamine, vitamin B2, niacin, and vitamin B6 ($P<0.001$) than white bread consumers, and on the average, whole wheat bread consumers met or exceeded the RDA for all of these nutrients, while white bread consumers fell below the RDA.

The association between bread type intake and self-reported chronic diseases (hypercholesterolemia, hypertension, type 2 diabetes, and CHD) was also examined among participants aged ≥40 years ($n=102$), since chronic disease prevalence was low (1.0–2.6 %) for those below the age of 40. However, 37.3 % of those aged ≥40 reported having been diagnosed with one or more chronic diseases, and this proportion was higher among white bread consumers than whole wheat bread consumers (46.5 % vs. 16.1 %, $P=0.004$) [9]. In univariate logistic regression analysis, the odds ratio (OR) of having one or more chronic diseases in the white bread group as compared to the whole wheat bread group was 4.52 (95 % CI: 1.56–13.10, $P = 0.006$). After controlling for other risk factors and possible confounders, including age group, BMI category, physical activity level, sex, smoking, rural/urban status, employment, and total fat intake, the OR increased to 9.85 (95 % CI: 2.64–36.71, $P = 0.001$).

Comments

The Bedouin Nutritional Study findings indicate that the intake of bread, the main traditional dietary staple, dropped from an estimated 60 % of the total energy intake in the 1960s [19] to 33 % in the early 2000s [9]. In terms of diet quality, the change was even greater, since traditionally the Bedouin consumed bread made from locally milled whole wheat flour, while in the Bedouin Nutritional Study sample, 73 % reported consuming primarily white flour bread. The Bedouin have simultaneously undergone many other lifestyle changes during this period, including the loss of the traditional non-mechanized agropastoral economy and its high physical activity demands; urbanization, which further reduced physical activity levels; improved access to markets and modern amenities; and greater integration into the Israeli labor and consumer markets. These lifestyle changes have been accompanied by dramatic increases in overweight and chronic disease rates [24, 25].

Bread type intake seems to serve as a marker of nutritional transition and acculturation in the Bedouin population. The transition away from whole wheat bread as the main dietary staple represents a Westernization of the traditional diet, and white bread intake was also associated with markers of Westernization/modernization, such as urbanization, the consumption of store-bought rather than homemade bread, and dieting practices. Urbanization has probably contributed to reduced whole wheat bread intake. In the traditional economy, the Bedouin raised grain, most of which was made into whole wheat flour for bread and served as their main dietary staple [19]. It is infeasible to maintain such practices in urban settings, and the Bedouin Nutritional Study findings indicated that a much lower proportion of urban than rural residents had a primarily whole wheat bread consumption pattern [9]. The consumption of store-bought bread is another by-product of modernization. In this particular context, it has also fuelled the transition away from whole wheat bread intake because white flour bread is the most readily available and affordable commercial bread product in Bedouin communities. In addition, dieting (which in the Bedouin Nutritional Study sample was done primarily for the purpose of losing weight [9]) is another modern phenomenon, perhaps linked to adopting more Westernized body image ideals. Dieting in the Bedouin Nutritional Study sample was associated predominantly with white bread consumption, perhaps indicating a lack of awareness of the benefits of whole-grain, high-fiber foods for maintaining a healthy weight [26].

The finding that those in the higher BMI categories (>25.0) were more likely to have whole wheat bread intake was surprising, given that the literature has tended to show increasing whole-grain intakes to be negatively associated with BMI [27, 28]. High whole-grain intake is often associated with lower total caloric intake as part of healthier overall dietary patterns with lower fat intakes than those found among people with high refined grain intakes [27, 28]. Among the Bedouin population, however, the whole wheat bread pattern represents maintaining traditional dietary patterns based upon very high bread intakes which provided the main source of energy for a physically demanding lifestyle. In the Bedouin Nutritional Study sample, those maintaining the whole wheat bread pattern had significantly higher absolute intakes of bread, energy, total fat, carbohydrates, and protein than did white bread consumers. This suggests that whole wheat bread consumers maintained more traditional dietary patterns in terms of both the *quantity* and quality of intake, despite the lower energy requirements of modern life. Thus, the combination of higher absolute energy intake, similarly sedentary physical activity levels, and lower reported dieting behaviors among whole wheat as compared to white bread consumers may explain the association of the whole wheat bread dietary pattern with higher BMIs.

The energy-adjusted micronutrient density of the whole wheat bread dietary intake was higher than that of the white bread intake. Whole wheat bread consumers were more likely to meet recommended intake levels for dietary fiber, iron, magnesium, zinc, and most B vitamins. In contrast, the energy-adjusted dietary fiber and micronutrient intake of white bread consumers fell below recommended levels in most cases.

The Bedouin Nutritional Study findings suggest that the Negev Bedouin are similar to other traditional/indigenous populations among whom the modernization/Westernization of diet and lifestyle and urbanization processes have been accompanied by sharp increases in chronic disease rates [29, 30]. White bread consumers aged ≥40 were over 9 times more likely to report having been diagnosed with at least one chronic disease (hypertension, hypercholesterolemia, diabetes, CHD) than whole wheat bread consumers after controlling for other known risk factors. Given the cross-sectional nature of the study and the multiple aspects of Negev Bedouin lifestyle aside from diet that have undergone change, this observational finding cannot be used to make causal inferences. However, it is consistent with the body of literature that has shown an association between whole-grain food intake and reduced risk for chronic diseases and is of public health importance for the nutrition transition that is occurring in this population.

Dietary acculturation among the Bedouin, in the form of replacing the traditional whole wheat flour with white flour, has negatively affected diet quality. A reversal of this process, through nutrition education and the preservation of traditional whole-grain dietary habits, in combination with other lifestyle interventions, may be a promising strategy for reducing chronic disease risk in this community. Prospective cohort and intervention studies that take into account additional aspects of dietary intake and acculturation, as well as concurrent changes in other relevant lifestyle factors, are needed to test and confirm the potential of such a strategy.

Arabs in the Wadi ‘Ara Region

Background and Dietary Traditions

The Arab population in the Wadi ‘Ara area was primarily an agricultural society historically [10, 17]. Data on Arab agriculture from the 1940s in the Jenin and Tulkarm districts (in which Wadi ‘Ara is located) indicate that 79 % of the arable land was used for grain (wheat and barley) production; 16 % for olive production; 3 % for vegetable, legume, and fruit (excluding citrus fruit) production; and 2 % for citrus/banana production [31]. Their traditional lifestyle demanded a high level of physical activity [8]. After the establishment of Israel in 1948, the loss of land together with other social, political, and economic changes led to an ongoing process of urbanization. As a result, this traditionally agricultural society was gradually transformed into a consumer society [8]. Furthermore, since the Arab population in this area lived in close proximity to Jewish towns and cities, they had a high level of exposure to multiple aspects of Jewish society in Israel, including foods and eating patterns.

There are no detailed published studies on food consumption or changes in food consumption patterns among the Arabs in the Wadi ‘Ara region as they underwent urbanization. However, a study on the traditional diet, dietary change, and health status in a semirural West Bank village in the mid-1990s [32], in which less than 10 % of men derived their livelihood from agriculture, may be similar. There did not appear to be a shortage of dietary energy at the household level, even in the poorest households. Flour was the most important contributor to energy intake, followed by olive oil and sugar. The intake of sweetened soft drinks, sweets, and chips had increased over the previous 10 years in over 80 % of the households surveyed, while that of selected animal-source foods (chicken, processed meat, and eggs) had increased in over 50 % of the households. Concurrently, the intake of legumes and whole wheat flour had decreased. The consumption of soft drinks and white bread increased as age decreased [32]. Obesity rates in those aged 30–65 years who participated in this study were 37.5 % among women and 18.8 % among men [33].

As the Arab population in Wadi ‘Ara urbanized and the majority were no longer engaged in agriculture [34], physical activity levels decreased [8]. At the same time, access to food increased, both in terms of quantity and variety. This included increased access to “fast foods” from kiosks and restaurant chains of both a Middle Eastern nature (e.g., *falafel* and *shawarma* sandwiches) and a Western nature (e.g., pizza, hamburgers, chips, and fast-food chains such as Pizza Hut, McDonalds, Kentucky Fried Chicken). While this community had high exposure to the same type of Westernized food environment found in neighboring Jewish communities, its socioeconomic level remained lower than that of the Jewish population in terms of employment and educational levels [12, 17]. There is evidence that where economic barriers existed, the nutritional quality of food intake among Arabs was poor [8]. These changes in diet and lifestyle were accompanied by increases in the rates of overweight/obesity and type 2 diabetes [10, 17].

The Hadera District Study

The Hadera District Study included a population-based, random sample of Jewish and Arab adults ($n = 1{,}100$) living in urban localities (towns with populations of 5,000 or more) [10, 17]. The sample was stratified equally across ethnic, sex, and 10-year age categories (age range, 25–76). The Hadera District Study provides recent data on diet and CVD risk factors among the Arab population in the Wadi ‘Ara region. Employment rates were 51 % among men and 11 % among women. Only 3 % of the sample was engaged in agriculture. Obesity rates were found to be 52 % among women and 25 % among men, though due to the sampling design, the older age groups (in which obesity rates are higher) were overrepresented in the sample.

Dietary intake was assessed among Hadera District Study participants using a food frequency questionnaire with 240 food items (including Arabic ethnic foods), and data was collected on dietary change during adulthood [11]. Prior to administration of the FFQ, participants were asked if they had made any dietary changes over the past 20 years (or if younger than 40 years, since the age of 20). If so, they were asked the reason for the change. During the administration of the FFQ, participants were asked about the intake of each food item (frequency of consumption, number of portions consumed, and portion size) and if they had made any changes in intake during the past 20 years. Participants’ reported dietary change was categorized as (1) none, (2) non-health-related change (e.g., made for “no special reason,” or no reason given), and (3) health-related change (e.g., change intentionally made for chronic disease management, weight loss, or health awareness reasons).

To identify dietary patterns, food items were collapsed into 51 groups and entered into principal component analysis. Dietary patterns were identified for the sample as a whole and for Arabs and Jews separately. In this chapter, we report selected findings from the dietary pattern analysis conducted separately for Arabs and from multivariate regression analyses conducted to assess associations between the dietary patterns and participant characteristics, reported dietary change, and daily energy and macronutrient intakes. Non-normally distributed nutrient variables were transformed using the natural log transformation, and general linear models were fitted to examine nutrient intake trends across tertiles of the dietary pattern intake scores, adjusted for sex, age, and total energy intake.

Five dietary patterns were identified from the FFQ data of the Hadera District Study Arab respondents: (1) fast foods, sweets, and snacks; (2) Western-style bread and poultry; (3) refined grains and meat dishes; (4) plant protein, whole grain, and vegetables; and (5) red meat, eggs, and dairy. For the purposes of this review, we will further explore the fast foods, sweets, and snacks pattern, which made the largest contribution of the five patterns to explaining the variance in dietary intake in the study sample and was also the most indicative of dietary acculturation. Respondents with a high score on this pattern had a high intake of fast foods and snacks (e.g., pizza and other savory cheese pastries, falafel

Table 17.3 Food groups in the fast foods, sweets, and snacks dietary pattern among Arabs in the Hadera District Study ($n = 551$)

Food groups	Factor loading
Pizza, savory cheese pastries	0.52
Desserts	0.47
Chips	0.45
Sweets	0.39
High-fat dairy	0.38
Nuts and seeds	0.36
Falafel sandwich in pita bread	0.33
Sweetened soft drinks	0.32
Pita bread	–0.54
Olive oil/olives	–0.61

The fast foods, sweets, and snacks dietary pattern includes a high intake of foods with a positive loading and a low intake of foods with a negative loading
(Previously unpublished data)

Table 17.4 Multivariate logistic regression analysis of the characteristics of Hadera District Study participants in the highest as compared to the two lower tertiles of the fast foods, sweets, and snacks pattern ($n = 551$)

Subject characteristics	Adjusted OR	95 % CI
Main effects		
Gender: female vs. male	0.77	0.51–1.16
Age (per 10 y increment in age)	0.56	0.47–0.66
Non-health-related dietary change vs. no change or health-related change	1.72	1.12–2.64
Obese[a] yes vs. no	1.09	0.69–1.73
Diabetes[b] yes vs. no	0.23	0.07–0.80
Interaction effects		
Diabetes × obesity	4.70	1.13–19.63

Characteristics of Arabs with a high intake of fast foods, sweets, and snacks
[a]BMI ≥ 30 kg/m^2
[b]Self-reported physician-diagnosed diabetes and/or hypoglycemic drug therapy

sandwiches, chips, and nuts), desserts, sweets, and sweetened beverages (Table 17.3). Those with a low score on this pattern had a high intake of olive oil/olives and pita bread, the staple foods produced by this traditionally rural population. Respondents were divided into tertiles by their score on this pattern, and this variable was dichotomized (highest tertile vs. two lower tertiles) and used to explore associations between participant characteristics and a high intake of the fast foods, sweets, and snacks dietary pattern.

In multivariate logistic analysis, the odds of being in the highest intake tertile of this dietary pattern decreased by over 40 % for every 10-year increment in age (Table 17.4). After controlling for age, no associations remained between socioeconomic status indicators (e.g., education, occupation, employment status) or health-related lifestyle behaviors (e.g., smoking, leisure-time physical activity) and the intake of this pattern. However, respondents who reported making non-health-related dietary change had higher odds of being in the top tertile of this pattern than those who reported not making any dietary changes or making dietary changes for health-related reasons. The effect of diabetes differed by obesity status. Among participants who were not obese, diabetics had 77 % lower odds than nondiabetics of being in the top tertile of this pattern (OR for main effect of diabetes in Table 17.4). However, among those who were obese, having diabetes was not associated with intake of this pattern (OR: 1.09; 95 % CI: 0.50–2.35).

The effect of the intake of this pattern across tertiles on mean daily energy and macronutrient intakes is shown in Table 17.5, adjusted for gender and age (and energy for macronutrients). Total daily energy increased across tertiles of the pattern. In addition, total fat and saturated and PUFA increased across intake tertiles, both in absolute terms and as a percentage of total energy intake. Sugar intake also increased significantly across tertiles of the pattern, while total carbohydrate, dietary fiber, and protein intakes decreased.

Comments

The fast foods, sweets, and snacks dietary pattern that emerged among the formerly rural Arab population in Wadi 'Ara represents a change from the intake of traditionally produced local food staples to a more Westernized diet. Although the Hadera District Study data are cross-sectional, a high

Table 17.5 Daily energy and macronutrient intakes across tertiles of the fast foods, sweets, and snacks dietary pattern among Hadera District Study Arab participants ($n = 551$)

Nutrients	Mean ± SE[a] T_1	T_2	T_3	P for trend
Energy (kcal/d)	2157 ± 62	2185 ± 58	2607 ± 61	<0.001
Protein (g/d)	100.5 ± 1.2	102.3 ± 1.1	96.8 ± 1.2	0.005
% of total energy	18.3 ± 0.2	18.2 ± 0.2	16.8 ± 0.2	0.008
Total fat (g/d)	82.7 ± 1.1	81.5 ± 1.1	91.0 ± 1.1	<0.001
% of total energy	31.6 ± 0.4	31.7 ± 0.4	35.1 ± 0.4	<0.001
Saturated fatty acids (g/d)	23.5 ± 0.4	25.7 ± 0.4	29.7 ± 0.4	<0.001
% of total energy	9.0 ± 0.2	10.1 ± 0.2	11.4 ± 0.2	<0.001
Monounsaturated fatty acids (g/d)	36.6 ± 0.6	32.4 ± 0.6	34.6 ± 0.6	0.290
% of total energy	14.1 ± 0.2	12.6 ± 0.2	13.6 ± 0.2	0.229
Polyunsaturated fatty acids (g/d)	17.4 ± 0.4	18.5 ± 0.3	21.2 ± 0.4	<0.001
% of total energy	6.7 ± 0.1	7.1 ± 0.1	8.0 ± 0.1	<0.001
Carbohydrates (g/d)	309.9 ± 3.1	309.8 ± 2.8	291.5 ± 3.1	0.002
% of total energy	53.2 ± 0.5	53.0 ± 0.5	50.7 ± 0.5	0.001
Sugars (g/d)	81.3 ± 2.2	96.4 ± 2.1	117.2 ± 2.2	<0.001
Dietary fiber (g/d)	19.3 ± 0.3	17.8 ± 0.3	17.0 ± 0.3	<0.001

Change in nutrient intakes as intake of the fast foods, sweets, and snacks dietary pattern increases (Previously unpublished data)

[a]For energy, controlling for gender and age; for macronutrients controlling for gender, age, and energy intake

intake of this pattern is strongly suggestive of dietary acculturation since those who reported making dietary changes "for no special reason" (and that were, in particular, not health motivated) had over 70 % higher odds than those who either had made no changes at all or had made changes for health-related reasons, of being in the top intake tertile. The negative association between age and indictors of dietary acculturation has been reported in other populations exposed to Western dietary influences [2, 32]. The Hadera District Study data suggest that young adults in the Wadi 'Ara population are more likely than older adults to have incorporated Western (e.g., pizza, nontraditional sweets) fast foods/snacks and traditional fast foods/snacks (e.g., falafel sandwiches, salted nuts) as major components of their diet, independent of educational level and income. This is likely related to the rapid proliferation of fast-food chains/kiosks that occurred during the urbanization process in Wadi 'Ara and that has created a new food environment/milieu in which young people now socialize. Younger adults are also more likely than older adults to work in the Jewish sector and thus to be more intensively exposed to the Westernized diet of the majority population. The lack of association between educational and occupational parameters and healthier eating behaviors may be reflective of the fact that on the whole, the socioeconomic level of the population is low, which has been associated in many populations with poorer access to healthy food and lower levels of health awareness [2, 8].

Adoption of this dietary pattern is likely to negatively impact diet quality as compared to the traditional diet, which was high in complex carbohydrates, plant-source proteins, and monounsaturated fats. Those with a high score on this pattern had significantly higher energy, total fat, saturated fat, and sugar intakes than those with a low score. As such, dietary acculturation in the form of a high intake of the fats, sweets, and snacks dietary pattern has the potential, theoretically, to increase chronic disease morbidity and mortality. In the Hadera District Study, interactions were found in the associations between chronic disease prevalence and the intake of this pattern and, given the cross-sectional nature of the data, may also be affected by reverse causality. Among nonobese participants, the fact of having DM was associated with much lower odds of having a high intake of fast foods, sweets, and snacks, as compared to nondiabetics. Since all residents of Israel have health insurance, people with diabetes are likely to have received information about adopting and maintaining healthy dietary and lifestyle behaviors and maintaining a healthy body weight. Nonobese people with diabetes may be compliant with these messages, which would explain their lower odds of having a high intake of fast foods, sweets, and snacks than generally healthy (nonobese, nondiabetic) people, who may have less exposure to healthy lifestyle messages and/or lower motivation to comply with such messages.

Among obese participants, having diabetes did not alter the odds of having a high intake of this pattern, despite the fact that it contains many foods/beverages that should not ideally make up a habitual part of the diet of someone with diabetes. This finding suggests that barriers to maintaining a healthy weight and adopting dietary and lifestyle behaviors that would optimize glycemic control, whether personal or structural, are not being adequately addressed and overcome among obese people with diabetes. They may represent a group with a special need for culturally appropriate and individualized interventions to address relevant personal, social, economic, and environmental barriers to adopting and maintaining healthy dietary and lifestyle behaviors [7, 34]. Since the data reviewed here are cross-sectional, they are suitable for exploratory analyses and hypothesis generation, but longitudinal studies are needed to test these hypotheses.

Conclusions

The studies reviewed in this chapter provide evidence of dietary acculturation among two distinct subgroups of the Arab minority population in Israel. The differences in dietary assessment methods and statistical analysis approaches used in these studies limit the comparability of the results. Nevertheless, some general observations can be made.

Traditionally, throughout the Middle East, Bedouin and rural villagers engaged in trade with each other for food products they did not produce. Nevertheless, the traditional diets of these groups differed because of the geographical determinants that most strongly affected their food production and consumption, as well as other aspects of their lifestyles. In both of these subgroups of the Arab minority in Israel, however, the traditional diet had qualities that are known to be protective against nutrition-related chronic diseases (high intake of whole grains, legumes, monounsaturated fats, and relatively low intake of saturated fats). Indications found among both subgroups suggest that dietary acculturation may be eroding positive, protective aspects of their traditional diets. It may thus contribute to increasing the risk for chronic disease morbidity in this population, particularly when combined with other factors such as increasingly sedentary lifestyles, socioeconomic barriers, unhealthy food environments, and low health awareness.

In the Bedouin Nutritional Study, age was not associated with the marker we used for dietary acculturation (bread type). This may be because bread type intake tends to be determined more at the household level or by the broader environment (urban vs. rural) than by individual characteristics. The Hadera District Study included only urban participants, and age was strongly associated with the indicator of dietary acculturation (fast foods, sweets, and snacks dietary pattern) in this population. The process of urbanization has been going on longer in Wadi ‘Ara than among the Bedouin in the Negev. It has been accompanied by a more intensive exposure to Western/majority population dietary influences, including the proliferation of a “fast-food environment.” As urbanization proceeds among the Negev Bedouin, the same type of process is likely to develop unless action is taken to prevent or modify it.

Finally, we note that educational level was not associated with the dietary acculturation indicators studied after controlling for age, and higher education did not appear to have the protective effect on diet quality, and healthy lifestyle generally, that has been reported in other populations.

This suggests that additional culturally appropriate health education efforts may be required within the formal educational system to increase awareness among members of the Arab minority in Israel about the potentially negative effect that dietary acculturation can have upon their diet quality and health.

The cross-sectional studies reviewed here highlight the urgency of collecting longitudinal data on this minority population, which has exhibited elevated prevalences of chronic disease morbidity and mortality as compared to the majority population [10, 13, 14, 17, 24, 25]. Given that diet is a major, modifiable risk factor, documentation of the process of dietary acculturation and its impact on diet quality and health is needed to provide an evidence base for developing sound public health policies and interventions for this minority population.

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18 Diet Quality in Developing Countries

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Key Points

- Dietary diversity (DD) is a strong predictor of dietary quality defined as micronutrient adequacy of the diet in women and children in developing countries.
- Validation studies using a standard methodology show that DD indicators are consistently and strongly associated with the micronutrient *density* of the diet in children and the micronutrient *adequacy* of the diet in women.
- For children 6–24 months of age, a 7-food group DD indicator has been adopted as one of the WHO-recommended 8 core indicators for measuring infant and young child feeding practices; a cut-off point of ≥ 4 is used to classify children as having minimum dietary diversity.
- For women of reproductive age, a 9-food group DD indicator is recommended based on results from a mutli-country validation study. Research is under-way to identify a suitable cut-off point for classifying individuals into low versus adequate DD.
- New studies confirm a positive association between dietary diversity indicators and anthropometric measures in both children and women after appropriately controlling for socio-demographic and economic factors.
- Research is needed in two broad areas: (1) to develop qualitative data collection tools to measure DD that minimize misreporting of foods and food groups among respondents and (2) to test the performance of DD indicators not only for descriptive purposes but also for measuring change over time and for tracking progress and program and policy impacts.

Keywords:

Anthropometry • child • diet quality • dietary diversity • food groups • indicators • micronutrient adequacy • women

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V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health, DOI 10.1007/978-1-4614-7315-2_18,

Abbreviations

BFP	Body fat percentage
BMI	Body Mass Index
CFI	Complementary Feeding Index
DD	Dietary diversity
DDS	Dietary diversity score
DHS	Demographic and health surveys
DQ	Dietary quality
EAR	Estimated average requirement
FAO	Food and Agriculture Organization
FFQ	Food frequency questionnaire
FGI	Food group indicator
FVS	Food variety score
HAZ	Height-for-age Z-score
LAZ	Length-for-age Z-score
MAR	Mean adequacy ratio
MMDA	Mean micronutrient density adequacy
MPA	Mean probability of adequacy
MUAC	Mid upper arm circumference
NAR	Nutrient adequacy ratio
NDA	Nutrient density adequacy
NPA	Nutrient probability of adequacy
NPNL	Non-pregnant non-lactating
qFGI	Qualitative food group indicators
QFGI	Quantitative food group indicators
RNI	Recommended nutrient intake
ROC	Receiver operating characteristic
Se/Spe	Sensitivity/specificity
WAZ	Weight-for-age Z-score
WHO	World Health Organization
WHZ	Weight-for-height Z-score
WLZ	Weight-for-length Z-score
WR	Weighed record

Introduction

Dietary quality contributes to an individual's nutrition and health status, with a high-quality diet providing the right nutrients in the right amounts for health and wellbeing. Attainment of a high-quality diet is particularly problematic among poor populations in low-income countries where diets are dominated by starchy staple foods, and nutrient-dense animal source foods, fruits, and vegetables are often unavailable or unaffordable. The measurement of dietary quality is also more difficult in these contexts, where a lack of resources and research capacity makes the collection and analysis of detailed quantitative dietary data for research or program planning difficult. Dietary diversity (DD), the number of foods or food groups consumed, is a key dimension of dietary quality, with diverse diets increasing the likelihood of adequate intake of essential nutrients. This chapter updates a 2003 review of DD indicators [1] and summarizes new evidence regarding their potential use as a proxy for dietary quality in developing country contexts. Box 18.1 describes key concepts used in this chapter.

The 2003 review concluded that individual level DD indicators were potentially useful tools to measure dietary quality, defined as micronutrient adequacy of the diet. DD indicators were found to be associated with the micronutrient adequacy of diets in both adults and children from developing countries and were also associated with child anthropometry. Given the limited number of studies that controlled for energy intake and household socioeconomic characteristics when looking at the associations between DD and micronutrient adequacy of the diet or anthropometry, however, it was not clear whether the DD indicators were just good proxies for socioeconomic status and/or for total energy intake, or whether they truly reflected micronutrient adequacy, independent of energy intake or socioeconomic status. The review recommended that further studies with appropriate control for potentially confounding factors be conducted to clarify the nature of these associations. The review also concluded that a lot remained to be done to validate the usefulness of DD indicators in different populations with different consumption patterns, and in different age groups with varying dietary intakes and nutritional requirements.

This chapter builds on these findings and reviews the evidence published on developing countries since 2003 to address the knowledge gaps identified. The focus is on the use of individual level DD indicators based on a recall of foods or food groups consumed over a given period of time, and on whether or not such indicators accurately reflect diet quality, narrowly defined as micronutrient adequacy. The chapter looks at new

Box 18.1: Definition of Key Terms

Dietary quality (*DQ*) = Historically, dietary quality has been used to refer to nutrient adequacy. Nutrient adequacy, in turn, refers to a diet that meets an individual's requirements for energy and essential nutrients. With the rise of overweight, obesity, and diet-related chronic diseases, the definition of dietary diversity has shifted to also include concepts of dietary diversity, proportionality (e.g., balance of certain key nutrients such as energy from fat or carbohydrates), and moderation.

Dietary diversity (*DD*)/*dietary variety* (*DV*) = The number of different foods or food groups consumed over a specified reference period.

Dietary Diversity Score (*DDS*)/*Food Variety Score* (*FVS*) = An indicator that measures dietary diversity/variety (e.g., the number of foods or food groups consumed over a specified reference period); the indicator can be used either at the individual or the household level and is often used synonymously with food group indicator (FGI).

Food frequency questionnaire (FFQ) = A data collection tool used to derive information on how often individual foods or food groups have been consumed during a specified period of time. The FFQ can be either qualitative or quantitative (if the latter, amounts consumed are also reported).

Food group indicator (FGI) = Synonymous to dietary diversity score (DDS) or food variety score (FVS)

Mean adequacy ratio (*MAR*) = Used to measure nutrient adequacy of the diet; computed by averaging the individual nutrient adequacy ratios (NARs) for a given set of nutrients.

Mean micronutrient density adequacy (*MMDA*) = Used to measure the average micronutrient density of the diet for a set of preselected micronutrients. This measure is

(continued)

Box 18.1 (continued)

used mostly in breastfed children 6–24 months of age because guidance on micronutrient intake for these children is provided in terms of micronutrient density, rather than intake, of complementary foods. MMDA is the average of the individual micronutrient density adequacies for each selected micronutrient.

Mean probability of adequacy (*MPA*) = Used to measure the nutrient adequacy of the diet; computed by averaging the individual micronutrient probability of adequacy (PA) for a given set of micronutrients

Micronutrient density adequacy (*MDA*) = Used to measure the micronutrient density of complementary foods for each preselected nutrient. MDA is computed as the ratio of the individual micronutrient density of each micronutrient over the desired (recommended) nutrient density for the child's age [2].

Nutrient adequacy ratio (NAR) = The NAR for a given nutrient is the ratio of an individual's nutrient intake over the current recommended intake for the individual's sex and age.

Probability of adequacy (*PA*) = Uses the probability approach to estimate adequacy for individual micronutrients [3]. PAs for individual micronutrients are computed by comparing estimated usual intakes to estimated average requirements (EAR) for each micronutrient.

Receiver operating characteristics (*ROC*) = An ROC curve is a graphical plot of the sensitivity (say, % correctly identified by DD indicator as having low dietary quality) vs. false-positive rate (% who are incorrectly identified as having low dietary quality by the indicator). In the papers reviewed, ROC curves were used to test and compare the predictive value of the DD

Box 18.1 (continued)

indicators tested, using the area under the curve. An indicator whose area under the curve is 0.5 is an indicator that is not significantly different from the "null" value and has no predictive value. Significantly larger areas under the curve indicate better predictive performance.

Sensitivity (Se)/specificity (Spe) analysis= In the literature reviewed, sensitivity (Se) is the percentage of individuals truly at risk of (or who have) low micronutrient adequacy who are correctly identified by the DD indicator as having low micronutrient adequacy; specificity (Spe) is the percentage of individuals who *are not at risk of* having (or do not have) low micronutrient adequacy who are correctly identified by the indicator as not having low micronutrient adequacy. Se/Spe analysis is used in the DD literature to identify best cutoff points for DD indicators that maximize the Se/Spe relationship and result in lower levels of misclassification (either false positives or false negatives).

validation studies[1] that test the performance of DD indicators in predicting micronutrient adequacy of the diet in young children and in adults, and at studies that look at different methodological issues related to the design and use of instruments to collect DD information in developing countries. The chapter also summarizes new evidence from recent studies that tested the association between DD diversity and anthropometric indicators in children and/or adults, controlling for potentially confounding factors, especially energy intake and socio-demographic characteristics. The chapter specifically addresses the following four key questions:

1. Do DD indicators accurately predict micronutrient adequacy or density of the diet in *children*?
2. Do DD indicators accurately predict micronutrient adequacy of the diet in *adults*?
3. Are DD indicators associated with anthropometry in children and women when controlling for potentially confounding factors?
4. What do recent studies looking at methodological issues tell us regarding the development and use of DD indicators to predict micronutrient adequacy?

Searching for Published Literature on Dietary Quality in Developing Countries

The search aimed to locate all published studies on the measurement of individual level dietary quality (DQ) and dietary diversity using simple tools in developing countries since 2003. The focus was on studies that validated the usefulness of simple DD indicators to reflect or predict dietary quality as measured by the micronutrient adequacy/density of the diet. The search also included studies that tested the association between indicators of DD at the individual level and anthropometric or socioeconomic outcomes. A non-systematic search was undertaken of relevant databases, including MEDLINE and Google Scholar, using key words "diet* quality" or "diet* diversity" and "validation" or "association" or "measure*." After initially identifying a set of relevant association and validation studies, the reference lists were reviewed as a means of acquiring additional relevant publications. Papers were included in the review if they were validation or association studies of diet quality indicators relating to the diets of individuals (rather than households) in low-income countries. Studies carried out in developed countries were excluded, as were studies that used indicators of

[1] Validation studies are defined here as studies that test the association and predictive power of a dietary diversity indicator against a gold standard, which in this case is defined as a quantitative measure of micronutrient adequacy (or density in young children) of the diet. In other words, studies are considered "validation studies" if they test whether or not DD indicators are associated with—and how well they or predict—micronutrient density or adequacy of the diet. Association studies, on the other hand, are those that look at the association between DD indicators and outcomes such as anthropometric indicators in children or adults. These latter studies are not considered validation studies because they do not test DD indicators against a gold standard measure of the construct they are supposed to reflect (i.e., micronutrient adequacy/density of the diet).

DQ that required detailed quantitative data on nutrient intakes or foods and portion sizes, such as studies using the healthy eating index [4] or other complex dietary quality scores [5], or studies that looked at DD indicators as a component of indices of complementary feeding practices [6].

Measurement of Dietary Diversity

Dietary diversity is calculated as the number of foods or preselected food groups consumed over a given reference period. Dietary Diversity Scores (DDSs) or food group indicators (FGIs) (used interchangeably in the literature) may include any number of food groups. In the recent literature, studies have tested different food groupings and numbers of food groups (ranging from 7 to 21 groups) and assessed the impact of varying the number of food groups on the accuracy of the indicators [7–13]. DD indicators have also been constructed using the number of discrete foods consumed; this indicator is usually referred to as a Food Variety Score (FVS), which can include any number of discrete foods. In order to discount small and non-nutritionally relevant amounts of a food, many indicators only count foods or food groups if a minimum quantity is reported consumed, often using a 1-, 10-, or 15-g cutoff point; again, several studies have looked at the impact of varying this minimum intake cutoff point [7–9, 11, 13]. Reference periods also vary, but recall of foods or food groups is often conducted with a 24-h reference period to minimize potential recall bias, which can occur when longer recall periods are used. Some studies have also assessed the effect of varying the recall time [14, 15], while others have used data collected from a 7-day recall (e.g., Demographic and Health Surveys (DHS)) [16] or a 7-day food frequency questionnaires (FFQ) [15].

Measurement of Dietary Quality

There are several methods for measuring dietary quality at the individual level [4]. As noted above, in this study, dietary quality was defined as the micronutrient adequacy of the diet in adults. In young children who are still breastfeeding, and hence receiving a significant but highly variable proportion of their nutrients from breast milk, studies have used micronutrient *density* (rather than adequacy) of the diet as a measure of diet quality [7]. This approach follows WHO guidance on micronutrient density adequacy of complementary foods [2, 17]. Micronutrient adequacy and density have been computed in different ways in the different studies reviewed. For micronutrient adequacy, the methods usually involve (1) selecting the specific micronutrients of interest; (2) computing intake of the individual micronutrients from quantitative dietary recalls (e.g., 24-h recall); (3) comparing each individual's intake to a measure of adequacy for each nutrient, such as the recommended nutrient intake (RNI) [15, 18] or probability of adequacy based on estimated average requirement (EAR) [9], and deriving a nutrient adequacy ratio (NAR) or probability of nutrient adequacy (NPA) for each nutrient; and (4) computing a mean adequacy ratio (MAR) by averaging the NARs or mean probability of adequacy (MPA) by averaging the NPAs.

A similar methodology is used for assessing the micronutrient density of children's diet; the differences are that in step 2, the micronutrient density of the diet (in g/kcal) is computed; in step 3, an individual (micro)nutrient density adequacy (NDA) is computed as the percentage of the desired micronutrient density for each nutrient taking into account the child's breastfeeding status and age; and in step 4, the mean micronutrient density adequacy (MMDA) is computed as the average of the NDAs [9].

Do Dietary Diversity Indicators Accurately Predict Micronutrient Adequacy or Density in Children?

Dietary diversity is particularly important for young children who require energy- and nutrient-dense foods for growth and development. International guidance for optimal infant and young child feeding practices recommends that young children be fed a variety of foods, including meat, poultry, fish, or eggs daily or as often as possible if specially fortified complementary foods are unavailable [17]. It is therefore critical to develop simple, yet valid tools to measure DD in young children in developing countries to identify at-risk populations, track progress over time, and measure the impact of interventions aimed at improving infant and young child feeding practices. This section summarizes the findings from recent studies that have validated DD indicators in young children (Table 18.1).

A multi-country study [7] led the way by developing a standard methodology and applying it to ten existing data sets from countries in Africa, Asia, and Latin America to validate indicators of DD in young children. The purpose was to assess how well DD indicators or sentinel food groups (selected nutrient-dense food groups) predicted the micronutrient adequacy of the diets of children 6–24 months of age from different populations with varying dietary patterns. The study used micronutrient density and MMDA as the gold standard against which to test DD indicators. MMDA was computed as the average of the NDA for 9 key micronutrients (10 for non-breastfed children and children over 12 months, where vitamin B12 was also included); NDAs were calculated as the percentage of the desired nutrient density for each age and breastfeeding status [16]. MMDA cutoffs used were <50 % for low nutrient density and ≥75 % for better nutrient density; 100 % could not be used as none of the children reached 100 % MMDA. The study trialled four candidate DD indicators: two FGIs with 7 or 8 food groups (the 8-group indicator included fats and oils) and each tested with 1- and 10-g minimum intake quantities. The associations between DD indicators and MMDA were tested using correlations and simple regression models; sensitivity and specificity analyses and receiver operating characteristic (ROC) analyses were undertaken to compare the performance of the different indicators and test their statistical significance, and to identify cutoff points or "sentinel foods" that best discriminated between low and adequate MMDA.

As expected, DD scores and MMDA varied by indicator and by site, although patterns were observed within geographic regions and within age and breastfeeding groups. The 7 FGI generally performed better than the 8 FGI and was positively and significantly correlated with MMDA in all locations and in all child age and breastfeeding groups. These associations, however, did not hold among children receiving fortified foods or infant formula; this is because these fortified products are formulated to provide all or a large proportion of the children's daily nutrient requirements, thereby reducing the reliance on dietary diversity to achieve micronutrient adequacy. For children not fed fortified foods, however, in all but one site (older non-breastfed children in India), ROC analysis showed that the 7 FGI could accurately differentiate those children with MMDA above or below 50 %; using the 10-g minimum cutoff rather than 1 g did not significantly improve the predictive power. Overall, the 7 FGI DD indicator with 1-g minimum was ranked as the most performing indicator and the one that could most accurately identify children with MMDA <50 %. The indicator performed more poorly at detecting those children with MMDA above or below 75 % due to very few children having an MMDA >75 %. The study also used sensitivity/specificity analysis to identify a unique cutoff point that could accurately differentiate between children with low or higher MMDA across study sites. While some patterns emerged and the cutoff point of ≤2 food groups was the most consistently associated with low MMDA, no universal cutoff point could be identified that minimized misclassification for children of all age groups across all sites. Similarly, when trying to identify sentinel food groups to predict MMDA, only the animal source food group showed any promise, but only at 50 % MMDA and only in some sites. The authors concluded that DD indicators are useful to predict micronutrient density in the diets of infants and young children in developing countries, with the exception of populations where fortified food or breast milk substitutes are consumed frequently. Results from this study informed the WHO-led process of developing simple indicators to measure infant and young child feeding practices, and the 7-food group DD indicator was selected as an indicator of adequacy of the micronutrient density of the diet in children 6–24 months of age. A cut-off point of ≥ 4 to identify children with minimum DD was selected based on extensive stakeholder consultations and discussions of the study results which showed that

Table 18.1 Summary of validation studies of dietary diversity indicators in children

Author	Country	Group studied (age/gender)	Type of study	Dietary assessment method	Dietary diversity indicator	Outcome	Analysis	Main findings	Conclusions
Steyn et al. [18]	South Africa (rural and urban, nationally representative)	Children, 1–8 y, non-breastfed, $n = 2{,}200$	Validation study testing correlation between DDS and FVS with MAR, and Se/Spe analysis to identify best cutoff points	24-h recall (repeated in 10 % of the sample)	1) DDS (9 food groups)	MAR of 11 micronutrients	1) Correlation between DDS and MAR and between FVS and MAR	1) Strong, statistically significant correlations between DDS and MAR (0.66) and between FVS and MAR (0.73)	Both FVS and DDS are useful, simple, and quick indicators of micronutrient adequacy of the diet in children 1–8 y
					2) FVS (45 food items)		2) Se/Spe analysis	2) DDS of 4 and FVS of 6 were best cutoff points for predicting MAR <50 % (highest sensitivity/specificity relationships)	
Working Group on Infant and Young Child Feeding Indicators [7]	Multi-country study: Bangladesh (rural), Brazil (urban), Ghana (urban), Honduras (urban), India (rural), Madagascar (urban), Malawi (rural), Peru (urban, 2 studies), Philippines (urban)	Children, 6–23 m, breastfed and non-breastfed, $n = 8{,}510$ d of breastfed and 2,482 d of non-breastfed	Validation study testing correlation between 4 FGI and MMDA, and using Se/Spe and ROC analysis to assess cutoff point with best predictive power	24-h recall (at least one/child; using recall or WR)	4 FGI: −2 with 8 food groups (1- and 10-g minimum intakes) −2 with 7 food groups (1- and 10-g minimum intakes, dropping fats/oil group)	MMDA (6–11 m breastfed: 9 micronutrients; 12–23 m breastfed and all non-breastfed: same 9 micronutrients plus vit B12)	1) Correlation between each FGI and MMDA	1) FGI scores and MMDA varied by indicator and by site	1) DD indicators are useful indicators of dietary quality for infants and young children in developing countries
							2) Se/Spe analysis and ROC curves analyses of FGI	2) All 4 FGIs were positively and statistically associated with MMDA at all ages in all sites	2) In all sites, all age groups, and for both breastfed and non-breastfed children, MMDA increased with increasing DD
							3) Se/Spe analysis of sentinel food groups	3) FGI-7 groups performed better than FGI-8 groups and better at MMDA cutoff points <50 % than ≥75 % (because few children reached this high MMDA level)	3) No universal cutoff point or sentinel food group could be identified to accurately identify children with low or adequate MMDA across age groups, breastfeeding status, and contexts
								4) A cutoff point of ≤2 could be recommended to identify breastfed infants 6–11 m with poor diet quality, but no universal cutoff point was identified for all age groups in all contexts	4) The findings above do not apply in populations consuming fortified foods or breast milk substitutes regularly
								5) FGI using 10-g minimum intake did not lead to greater Se/Spe	
								6) Sentinel food groups showed inconsistent results in predicting MMDA	

(continued)

Table 18.1 (continued)

Author	Country	Group studied (age/gender)	Type of study	Dietary assessment method	Dietary diversity indicator	Outcome	Analysis	Main findings	Conclusions
Kennedy et al. [19]	Philippines (urban and rural, nationally representative)	Children, 24–71 m, non-breastfed, $n = 3{,}164$	Validation study testing orrelation between two DD indicators and MPA, and using Se/Spe analysis to determine best cutoff points to identify children with high probability of inadequate intake	24-h recall	1) DDS (9 food groups)	MPA of 11 micronutrients	1) Correlation between each DDS and MPA	1) Significant correlations between DDS and MPA (0.36) and between DDS-10 g and MDA (0.44)	Study findings confirm utility of indicators of DD to predict adequate intake of micronutrients in diets of young, non-breastfed children. Imposing a 10-g minimum intake increased the correlation between DDS and MPA, but trade-offs between increased accuracy and greater complexity in data collection need to be considered
					2) DDS (10-g minimum intake)		2) Se/Spe analysis and ROC curves analyses of DDS to identify best cutoff point to identify children with high MPA	2) Best DDS cutoff point to detect MPA of 50 % = 5 food groups and to detect MPA of 75 % = 6 food groups	
Moursi et al. [8]	Madagascar (urban) (case study from WGIYCFI 2006 study above)	Children, 6–23 m, breastfed and non-breastfed, $n = 702$	Validation study testing correlation between 4 DDS scores and MMDA, and using Se/Spe and ROC analysis (same methodology as WGIYCFI 2006)	24-h recall	4 FGIs –2 with 8 food groups (using a 1- or 10-g minimum intake) –2 with 7 food groups (dropping fats/oil group and using 1- or 10-g minimum intake) (same as WGIYCFI 2006)	MMDA of 9 micronutrients (same as WGIYCFI 2006 study above)	1) Correlation between each DDS and MMDA	1) Mean DDS and MMDA were higher for non-breastfed compared to breastfed infants	Results were part of the evidence provided by the WGIYCFI 2006 multi-country validation study confirming the usefulness of DD to predict diet quality in young children
							2) Se/Spe analysis and ROC curves analyses of different DDS and cutoff points	2) All DDSs were positively correlated with MMDA, but correlations were higher with the FG I-7compared to the FGI-8 score and slightly higher with the 10-g minimum indicator	
								3) Using the 7-group DDS, a score of ≤2 best predicted low dietary quality, defined as MMDA < 50 %; the 10-g minimum score indicator led to greater misclassification and therefore did not justify its use	

Daniels et al. [20]	Philippines (urban)	Children, 24 m, non-breastfed, $n = 1{,}810$	Validation study testing the association between two DDS and MPA, and micronutrient density, and Se/Spe analysis to identify best cutoff points	24-h recall	DDS (9 food groups, 0- and 10-g minimum intakes)	MPA of 6 micronutrients, micronutrient density	1) Correlation between each DDS and MPA	1) Both scores were significantly correlated with nutrient adequacy and density and predicted statistically significant increases in probability of adequacy for all nutrients; controlling for energy intake slightly reduced but did not remove these associations	1) DDSs are a promising method for identifying populations at increased risk of malnutrition
							2) Se/Spe analysis and ROC curves analysis of different DDS	2) The 10-g cutoff improved the score's ability to predict low nutrient adequacy and reduced subject misclassification for all comparisons	2) In this study, applying a 10-g minimum portion requirement and controlling for energy, DDS for small children could be improved. However, adding the 10-g minimum increases complexity of data collection, and trade-offs between simplicity and accuracy should be considered carefully
								3) Best cutoff point for the 10-g DDS was 4, which correctly identified 87 % of low MPA children with modest misclassification (~10 % false positives and negatives)	

Sources: Steyn et al. [18], Working Group on Infant and Young Child Feeding Indicators [7], Kennedy et al. [19], Moursi et al. [8], Daniels et al. [20]

Steyn et al.'s study uses MAR of 11 micronutrients including vitamins A, B6, B12, and C, niacin, thiamin, riboflavin, folate, calcium, iron, and zinc. The multi-country study done by the Working Group on Infant and Young Child Feeding Indicators in 2006 used an MMDA for breastfed 6–11-month-old children of 9 micronutrients including vitamins A, B6, and C, thiamin, riboflavin, folate, calcium, iron, and zinc, whereas for breastfed 12–23-month-olds and all non-breastfed children, the MMDA included these 9 micronutrients plus vitamin B12. The Moursi et al. [8] study used the same base 9 micronutrients from this study. The MPA of 11 micronutrients in the Kennedy et al. [19] study included vitamins A, B6, B12, and C, folate, zinc, calcium, thiamin, riboflavin, niacin, and iron, whereas Daniels et al. [20] only included the 6 micronutrients of vitamin A, calcium, thiamin, riboflavin, niacin, and iron in MPA

DD dietary diversity, *DDS* dietary diversity score, *FGI* food group indicator, *FVS* food variety score, *MAR* mean adequacy ratio, *MMDA* mean micronutrient density adequacy, *MPA* mean probability of adequacy, *ROC* receiver operating characteristic, *Se/Spe* sensitivity/specificity, *WR* weighed record children who consumed 4 groups were more likely than those who consumed a lower number of food groups to have consumed at least one animal source food and one fruit or vegetable in addition to a staple food [21].

Results from one of the study sites, urban Madagascar, were published in 2008 [8] and showed similar findings. In this study, all DD indicators were significantly associated with MMDA and the 7 FGI performed better. The 10-g minimum generated higher correlations with MMDA, but the sensitivity/specificity analysis showed greater misclassification and no substantial improvement in the overall performance of the indicator. Using the 7 FGI, a cutoff of ≤2 food groups best predicted low MMDA in this population.

Three other validation studies were carried out in non-breastfed children, a group for whom the results of the 2006 multi-country study held least consistent. The studies used different methodologies and validated different DD indicators, in addition to measuring the micronutrient adequacy of the diet differently. One study [18] used 24-h recall data from a nationally representative sample in South Africa and measured micronutrient adequacy using the MAR. The analysis aimed at validating a 9-food group DD score and a 45-FVS in non-breastfed children 1–8 years of age against the MAR of 11 micronutrients. Both indicators showed statistically significant correlations with MAR ($r \geq 0.6$), and best cutoff points for predicting MAR <50 % (i.e., cutoff points that maximized sensitivity and specificity) were 4 for the DDS and 6 for the FVS indicator. The authors concluded that in this population, both FVS and DDS were useful, simple, and quick indicators to assess the micronutrient adequacy of the diet in children 1–8 years. This study also tested the association of the indicators with nutrition outcome measures; the results are presented below in the section on association studies.

One study [19] carried out in the Philippines among non-breastfed children aged 24–71 months validated two DD 9 FGIs derived from a 24-h recall, one without a minimum intake and the other one with a 10-g minimum intake, and used the mean probability of adequate intake (MPA) of 11 micronutrients to measure the micronutrient adequacy of the diet. Both DD indicators were significantly correlated with MPA, but higher correlations were found for the 10-g minimum indicator. The cutoff points maximizing sensitivity and specificity at MPA <50 % and >75 % were 5 and 6 food groups, respectively.

Another study [20] focused on non-breastfed children 24 months of age in urban Philippines to test the association between a DDS of 9 food groups (using 0- and 10-g minimum intakes) and the MPA of 6 micronutrients and micronutrient density. The findings confirmed that DDSs were promising indicators for identifying at-risk populations as both indicators were significantly correlated with MPA and micronutrient density, and predicted increases in the NPAs for all nutrients. Applying a 10-g minimum intake improved the score's ability to predict low nutrient adequacy and reduced subject misclassification. As in previous studies, the authors highlighted the need to consider the trade-offs between accuracy and ease of use when selecting DD indicators.

As a whole, the new body of evidence from validation studies in children confirms that DD indicators are a useful tool to predict dietary quality in both breastfed and non-breastfed children living in developing countries. The 7-food group DD is incorporated in WHO's 8 core indicators to measure infant and young children feeding practices, and a cut-off point of ≥ 4 is used to define minimum DD.

Do Dietary Diversity Indicators Accurately Predict Micronutrient Adequacy of the Diet in Adults?

Dietary quality is of particular concern in women, especially during pregnancy and lactation, as a woman's nutritional status has a direct effect not only on her own health and wellbeing but also on the future nutrition, health and survival of her child. Low micronutrient intake in women is found to be common in the few studies that have assessed it, but there is a large gap in the data available on this aspect of women's diet quality [22]. Recent validation studies have assessed the utility of DD indicators in women of reproductive age (Table 18.2), a first step in helping fill the information gap

Table 18.2 Summary of validation studies of dietary diversity indicators in women and adults

Author	Country	Group studied (age/gender)	Type of study	Dietary assessment method	Dietary diversity indicator	Outcome	Analysis	Main findings	Conclusions
Torheim et al. [23]	Mali (rural)	Adults, 15–45 y, $n=502$	Study testing the correlation between DDS and FVS, and MAR derived from a FFQ; study also tested determinants of DDS, FVS, and MAR	7 d FFQ (104 food items)	1) DDS (10 food groups)	MAR of energy and 9 micronutrients	1) Correlations between both DDS and FVS, derived from a 7-d FFQ, and MAR	1) Both DDS and FVS were positively correlated with MAR	1) Simple counts of food items and food groups can be used as indicators of nutrient adequacy in rural Mali
					2) FVS		2) Analysis of the determinants of DDS, FVS, and MAR using linear regression	2) Most important determinants of MAR were the number of milk products, vegetables, and green leaves consumed; sex; and number of crops produced by household	2) In order to design good and locally relevant DDS data collection instruments, it is recommended to do an initial quantitative or qualitative assessment of food items and food groups that are main contributors of nutrient adequacy in the population
								3) Determinants of DD were SES, residence, and age. The effect of SES on DDS was caused by only some food groups: fruit, meat, milk, and eggs increased significantly across the SES-tertiles, while for the other food groups, there was no difference	

(continued)

Table 18.2 (continued)

Author	Country	Group studied (age/gender)	Type of study	Dietary assessment method	Dietary diversity indicator	Outcome	Analysis	Main findings	Conclusions
Arimond et al. [9]	Multi-country study: Burkina Faso (urban), Mali (urban), Mozambique (rural), Bangladesh (rural), Philippines (urban and peri-urban)	Women, 15–45 y, *n* = 178, 102, 409, 412, and 2,045	Validation study testing correlation FGI and MPA, and using ROC analysis to assess cutoff point with the best predictive power (highest Se/Spe relationship)	24-h recall (repeated)	8 FGIs (6, 9, 13, or 21 food groups; 1- and 15-g minimum intake)	MPA for 11 micronutrients	1) Correlation between each FGI and MPA	1) MPA ranged from 0.34 to 0.54 in NPNL women and 0.24 to 0.34 among lactating women, suggesting very low MPA in women	1) Simple FGI indicators hold promise as proxy indicators of micronutrient adequacy in women of reproductive age
							2) Regression analysis to control for energy intake	2) FGI scores varied by indicator and by site	2) FGIs should be developed and adapted locally
							3) Se/Spe analysis and ROC analyses for different FGI	3) All 8 FGIs were correlated with MPA in all sites; this association remained when controlling for energy intake	
								4) ROC analysis showed that the predictive strength for the best choice indicators varied by site, meaning a universal indicator and cutoff was not identified	

Sources: Torheim et al. [23], Arimond et al. [9]

Torheim et al. [23] uses an MAR of energy and the following 9 nutrients: vitamin A, vitamin C, calcium, iron, niacin, riboflavin, thiamin, fat, and protein. The Arimond et al. [9] study includes 11 micronutrients for MPA, which are vitamins A, B6, B12, and C, calcium, iron, niacin, riboflavin, folate, zinc, and thiamin

DDS dietary diversity score, *FGI* food group indicator, *FFQ* food frequency questionnaire, *FVS* food variety score, *MAR* mean adequacy ratio, *MPA* mean probability of adequacy, *NPNL* non-pregnant, non-lactating, *ROC* receiver operating characteristic, *Se/Spe* sensitivity/specificity, *SES* socioeconomic status regarding women's diet quality. A few studies also validated such indicators in adult males.

As in children, a multi-country study using a standard methodology and data sets from 5 countries (Bangladesh, Burkina Faso, Mali, Mozambique, and the Philippines) was carried out to validate a variety of DD indicators in women of childbearing age living in urban or rural settings [9]. The study systematically trialled 8 different DD indicators based on 6, 9, 13, or 21 food groups, with 1- or 15-g minimum intake. DD indicators were validated against micronutrient adequacy of the diet using an MPA methodology for 11 micronutrients. The findings show generally low MPA in all women, either pregnant, lactating, or neither. All 8 indicators were positively and significantly correlated with MPA in all sites, even controlling for energy intake. The predictive strength of the different indicators varied according to site, with no single indicator consistently performing best; the 9-food group indicator, however, generally performed well and was adopted by the Food and Agriculture Organization (FAO) in its guidance on measuring household and individual dietary diversity [27]. No universal cutoff point for the DD indicators was identified for use in all contexts, and research using new data sets is ongoing to explore further the possibility of identifying cut-off points that accurately reflect low versus adequate DD across contexts. Some of the data sets included in this multi-country analysis were also used to address some of the methodological issues related to the construction and use of DD indicators. These are discussed below in a separate section on methodological issues.

An earlier study of adult men and women in rural Mali [22] also tested the association between two DD indicators and micronutrient adequacy using the MAR methodology. In the study, 2 DD indicators, a 10 food group score and a FVS of 76 foods, were derived from an FFQ with a 7-day recall period, and associations with the MAR of energy and 9 micronutrients were tested, controlling for household and individual level socio-demographic characteristics. Both indicators showed a positive correlation with MAR, with stronger associations in men than women. The study also looked at the determinants of MAR and DD indicators and found that milk products, vegetables, and green leaves were important determinants of MAR, along with gender and the number of crops produced by the household. Determinants of dietary diversity included socioeconomic status, residence, and age.

Overall, the validation studies of DD indicators carried out since the 2003 review support the use of DD indicators to measure diet quality in children and adults in developing countries. Recent studies show that DD indicators are consistently associated with and accurately reflect the micronutrient adequacy or density of the diet and are simple and easy to use. In children, a 7-food group DD indicator is now incorporated in WHO's set of 8 core indicators to measure infant and young child feeding practices for 6–24 month old children, and the cut-off point of ≥ 4 is used to characterize minimum DD. For adult women, the 9-food group DD indicator tested in the multi-country study is now widely used and new research is under way to identify valid cut-off points to characterize low versus adequate DD in adults.

Are Dietary Diversity Indicators Associated with Anthropometry in Children and Women, and How Does This Interact with Confounding Factors?

The association between DD and child nutritional status has been shown previously [3]. Some of these earlier studies, however, have failed to adequately control for potentially confounding factors, especially household socioeconomic factors and energy intake, which are known to be associated with both child nutrition and dietary diversity. A few new studies have further tested the association between child anthropometry and DD indicators, controlling for these and other potentially confounding socio-demograhic and economic factors (Table 18.3).

A multi-country study using data from 11 DHS [16] looked at the association between a 7 food group FGI based on a 7-day qualitative recall and height-for-age Z-score (HAZ) in children aged 6–23 months. DD was significantly associated with

Table 18.3 Summary of studies of the association between dietary diversity indicators and anthropometric outcomes in children

Author	Country	Group studied (age/gender)	Type of study	Dietary diversity indicator	Outcome	Main findings	Conclusions
Arimond and Ruel [16]	Benin, Cambodia, Colombia, Ethiopia, Haiti, Malawi, Mali, Nepal, Peru, Rwanda, Zimbabwe (rural and urban, nationally representative DHS surveys)	Children, 6–23 m, breastfed and non-breastfed, n = 958–3,662	Association of DDS with HAZ	DDS (7 food groups) derived from 7-d recall; DHS surveys	HAZ	1) Mean DDS ranged from 1.7 (Mali) to 4.8 (Colombia)	Dietary diversity is associated with child nutritional status, and the effect is independent of socioeconomic factors
						2) DDS was significantly associated with HAZ, either as a main effect or in an interaction, when controlling for a variety of child, maternal, and household socioeconomic factors, in all but 1 of the countries analyzed	
Steyn et al. [18]	South Africa (rural and urban, nationally representative)	Children 1–8 y, non-breastfed, n = 2,200	Association of MAR, DDS, and FVS with HAZ, WAZ, and WHZ	1) DDS (9 food groups)	HAZ, WAZ, and WHZ	1) MAR, FVS, and DDS were statistically significantly correlated with anthropometric measurements for the group as a whole and for all age groups, with the exception of WHZ in the 1–3-year-old group	Results confirm that DD indicators and MAR in 1–8-year-old children were correlated with child anthropometric indicators, but the study did not control for potentially confounding factors
				2) FVS (45 food items) derived from 24-h recalls; repeated in 10 % of the sample		2) Vitamins A, C, and B12 showed little or no correlation with anthropometric indicators	

Sawadogo et al. [24]	Burkina Faso (rural)	Children, 6–35 m, breastfed and non-breastfed, $n = 2{,}466$	Association of DDS and FVS with HAZ and WHZ	1) DDS (8 food groups)	HAZ, WHZ	1) FVS and DDS were positively and significantly associated with HAZ in children <24 m, and FVS was negatively associated with WHZ in children 6–11 m, when controlling for several child, maternal, and household factors	DDS is associated with anthropometric indicators in young children, even when controlling for a variety of potentially confounding factors at the child, maternal, and household level
				2) FVS (past 24 h) derived from qualitative 24-h recalls		2) None of the individual food groups tested (e.g., animal source foods, pulses and nuts, fats and oils, fruits and vegetables), as opposed to the total DD score, were significantly associated with anthropometric indicators	

Sources: Arimond and Ruel [16], Steyn et al. [18], Sawadogo et al. [24]

DD dietary diversity, *DDS* dietary diversity score, *DHS* demographic and health surveys, *FGI* food group indicator, *FVS* food variety score, *HAZ* height-for-age Z-score, *MAR* mean adequacy ratio, *WAZ* weight-for-age Z-score, *WHZ* weight-for-height Z-score

HAZ as a main effect in 7 countries, and in an interaction in a further 3 countries, after controlling for a variety of child, maternal, and household characteristics, including maternal height, education, and literacy; rural vs. urban residence; and household wealth. The factors that most frequently interacted with dietary diversity were child's age and current breastfeeding status. For the latter interaction, findings from two countries showed that dietary diversity was more strongly associated with HAZ among non-breastfed, compared to breastfed children. This finding has important programmatic implications, highlighting the importance of promoting dietary diversity among non-breastfeeding children who no longer benefit from the contribution of breast milk for their intake of essential micronutrients. The direction of the interaction between DD and child age was not consistent across countries; in some, younger children benefited most from greater DD, while in others, older children did. This finding likely reflects differences in child feeding practices and other contextual factors between countries.

Studies in South Africa [18] and Burkina Faso [24] also confirmed the association between DD indicators and child anthropometry. In South Africa, DD indicators and MAR were correlated with all three anthropometric indicators (HAZ, weight-for-age Z-score [WAZ], and weight-for-height Z-score [WHZ]) in children aged 1–8 years, with the exception of WHZ in the 1–3-year-old group. This study, however, did not control for confounding factors.

In the rural Burkina Faso study, DDS of 8 food groups and FVS were positively associated with HAZ in children <24 months, and FVS was *negatively* associated with WHZ in children 6–11 months, when controlling for child, maternal, and household factors. The authors also tested the association between child anthropometry and individual food groups, such as animal source foods, pulses and nuts, fats and oils, and fruits and vegetables and found no association for any of the food groups.

A series of studies in rural Burkina Faso also assessed associations between *women*'s DD and nutrition outcomes (Table 18.4). The first [25], which tested the association between a 14-food group FGI and a FVS, and maternal Body Mass Index (BMI), mid upper arm circumference (MUAC), and body fat percentage (BFP) found positive associations with BMI and BFP when controlling for the subject's socio-demographic and economic characteristics. The second [26] assessed whether DD indicators were sensitive to seasonal variations and looked at differences in the association between a 9 FGI and women's BMI, MUAC, and BFP during the harvest compared to the shortage season. The analyses controlled for market days and a series of women and household socio-demographic and economic characteristics. Although they found positive associations between DD indicators and women's nutritional status indicators in both seasons, these associations were weaker during the harvest compared to the shortage season. DD indicators, however, were associated with women's age, wealth, and education. A third study [10], this time in an urban population in Mali, did not find an association between two different DD indicators and anthropometry.

The set of recent studies reviewed confirm the positive association between DD indicators and anthropometric measures in both children and women and show that these associations are independent of socio-demographic and economic factors.

What Do Recent Studies Looking at Methodological Issues Tell Us Regarding the Development and Use of Dietary Diversity Indicators to Predict Micronutrient Adequacy?

Several recent studies have examined measurement issues related to DD indicators, including how variations of foods, food groupings, minimum quantities, recall periods [13, 14], or the use of sentinel food groups [7, 12] affect the performance of the indicators in predicting micronutrient adequacy. Studies have also compared different data collection tools such as qualitative vs. quantitative lists of foods [13] or 7-day quantitative food frequency recalls vs. 2-day weighed records [15] (Table 18.5). A summary of results from these studies is provided below.

Table 18.4 Summary of studies of the association between dietary diversity indicators and anthropometric outcomes in women and adults

Author	Country	Group studied (age/gender)	Type of study	Dietary diversity indicator	Outcome	Main findings	Conclusions
Savy et al. [25]	Burkina Faso (rural)	Women, mothers of children under 5 y, $n=691$	Association of DDS and FVS with BMI, MUAC, and BFP	1) FVS	BMI, MUAC, and BFP	1) Generally, women had poor diet quality, with a mean FVS of 8.3 and DDS of 5.1	Dietary diversity indicators are associated with women's nutritional status in rural Burkina Faso
				2) DDS (14 food groups) derived from qualitative recall of foods consumed in past 24 h		2) FVS and DDS (in terciles) were associated with most nutritional indices, even after controlling for socio-demographic and economic characteristics; stronger associations with BMI and BMP than MUAC	
Savy et al. [26]	Burkina Faso (rural)	Women, mothers of children under 5, $n=550$	Association of DDS with BMI, MUAC, and BFP and how it is modified by seasonal factors	DDS (9 food groups) derived from qualitative recall of foods consumed in past 24 h (repeated twice to capture seasonality)	BMI, MUAC, and BFP	1) Women's BMIs were higher when their DDSs were higher, but this was less marked in September, which is the end of cereal shortage season	DD is sensitive to seasonal variations; seasonal variations modify the association between DD and women's body composition
						2) Same results were obtained for MUAC and BFP	
Savy et al. [14]	Burkina Faso (urban)	Women, 20–59 y, $n=557$	Association of DDS with BMI, MUAC, and BFP	DDS (9 and 22 food groups) derived from qualitative recall of foods consumed in past 24 h (repeated on 3 different days)	BMI, MUAC, and BFP	1) Mean DDS was higher than in rural areas (see Savy et al. [14]); DDS-9 was 4.9 and DDS-22 was 6.5	DDS in this urban environment where overweight and obesity in women was common (37 %) was not associated with anthropometry
						2) Neither the DDS-9 nor the DDS-22 was associated with women's anthropometry in this urban area, although there was a trend for fewer overweight women in the lowest DDS-22 tercile	

Sources: Savy et al. [14, 25, 26]

BFP body fat percentage, *BMI* Body Mass Index, *DD* dietary diversity, *DDS* dietary diversity score, *FVS* food variety score, *MUAC* mid-upper arm circumference

Table 18.5 Summary of studies that looked at methodological issues for the design and use of dietary diversity indicators

Author	Country	Group studied (age/gender)	Type of study	Dietary diversity indicator	Outcome	Main findings	Conclusions
Torheim et al. [15]	Mali (rural)	2 studies: adults, 15–59 y, $n=75$	Validation study testing the correlation between DDS and FVS, and MAR derived from an FFQ compared to results derived from a 2-d WR	1) DDS (10 food groups)	MAR of energy and 9 micronutrients	1) Correlations between FVS from FFQ and WR for men were between 0.4 and 0.5; for DDS, they were 0.2 and 0.4. Correlations were lower in women	1) FVS, DDS, and MAR can be derived from FFQ
		Adults, 15–45 y, $n=70$		2) FVS (69 and 164 food items) derived from:		2) Correlations for the 2 DD scores from FFQ and WR and MAR were 0.3 and 0.5 for men, respectively, and lower or not significant for women	2) FVS and DDS reflect diet quality and are simple tools for monitoring diet variation and diet quality over time, though they gave better results for men than women
				1) 7 d FFQ			
				2) 2 d WR			
Savy et al. [14]	Burkina Faso (rural)	Women, mothers of children under 5 y, $n=550$	Study testing the association of DDS with BMI, MUAC, and BFP and it compares DDS derived from 1-d and 3-d recalls	DDS (9 food groups) derived from 1-d and 3-d recalls	BMI, MUAC, and BFP	1) DD scores were higher with the 3-d (4.4) than 1-d recall (3.5)	1) DDS calculated from 1-d recall was sufficient to predict women's BMI
						2) DDS (1 d) was associated with BMI, % of women underweight, and BFP; after controlling for confounders, results were not found with 3-d recall	2) In such context, attention should be paid to market days, which directly affect dietary diversity estimates
						3) Higher 1-d DDSs were found on market days	
Kennedy et al. [12]	Mali (urban)	Women, 15–49 y, $n=96$	Study testing the association between intake of 21 possible food groups and MPA for 11 micronutrients	FGI: (21 food groups) derived from 24-h recall (2 on nonconsecutive days)	MPA for 11 micronutrients (using methodology from Arimond et al. [9])	1) Correlations between food intake (g) and MPA showed the intake of the following food groups to be associated with MPA: nuts/seeds, milk/yogurt, and vitamin A-rich, dark, green, leafy vegetables (DGLV), and vitamin C-rich foods	1) This chapter helped to draw attention to the performance and role of certain food groups (possible "sentinel food groups") in achieving better MPA in this particular population from urban Mali. Similar analyses done for other countries of the women's multi-country study (Arimond et al. [9]) reveal that the food groups contributing most to micronutrient adequacy vary by study site and context
						2) Women in the highest consumption groups of nuts/seeds and DGLV had five and sixfold greater odds of an MPA >50 %, respectively (binary logistic regression results controlling for energy intake and age)	2) Overall the results support using combinations of food groups rather than single food groups in isolation to serve as sentinel food groups, but the specific food groups need to be defined for each context

Martin-Prével et al. [13]	Burkina Faso (urban)	Women, 17–49 y, $n = 181$	Validation study testing the correlation between 8 FGIs and MPA and comparing FGI indicators derived from a qualitative, list-based 24-h recall of food groups and indicators derived from detailed quantitative 24-h recalls (both on 2–3 separate days)	8 FGIs (6, 9, 13, or 21 food groups and 1- and 15-g minimum intake) (using a methodology described in Arimond et al. [9], as one of the case studies in multi-country study)	MPA for 11 micronutrients (using methodology described in Arimond et al. [9])	1) Little agreement between qFGI and QFGI in paired comparisons	1) Results highlight the trade-offs between accuracy and simplicity when operationalizing FGI through qualitative questionnaires
						2) With 1-g minimum, the mean differences between qFGI and QFGI ranged from 0.05 to 0.28 food groups; for 15-g minimum, they ranged from 0.12 to 0.88; the more disaggregated the indicator (>food groups), the larger the differences	2) Authors recommend testing other approaches for collecting qualitative DD information such as a qualitative free recall (i.e., qualitative, chronological review of foods consumed the previous day, rather than using a pre-classified list of food groups)
						3) Results of ROC analyses show the following: qFGI with 1-g minimum tended to underreport and qFGI with 15-g minimum tended to overreport	
						4) Food groups most often misreported were nutrient-dense (flesh foods and vegetables) put in small quantities in sauces	

Sources: Torheim et al. [15], Savy et al. [14], Kennedy et al. [12], Martin-Prevel et al. [13]

The MAR in the Torheim et al. [15] study includes energy and 9 micronutrients: vitamin A, vitamin C, calcium, iron, niacin, riboflavin, thiamin, fat, and protein. Two studies from 2010—Kennedy et al. and Martin-Prével et al.—both use an MPA for the following 11 micronutrients: vitamins A, B6, B12, and C, folate, zinc, calcium, thiamin, riboflavin, niacin, and iron

DDS dietary diversity score, *FVS* food variety score, *MAR* mean adequacy ratio, *WR* weighed record

Varying Foods, Food Groupings, Minimum Quantities, or Use of Sentinel Food Groups

Most of the validation and association studies reviewed in the previous sections included comparisons of different DD indicators with varying foods, food groupings, and minimum quantities. Overall the results from both validation and association studies were robust to these changes in the construction of DD indicators. Imposing a minimum quantity consumed sometimes resulted in a minor improvement in the indicators' performance, but the consensus was that the added benefit did not justify adding complexity and cost to data collection.

Experimenting with sentinel (nutrient-dense) food groups as proxies for micronutrient adequacy did not lead to any consistent findings in children [7]. In women, an analysis of data from an urban sample in Mali [12] tested which individual food groups best predicted micronutrient adequacy, using MPA for 11 micronutrients. They identified some food groups that were positively correlated with micronutrient adequacy such as nuts, dairy, dark green leafy vegetables, and vitamin C-rich vegetables. The authors, however, concluded that combinations of food groups were more useful to predict diet quality in women than single food groups used in isolation. They note that similar analyses conducted in other sites of the women's multi-country study showed that the "sentinel" food groups that predicted micronutrient adequacy varied by study site and should therefore be defined and validated in each context.

Varying Recall Period or Data Collection Tool

In rural Burkina Faso, Savy and collaborators [14] compared DD scores measured using a qualitative dietary recall over a 1-day compared to 3-day period. As expected the score itself increased with a longer recall period. Associations with women's anthropometric measures were found for the 1-day recall indicator, but not for the 3-day recall, after adjusting for socio-demographic and economic factors. The authors concluded that the choice of 1- vs. 3-day recall should be based on the objectives of the study; they note, however, that for many purposes, the 1-day recall would be sufficient and has the advantage of being rapid, reliable, and cheaper than the 3-day recall. Note that the study did not test the performance of the two indicators at predicting micronutrient adequacy.

Torheim and collaborators [15] compared two approaches for deriving DDS and FVS in adults in Mali: a 7-day quantitative FFQ and a 2-day weighed records (WR). Correlations between scores derived from the two approaches ranged between 0.2 and 0.5 and were stronger in men than in women. DDS and FVS scores derived from the FFQ were also correlated with dietary adequacy for energy and 9 micronutrients (MAR) and were again stronger for men than women. The authors conclude that DD indicators can successfully be derived from FFQ.

Finally, the urban Burkina Faso study from the women's multi-country validation study [13] compared sets of DD indicators derived from a quantitative vs. a qualitative, list-based 24-h recall of food groups. The study found a troubling lack of agreement between the two methods in the number of food groups reported. In this context, misreporting of nutrient-dense foods such as flesh foods and vegetables often consumed in small quantities in sauces was particularly high. The authors conclude that DD indicators based on qualitative list-based questionnaires can be useful for assessing diet quality at the population level but note that they need to be adapted in each specific context to minimize misreporting of food groups. They also recommend testing other approaches for collecting qualitative DD information such as a qualitative free recall using a chronological review of foods consumed the previous day rather than a pre-classified list of food groups.

Conclusions: Are Dietary Diversity Indicators Useful for Measuring Individual Dietary Quality and What Are the Remaining Knowledge Gaps?

The new body of evidence confirms that DD indicators are strongly and consistently associated with dietary quality, defined as diets that provide adequate micronutrient content and/or density. Studies done in different contexts and in populations with vastly different dietary patterns show a strong and robust, positive association between DD indicators and diet quality in both children and women. These are two population groups that are particularly prone to poor diet quality and likely to suffer from its devastating consequences on micronutrient deficiencies and poor growth. Several recent studies also confirm the positive association between dietary diversity and anthropometry in both children and women, even when controlling for a variety of individual and household sociodemographic and economic factors. Similarly, new evidence confirms that greater dietary diversity is associated with higher energy intake, but that the association between dietary diversity and micronutrient adequacy remains when controlling for energy intake.

Although the association between DD indicators and diet quality is generally robust, the search for a universal cut-off point for DD indicators in adult women has not yet been successful. An on-going multi-country analysis using new data sets is currently revisiting this issue. In children, the process used to identify a suitable cut-off point to identify minimum DD included a similar multi-country research process, complemented by a high-level consultation with multiple stakeholders and additional analyses of children's dietary patterns. The consultation led to the selection of the cut-off point now included in WHO recommended indicators for children 6-24 months ($\geq$ 4 food groups, using a 7-food group DD indicator). Although it is recognized that cut-off points always result in some level of misclassification errors, there is also a general consensus that cut-off points are highly valuable for population-level prevalence estimates, for international comparisons and for advocacy and communication with policy makers. For this reason, research to identify a valid cut-off point for DD in adult women continues.

The review also highlights that, for local use and in order to achieve greater precision and accuracy in predicting micronutrient adequacy of the diet, it may be useful to develop context-specific indicators and cut-off points. Future research should experiment with developing and testing approaches and tools to develop context-specific indicators, including the selection of food groups and groupings, minimum quantities, and best cut-off points. This work can be based on the use of existing data and simple analyses, but will require the involvement of knowledgeable local experts familiar with the dietary patterns of the populations and age groups of interest. Secondary data analysis can also be complemented by targeted and focused qualitative research on a few specific issues that will help enhance the performance of the indicators. Useful guidance has already been developed by the WHO on how to construct and adapt DD indicators for children less than 2 years of age [21] and by the FAO for adults [27]. The FAO document also provides guidance for the development of household level DD indicators.

Another area where future work is needed is in the development of effective qualitative data collection tools to accurately report on foods and food groups consumed. The study by Martin-Prével and colleagues [13] raised serious concerns related to the use of DD indicators derived from qualitative data collection tools, as these indicators led to significant misreporting compared to indicators derived from quantitative 24-h recalls. Given that the purpose of simple, qualitative DD indicators is precisely to avoid having to use complex and costly quantitative dietary assessment methods, research should focus on developing effective qualitative data collection tools that facilitate and ensure accurate recall of the types of foods consumed by respondents over a given period.

Finally, an additional area of future research is the assessment of the performance of simple DD indicators for monitoring, tracking progress, and evaluating the impact of programs and policies. With very few exceptions, the body of evidence regarding the performance of DD indicators comes from cross-sectional studies. Little is known about how these indicators respond to changes (positive or negative), how fast they respond, and what is the magnitude of change that can be expected from different types of development programs aimed at improving dietary quality, or from shocks. The only study that looked at DD indicators at two points in time [26] showed seasonal variations in the association between DD and women's anthropometry and socioeconomic factors. This study, however, did not investigate whether or not there were seasonal differences in the performance of the indicators in predicting micronutrient adequacy. With increasing use of DD indicators, it will be important to understand their performance not only for descriptive purposes but also for tracking progress and assessing program and policy impacts.

The main conclusion of the review is that DD indicators are useful, simple indicators for assessing diet quality among children and adults in developing countries. Their simplicity and the fact that they accurately reflect the micronutrient adequacy of the diet makes them an ideal tool for measuring diet quality in developing countries where resource constraints often prevent the use of detailed dietary assessment methods.

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19 Dietary Quality and the Nutrition Transition in Sub-Saharan Africa

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Key Points

- In sub-Saharan Africa, dietary quality cannot be dissociated from the nutrition transition from traditional to less healthy eating and lifestyle patterns, or from the double burden of undernutrition and 'overnutrition'.
- Data-driven dietary patterns and dietary diversity may be more appropriate than a priori indexes to assess dietary quality in Africa until location-specific dietary guidelines are available to develop such indexes.
- The dietary transition reflects globalization of food culture, and its effects are in general negative, but some aspects of 'western' dietary patterns may be positive.
- Traditional dietary patterns are usually healthier (with minor improvements) than modern diets and would need to be strongly promoted through social marketing.

Keywords

Sub-Saharan Africa • Diet quality • Dietary patterns • Nutrition transition • Non-communicable diseases • Double burden of malnutrition

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V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health, DOI 10.1007/978-1-4614-7315-2_19, © Springer Science+Business Media New York 2013

Abbreviations

AMI	Acute myocardial infarction
BMI	Body mass index
CI	Confidence interval
DC	Developing country
FFQ	Food frequency questionnaire
Hb	Haemoglobin
HDL	High-density lipoprotein
LDL	Low-density lipoprotein
NCD	Non-communicable disease
OR	Odds ratio

Introduction

The concept of dietary quality, whether objective or subjective, is connected with health. The subjective concept refers to a diet thought of as being healthy [1]. From a nutritional standpoint, dietary quality is objectively measured on the basis of dietary recommendations. A high-quality diet provides the necessary macro- and micronutrients in right amounts and proportions for normal growth, body composition, nutrient stores, and functional integrity, while being protective vis-à-vis nutrition-related non-communicable diseases (NCDs). Dietary patterns, rather than single-nutrient intakes, have been the focus of a growing number of studies worldwide. Assessing the diet as a whole takes into account the interactions between food and nutrients and the role played by non-nutritional components of food.

Developing countries (DCs) are undergoing major and sometimes very rapid demographic and epidemiologic transitions. One aspect is the nutrition transition [2], a process propelled by urbanization, globalization, and technological changes. After the initial stages of overcoming famines and overt hunger, the nutrition transition involves dietary and lifestyle changes and their health consequences of increased prevalence of obesity, diabetes, and other diet-related chronic diseases. The term ‘dietary transition’ refers specifically to progressive shifts from traditional foods and eating practices towards, in most cases, a less healthy diet characterized by higher amounts of saturated fat, sugar, and salt, as well as highly processed foods, along with a decline in dietary fibre and, in several cases, vegetables (Fig. 19.1). Therefore, assessing dietary patterns and quality is one means of staging dietary transition in developing countries. Dietary transition is complex and needs to be better documented in a context-specific manner.

Dietary quality is still little studied in sub-Saharan Africa. This chapter focuses on dietary changes and quality in sub-Saharan Africa. First, we present an overview of nutrition and dietary transitions. Then, we review the data on dietary patterns and quality and on their relationship with health and disease. Finally, we discuss methodological issues and the challenges of assessing dietary quality in Africa.

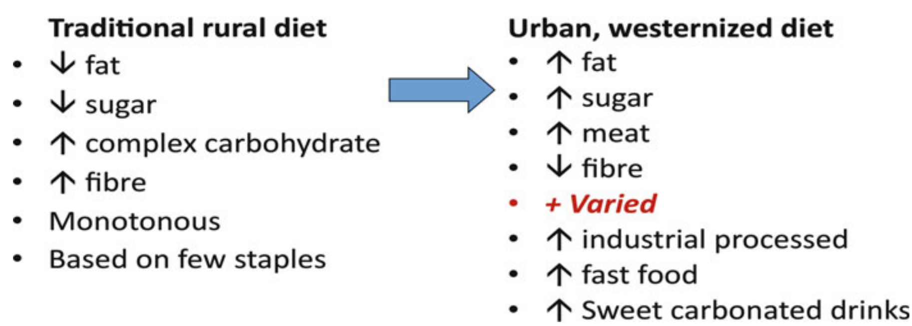

Fig. 19.1 Dietary transition (adapted from Popkin [2] and Vorster et al. [3])

Nutrition and Dietary Transitions: An Overview

Nutrition Transition Features and Consequences

The nutrition transition exhibits common features regardless of where it occurs, but it also has location-specific traits. By and large, the nutrition transition must be recognized as negative, which is at variance with demographic and epidemiologic transitions and their largely positive impact. Globalization of the marketplace is a major driver of nutrition transition [4]. By radically altering the nature of food systems, globalization also alters the food supply in terms of the quantity, type, cost, and desirability of foods available for consumption. Dietary convergence and dietary adaptation are components of the globalization process. 'Convergence' refers to the same basic foods becoming staples worldwide: a narrow range of grains; increasing consumption of animal products, oil, salt, and sugar; and lower intake of fibre [2]. Sometimes referred to as 'coca-colonization' [5], it describes the homogenization of food patterns. Dietary 'adaptation' or 'differentiation' is characterized by increased consumption of commercially processed foods, eating away from home, and food choices being governed by the attractiveness of advertised new food items. While convergence is driven by income and (low) prices, adaptation is governed by convenience, advertising, availability of new industrial foods, new food retail outlets [4] as well as by purchasing power [6], and we may also add, health concerns. According to Hawkes [4], globalization may exacerbate dietary disparities between the rich and the poor. As high-income groups in developing countries accrue the benefits of a more dynamic marketplace, lower-income groups may well resort to cheap but poor-quality obesogenic diets, as observed in industrialized countries.

Sub-Saharan countries represent the last region to undergo the nutrition transition, but they are not all at the same stage of the nutrition transition. According to a recent report on 40 countries with sufficient data [7], South Africa, Ghana, Gabon, Cape Verde, and Senegal were at more advanced stages, with relatively low infant mortality but also high levels of overweight/obesity in women and high intakes of energy and fat.

In both low-income and middle-income countries, this transition is associated with rising prevalence of obesity and other diet-related NCDs. In the former, however, nutritional disorders associated with overall or specific nutrient deficiencies persist at sometimes high prevalence rates, resulting in the double burden of malnutrition. The study of dietary quality in low-income countries cannot be dissociated from the nutrition transition and from the double burden of under- and 'overnutrition' which may be observed at both national and household levels [8–11].

Dietary and lifestyle changes vary according to location, socioeconomic level, age, cultural circumstances, and local food supply. For instance, the young and more educated may be more influenced by western (food) culture through the media, as observed in The Gambia [12]. Furthermore, the adverse impact of such changes on NCD incidence is likely magnified in populations that have experienced high levels of child undernutrition in the recent past, according to the theory of the developmental origins of chronic disease [13]. This theory, based on developmental plasticity, posits that individuals exposed to undernutrition in utero or in early infancy would be programmed for a nutritionally deprived environment and would consequently be ill fit for an obesogenic environment. This is how NCDs are said to be programmed early in life. Additionally, there are genetic variations in the vulnerability to NCDs. For instance, African origin populations are known to be more susceptible to hypertension than Caucasians, while exhibiting a lower risk of atherosclerosis by virtue of a more protective blood lipid profile [14].

Dietary Transition

Dietary transition amounts to a simplification of the food culture. Trade liberalization has facilitated this transition, particularly through the increasing supply of, and economic access to, imported processed foods and animal products [4, 15]. The transnational corporations controlling world food systems also exert direct control over the dietary transition and consequent NCDs. The outsourcing of food production, marketing, and distribution has contributed to food insecurity and reliance on imported low-quality staples [16]. Food self-sufficiency has declined while cheap imports have soared. We observe a progressive displacement of traditional foods and eating patterns by the globalized food culture and products. The eroding knowledge and skills regarding traditional foods, their value, and their preparation are involved in the nutrition transition in Africa. For instance, the use of traditional vegetables was found to decline in South Africa in spite of their availability because of the loss of indigenous knowledge and a negative attitude towards these vegetables [17]. Supermarkets have supplanted traditional markets, although the process is at an earlier stage in Africa than in Asia or Latin America. Eating patterns typical of urban populations in any developing country (DC) include snacking between meals, eating outside the home, and consuming street foods, processed foods, and drinks. These are attributes of dietary transition, with related increases in intake of fat, particularly animal fat, free sugar, and salt, and declining consumption of grains and various sources of fibre (see Fig. 19.1).

Studies on Dietary Patterns and Quality in Africa

Since urbanization is a major driver of the process, dietary transition has been primarily studied in cities. Many dietary studies have been conducted in South and East Africa and a few in West Africa (section 'Dietary Studies'). Dietary patterns and quality are increasingly being studied in Africa in connection with obesity and NCDs, which is not surprising in view of the increasing prevalence of nutrition-related chronic diseases (section 'Studies Linking Diets and Non-communicable Disease Risk'). Table 19.1 summarizes the design and methods of dietary studies conducted in sub-Saharan Africa.

Dietary Studies

Dietary pattern studies in Africa have usually identified as dichotomous the traditional and the western diet types, with the dietary transition operating the shift from the former to the latter. However, the definition of western dietary patterns requires a nuanced interpretation [37]. As shown in Mauritius [18] and as is probably the case in other African countries, a purely traditional dietary pattern devoid of western foods may now be extinct. Western diets usually emphasize wheat as a staple food (often consumed as white bread), meat as a central element of meals, and processed foods and dairy products. Typically western foods are sweets, carbonated beverages, salty snacks, and processed meats. Dietary 'westernization' refers to the diffusion and adoption of these foods and eating practices. Conversely, foods generally associated with preventive or prudent dietary patterns are fruits and vegetables, whole-grain cereals, legumes, and fish. Poultry and non-fat dairy products may also be part of the preventive dietary patterns, depending on local food culture. However, there is no consensus about the specific foods involved in westernization, as these may vary according to local culture and may not be exactly the same foods that characterize the western dietary pattern in developed countries. For instance, while processed meats and other refined foods and savoury snacks tend to be consistently associated with transition towards western dietary patterns in Mauritius, local or imported wheat and rice, dairy products, and sweets may or may not be regarded as western foods (Table 19.2). In the Mauritius study [18], which involved three surveys over a 10-year period, ten traditional or western food items were used as indicators or sentinel foods of dietary westernization. Rice, legumes, and whole milk were considered indigenous foods, while bakery bread, processed meat, processed dairy products, and margarine were considered western in Mauritius; poultry, fish, and butter were neither traditional nor western. Based on factor analysis, four dietary patterns were extracted as principal components based on these ten foods, including a 'western' and a

Table 19.1 Summary of studies on dietary patterns and quality in sub-Saharan Africa

		Dietary intake assessment			Dietary quality assessment			Outcome variables	
Study site and year	Design and subjects	24-h recall	FFQ	Quantitative (✓)	Dietary patterns	Dietary diversity	Energy/nutrient intake	Nutritional status	Chronic disease risk factors
Mauritius, 2005 [18]	3 surveys over 10 years, each on ~1,000–2,000 adults <75 y	✓ (in 1 survey only)	✓ (3), last 3 months		✓ Principal components analysis + consumption frequency of 10 sentinel foods [4 patterns]				
Tanzania, 2003 [19] (CARDIAC study)	Men and women 47–57 y, 3 sites (N=445)		✓ in last week		✓ Consumption of 5 selected food items (meat, fish, green vegetables, whole milk, coconut milk)			✓ BMI	✓ Obesity; blood pressure; blood lipids; glycated Hb; urinalysis
Tanzania, 2010 [20] (CARDIAC study protocol)	Men 20–50 y, shore of Lake Victoria (N=97)		✓ 9 levels of fre-quency, 135 food items		✓ Correlation of consumption of 38 items rated as good or bad with age				✓ Obesity; blood pressure; blood lipids; glycated Hb; urinalysis
Tanzania, 2011 [21]	Rural women 16–45 y, 3 seasons (N=252)	✓ (3)		✓	✓ Principal component analysis Mean intake, 12 food groups [5 patterns]			✓ Hb, BMI	
Kenya, 2011 [22]	Men and women ≥18 y, 3 districts (N=1,200)	✓ (2)		✓	✓ N meals and snacks; food group intake and % of total energy; 6 major food groups, 17 subgroups		✓ Energy and macronutrient intake	✓ BMI	
South Africa—NW province, 2005 [3]	Men and women, ≥15 y, apparently healthy, 37 sites, from rural to highly urbanized (N=1,854)		✓	✓	✓ Consumption of individual food items		Energy, macronutrient, micronutrient intake	✓ Anthropometry	✓ Blood pressure; glucose tolerance test; blood lipids and several other clinical parameters
South Africa, 2011 [23]	Men and women ≥16 y, nationally represen-tative sample (N=3,287)	✓ (1)				✓ (9 food groups) poor diversity: <4			

(continued)

Table 19.1 (continued)

Study site and year	Design and subjects	Dietary intake assessment			Dietary quality assessment			Outcome variables	
		24-h recall	FFQ	Quantitative (✓)	Dietary patterns	Dietary diversity	Energy/nutrient intake	Nutritional status	Chronic disease risk factors
Botswana, 2005 [24]	Older people ≥60 y in national survey (N=1,085)	✓	✓ in last week			✓ 5 food groups; variety based on consumption of 16 types of foods		✓BMI; Hb	
Botswana, 2011 [25]	Adolescent school children in cities, towns, villages (N=746)	✓ (1)			✓ Servings of 7 traditional items, of 5 'healthy' items, of snacks				✓ Overweight
Burkina Faso, 2011 [26, 27]	Ouagadougou school children, age 11.7 ± 1.4 y (N=769)		✓(previous week)		✓ Frequency of 5 'healthy' foods and 5 'unhealthy' foods			✓Anthropometry; Hb; serum iron and retinol (on subsample of 200)	✓ Overweight; blood pressure, blood glucose, serum lipids
Burkina Faso, 2007 [28]	Women average age 37 y Ouagadougou (N=481)	✓ (1)				✓ 9 or 22 food groups		✓ Anthropometry	
Burkina Faso, 2010 [29]	Men and women aged 20–65 y, capital city (N=1,072)		✓ 82 food items		✓ Principal component analysis, 22 food groups [2 patterns]				✓ Overweight
Burkina Faso, Mali, Mozambique, 2010 [30–32]	Women aged 29–35 y Burkina Faso, urban (N=178); Mali, urban (N=102); Mozambique, rural(N=409)	✓ (1–2)		✓		✓From 6 to 21 food groups	✓ Intake adequacy of 11 micronutrients		
Benin, 2008–2011 [33–36]	Men and women aged 25–60 y, apparent l y healthy; city, town, rural area	✓(2 or 3)		✓	✓ Cluster analysis, 11 food groups [3 patterns]	✓	✓ Micronutrient adequacy score and preventive diet score	✓BMI	✓ Cardiometabolic risk factors

Table 19.2 Food items perceived as indigenous or western in Mauritius

Indigenous foods	Western foods
Indian breads, salted/ smoked fish, lean meat (venison; goat), curry and other sauces (eaten with rice or Indian breads), fresh tomatoes and other vegetables, local fruits (mango, papaya, guava), pickles made from fruits, tea, and sugar	Whole-grain bread, breakfast cereal, pastries, cheese, red meat, barbecued/grilled meat, lettuce and other salad greens, salad dressing, tomato sauce, apples (imported), coffee, salty snacks, soft drinks (regular or diet), burgers, pizza, commercial fried chicken, French fries

Adapted from Uusitalo et al. [18], with permission from the author

'traditional' pattern. The western pattern loaded high on white bread, poultry, processed meat, fish, margarine, and skimmed or low-fat milk but reflected lower consumption frequency of white rice, legumes, butter, and whole milk. The traditional pattern had high loadings on legumes and whole milk but also on processed meat (western food) at baseline, while in the subsequent surveys, rice was more frequent than bread, but low-fat or skimmed milk and margarine frequencies were consistently low. According to 24-h recalls of the second survey, the western dietary pattern was also more associated with foods like breakfast cereal, soft drinks, fruit juice, and sweets than was the traditional pattern, which was characterized by higher consumption of tubers, sugar, and traditional sauces normally eaten with rice. In the last survey, the consumption frequency of several fast foods such as burgers, fried chicken, and salty snacks was associated with the western pattern, but so were salads, brown bread, fat-reduced milk, and unsweetened soft drinks. This study showed that western influences in a non-western environment are not necessarily negative, given the increased consumption of whole-grain bread, breakfast cereal, and salads. The dietary transition in Mauritius appeared to be somewhat moving towards the last stage, that is, voluntary choice of healthy foods. Of note is that younger age, higher education, and higher income were correlated with the western pattern.

It is generally assumed that the dietary transition is typically urban. In Tanzania, dietary patterns (and nutritional correlates) were studied in rural women to investigate whether the nutrition transition was also occurring in rural areas [21]. Dietary patterns were generated by principal component analysis on the basis of three 24 h food recalls on non-consecutive days. Five dietary patterns emerged from the analyses of mean intakes of 12 food groups: (1) 'traditional coast', in which fruits, nuts, starchy plants, and fish dominated; (2) 'purchase', characterized by foods that are usually not self-produced, such as bread, cakes, sugar, and tea; (3) 'traditional inland', with predominance of cereals and of vegetables fried or cooked in oil; (4) 'pulses', in which various pulses are widely consumed, while vegetables are not; and (5) 'animal products', characterized by high loading of the animal food group (excluding fish). Starchy plants, oil, and fat were also important in this last pattern. While patterns varied according to district, pattern 5 was, as expected, positively associated with wealth. Women's occupation also influenced dietary patterns, with a higher proportion of working women in the 'purchase' pattern, which may be considered more urban and which reflects emerging dietary transition.

In Ouagadougou, capital city of Burkina Faso (West Africa), data-driven dietary patterns were assessed in over 1,000 men and women [29]. A qualitative food frequency questionnaire (FFQ) covering the previous week was used. The food list included 27 items, which were then collapsed into 22 food groups (see Table 19.3). Dietary patterns were identified using principal component analyses. There were two major components explaining 28.5 % of the variance of dietary consumption, the first type labelled 'snacking' and the second 'modern food'. The snacking pattern, with frequent consumption of food items outside the main meals, was more common among younger and single subjects, Moslems, and those employed in the formal sector. It was also positively associated with the economic score. Consumption of modern foods was also positively associated with economic status, district of residence, and ethnic group. Interestingly, food groups were plotted according to the snacking

Table 19.3 Food groups and subgroups in selected studies on dietary diversity in sub-Saharan Africa

Botswana [24] (5 groups)	Burkina Faso, Mali, Mozambique (and Philippines, Bangladesh) [30] (6 groups)	(9 groups)	(21 groups)	Kenya[a] [22]	South Africa [23] (9 groups)	Benin [36] (11 groups)
Grains	Starchy staples	Starchy staples	Grains	Grains	Cereals, roots, tubers	Cereals
			Roots and tubers	Roots and tubers		Roots and tubers
	Legumes, nuts	Legumes, nuts	Peas, beans	Legumes, pulses	Legumes, nuts	Legumes, nuts
			Soybeans	Nuts and oily seeds		
			Nuts, seeds			
Vegetables	Vitamin A-rich fruits and vegetables	Vitamin A-rich dark green leafy vegetables	Vitamin A-rich dark green leafy vegetables	Vegetables	Vitamin A-rich fruits and vegetables	Vegetables
		Vitamin A-rich yellow/orange/red vegetables	Vitamin A-rich yellow/orange/red vegetables			
		Vitamin C-rich vegetables	Vitamin C-rich vegetables		Other vegetables	
Fruits	Other fruits and vegetables	Vitamin A-rich fruits	Vitamin A-rich fruits	Fruits	Other fruits	Fruits and fruit juice
		Vitamin C-rich fruits	Vitamin C-rich fruits			
		Other fruits and vegetables	Other fruits and vegetables			
Meat	Animal source foods	Organ meat	Organ meat	Meat, poultry, eggs	Meat, poultry, fish	Meat, poultry
		All other flesh foods and small animal protein foods	Large fish, dried fish, shellfish, seafood			
			Red meat, game meat			
			Poultry, pigeon, game birds	Fish		Fish
			Insects, rodents, snakes, other small animals			
		Small fish (eaten whole with bones)	Small fish (eaten whole with bones)			
		Eggs	Eggs		Eggs	Eggs
Dairy	Dairy	Dairy	Milk, yogurt	Milk, milk products	Dairy	Dairy
			Cheese			
				Fats	Fats and oils	Fats and oils
				Sugar and sweets		Sweets, sweet drinks
				Mixed dishes		
				Soft drinks		
				Tea, coffee, hot chocolate with milk and sugar		

[a]No diversity score based on number of food groups

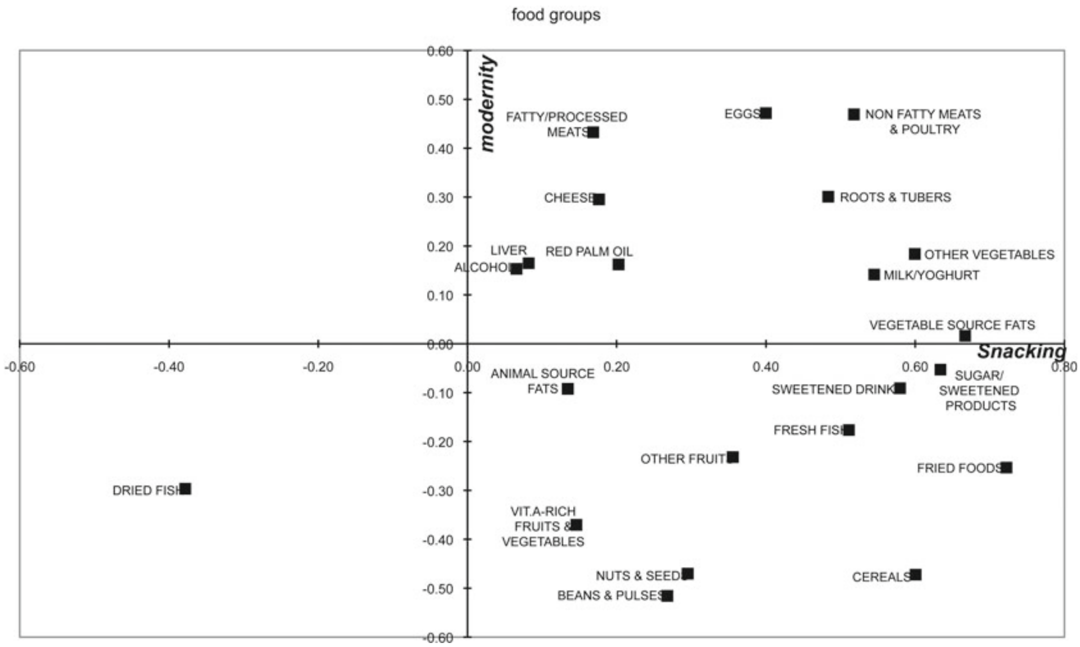

Fig. 19.2 Plot of factor loadings of food groups along two axes (with permission from Becquey et al. [29] who provided the black-and-white version)

and modernity scales (see Fig. 19.2). The modern food pattern was independently associated with a higher prevalence of overweight, which was not the case for the snacking pattern.

The 'modern' food pattern of Ouagadougou is somewhat similar to the 'transitional' dietary pattern that we identified in a neighbouring country, Benin. Since 2005, studies on the nutrition transition and cardiometabolic risk factors have been conducted among apparently healthy adult men and women in Cotonou, Benin's economic capital, as well as in the town of Ouidah and its surrounding rural areas [33–36]. The dietary patterns were data-driven (11 food groups, see Table 19.3), using cluster analysis. We identified three distinctive dietary patterns: the traditional and the modern patterns, and a transitional pattern between them (Fig. 19.3). The traditional pattern was characterized by high intakes of cereal, legumes, and fish (local staple for these coastal areas). The modern cluster was highest in tubers, eggs, milk, vegetables, and fats and lowest in cereal and fish. The transitional pattern fell between these two but had the highest level of sweets (including soft drinks) and meat and the lowest legume content. The findings support the view that dietary transition has some location-specific features.

In the Benin study, we examined the nutritional quality of the dietary patterns using two composite scores developed for international use on the basis of WHO/FAO recommended intakes [34–36]. The 'micronutrient adequacy score' is the summation on a dichotomous scale of meeting or not meeting (1, 0, respectively) the recommended intakes for 14 vitamins and minerals. The 'preventive diet score' measures compliance with WHO dietary recommendations for prevention of diet-related chronic diseases: total fat, saturated fat, total polyunsaturated fat, protein, and sugar as % of total energy; and intake of cholesterol, dietary fibre, fruits, and vegetables. The scale is also dichotomous. Dietary patterns showed significant differences not only in the preventive diet score but also in micronutrient adequacy. The traditional diet was of significantly higher nutritional quality than was the modern diet for both criteria; it was also significantly better than the transitional diet, but for prevention only.

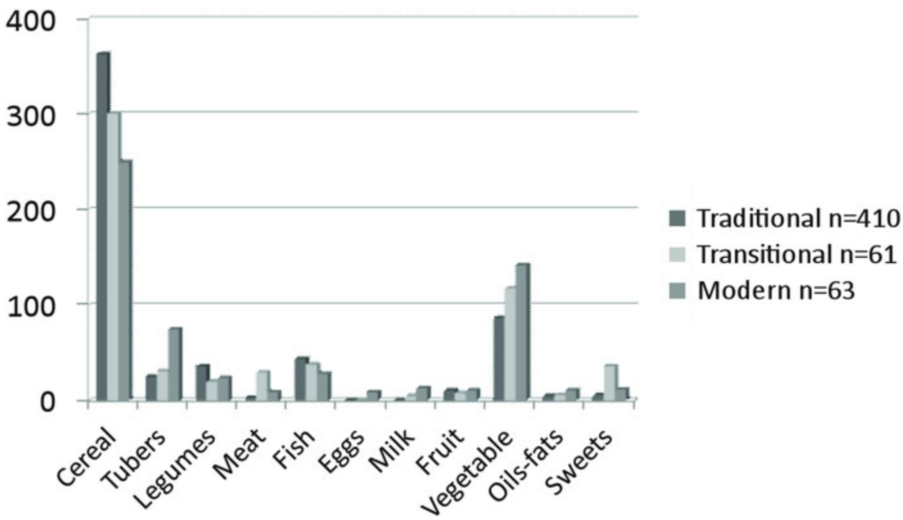

Fig. 19.3 Frequency of consumption of 11 food groups according to dietary patterns (Delisle et al. [38], with permission from the Journal of Applied Physiology, Nutrition, and Metabolism)

Mineral density (per 1,000 kcal) was higher in the traditional diet, owing to more legumes and cereal, although this may not translate into higher mineral bioavailability. Conversely, the modern diet showed significantly higher density for vitamins A, C, and E and folate. The traditional diet included the highest proportion of carbohydrates, polyunsaturated fat, and fibre and the lowest amount of free sugar and cholesterol, which explains its higher preventive score compared with the other diet clusters. The modern diet was predominantly urban (26 % of Cotonou vs. 5 % of Ouidah and 2 % of rural subjects) and more common among the more educated and relatively well off. Beninese diets were (still) relatively health-protective, with low total and saturated fat, low free sugar, low cholesterol, and high fibre intakes relative to the recommendations in all three dietary patterns. For this reason, the term 'modern' rather than 'western' was used to characterize the dietary pattern that appeared the most distinct from the traditional one.

In Kenya, dietary patterns were assessed on the basis of food group contribution to total energy intake, in 1,200 adults living in three districts [22]. Two non-consecutive 24 h food recalls were conducted and portion sizes were estimated. Consumption was categorized into six major food groups (and 17 subgroups, see Table 19.3). There was no difference in meal patterns across ethnic groups, with 73–88 % reporting three or more meals per day. Snacking patterns varied more widely. Marked differences across ethnic groups appeared in food group consumption and their contribution to energy intake. For instance and unsurprisingly, milk consumption was highest among the Maasai. Fat intake was also highest among the Maasai, providing nearly 30 % of energy intake, compared to half that proportion in other ethnic groups. Other animal products (meat, poultry, and eggs) contributed only 3–7 % to total energy intake in all three ethnic groups, and overall protein energy % was within the normal range, at 11–14 %.

A few dietary studies were conducted among African children and adolescents. In Botswana, eating patterns were examined in association with overweight/obesity status among secondary school adolescents [25]. The observed rate of obesity was 16 % in this age group. Food patterns were examined in the light of location and socioeconomic status. Seven hundred participants self-recorded their intake of the previous day, without quantities. 'Traditional' diet was identified by the number of times students reported having eaten any of the seven traditional food items or dishes.

A 'healthy' diet was defined on the basis of what students perceived as such, i.e. eating complex carbohydrates, non-fried protein foods, fruits, vegetables, and milk (five items). Snacks were defined on the basis of their high fat and sugar content, whether salty or sweet, with a total number of 10 items. Fruits and vegetables were neglected foods: 84 % of respondents had not eaten fruits and 64 % had not eaten vegetables the previous day. Paradoxically, overweight/obese subjects reported eating more vegetables, in addition to more salty snacks. This may be related to the local habit of eating vegetables with added fat. Although traditional and healthy food scores were not different in overweight and normal-weight subjects, it was found that better-off students ate less traditional foods and milk but ate more fruits and vegetables, as well as snacks. We made similar observations among urban primary school children in Burkina Faso (see below) with those from private schools eating more often of both 'healthy' and 'unhealthy' food items [26, 27]. In the Botswana study, better-off children ate out more often and skipped breakfast less frequently [25]. Differences according to socioeconomic status somewhat mirrored the differences between urban and rural subjects and the differences between overweight and normal-weight subjects.

In Burkina Faso, we examined dietary patterns of urban primary school children (mean age 11.7 ± 1.4 years), along with their nutritional status, in a baseline study to inform a school nutrition program [26, 27]. The frequency of consumption of a predefined list of 'healthy' and 'unhealthy' food items was assessed using a pretested questionnaire. Selected healthy foods were fruits, vegetables, fish, meat, and legumes; unhealthy or superfluous food items were cakes, cookies, candy, soft drinks, and ice pop. Over the week covered by the frequency questionnaire, a high proportion of pupils had eaten nothing from certain healthy food groups: 25 % no fruit, 20 % no meat, 20 % no legumes, 17 % no fish, and 17 % no vegetables. The frequency of consumption of unhealthy items was much higher than that of healthy foods. As mentioned above, the private school children, who were likely from higher socioeconomic status households than public school children, consumed both healthy and unhealthy food items more frequently than did the public school children. While this simple method cannot be used to assess dietary quality, it may raise concern about eating patterns at school age in an urban setting.

The THUSA study in the North West province of South Africa was a pioneer in nutrition transition research in Africa [3]. A cross-sectional study was conducted in apparently healthy men and women aged 15 years and older in 37 randomly selected sites of the province. Subjects were grouped according to urbanization stage based on residence and occupation, from rural (1) to highly urbanized (5). A quantitative FFQ was administered. Anthropometric and nutritional status data were also collected. A declining consumption of the staple maize porridge was observed with urbanization, while sugar intake remained stable across groups, as well as ingredients of the stew that was usually eaten with staple cereal (cabbage, onion, tomato, and oil). Only in the urban groups did fruit and milk list in the top ten foods, eaten by more than 85 % of subjects. While the contribution of complex carbohydrate foods to energy intake declined with urbanization, the contribution of animal-derived foods and fats and oil increased, as did that of fruits and vegetables (although lower than the recommended 400 g/day). Differences in food patterns were reflected in nutrient intakes. The percentage of total energy from protein and fat gradually increased with urbanization as energy provided by carbohydrates declined. Cholesterol intake increased and the ratio of polyunsaturated to saturated fatty acid decreased, reflecting increasing consumption of animal products with urbanization. There was also a slight increase in fibre intake, probably connected with higher fruit and vegetable consumption in cities. There was a trend towards improved micronutrient intakes with urbanization, which was at variance with our observations in Benin [36]. In 2009, a nationally representative survey was conducted in men and women aged 16 years and older stratified to include all provinces, geographic areas, and ethnic groups of South Africa [23]. Non-quantified

24 h recalls were used to assess dietary diversity. There were nine food groups (see Table 19.3), and acceptable diversity was set at four groups. At the national level, mean diversity was barely above 4, and nearly 40 % of South Africans had consumed only 1–3 different food groups on the day prior to the survey. Dietary diversity, which is regarded as reflecting food security [39, 40], was lower in lower socioeconomic status groups.

At least one study has been carried out among older persons in Botswana [24]. The researchers examined whether dietary variety (number of different foods) or dietary diversity (number of different food groups) was associated with physical and cognitive functioning in a nationally representative sample of subjects aged 60 years and older. The non-quantitative FFQ included 16 types of foods, either on their own or combined into five food groups (see Table 19.3). The dietary diversity score was the total number of food groups reported as consumed at least once in the past week, while the dietary variety score was computed by summing the frequency scores (maximum of 7 every day) for the selected 16 food items. Dietary patterns were characterized by low dietary variety or diversity, with 59 % consuming fruits, 22 % consuming vegetables less than once a week, and 33 % consuming no milk or dairy products. Low variety was associated with a limited number of meals (1–2/day), no education, no ownership of cattle, and living in a rural area. Based on the findings, a nutritional risk index was proposed as a screening tool, and subjects were then characterized according to differences in self-reported health status, physical functioning and performance, cognitive functioning and memory, as well as underweight and anaemia.

Studies Linking Diets and Non-communicable Disease Risk

Several studies on diets in Africa have also examined associations with health risk. A major concern has been the higher risk of obesity and NCDs associated with advancing dietary transition. In Ouagadougou, for instance, the modern food pattern was independently associated with a higher prevalence of overweight [29]. Similarly, the THUSA study in South Africa showed that obesity increased and the serum lipid profile worsened with urban diets [3]. Another example is the association of the 'purchase' dietary pattern with higher body mass in rural Tanzanian women, whereas the 'animal product' pattern was positively associated with haemoglobin level [21]. A few studies that investigated the links between dietary patterns and NCD risk in more depth are further described in this section.

Probably the first large study linking dietary patterns with NCDs, in Africa and other continents, was the INTERHEART case-control study conducted in 52 countries, including nine sub-Saharan African countries [41]. More than 12,000 patients with incident cases of acute myocardial infarction (AMI) were enrolled, along with close to 15,000 controls. Dietary patterns were assessed in a non-quantitative manner using the same 19-item FFQ. Three distinct food patterns were derived from factor analysis. The 'oriental' diet type had high loading on tofu and on soy and other sauces. The 'western' type featured high consumption frequency of fried foods, savoury snacks, and meat. The 'prudent' type had high loadings on fruit and vegetable intake. Consistent with smaller-scale studies, this study disclosed a positive association of the western pattern and a negative association of the prudent pattern with AMI. However, the association of the western pattern with AMI was not significant in Africa, unlike the significant association seen in Central Europe, Southeast Asia, China, and South America. The prudent diet type was not associated with AMI risk in Africa nor in the Middle East or Central Europe, which is at variance with the significantly reduced odds of AMI in upper quartiles of the prudent diet observed in other developed or developing countries. Single foods associated with AMI were fruits and vegetables (inverse association) and fried foods, salty snacks, and meat (positive association). A dietary risk score based on consumption of the latter food items exhibited a dose–response and positive association with AMI, but the strength of the association varied by region, and the trend was not significant in Africa. As underlined by Hu [42], this study provided evidence for reproducible dietary patterns in diverse regions, with somewhat similar health consequences in spite of widely different food habits. Nevertheless, the findings also suggest differences across regions in the risks associated with western dietary patterns, which calls for location-specific studies on diet and other risk factors for cardiovascular disease and diabetes.

Links between dietary patterns and cardiometabolic risk factors were examined in depth in the Benin study [33–36]. The metabolic syndrome components that appeared most widespread were obesity among women, particularly abdominal obesity, hypertension, and possibly insulin resistance. Multivariate regression models of risk factors, controlling for demographic, socioeconomic and lifestyle components (physical activity, alcohol, tobacco consumption), disclosed no relationship of dietary patterns with obesity but a significant association with hypertension and with insulin resistance. The likelihood of hypertension was significantly lower in the transitional than in the traditional diet group (odds ratio [OR] = 0.4, CI [confidence interval $p = 0.05$] = 0.6–1.01; $p = 0.053$); the difference between the traditional and the modern groups was not significant. Regarding insulin resistance, the OR was more than twice as high in the modern diet group as in the traditional one (2.3; CI = 1.2–5.0; $p < 0.01$). The apparently paradoxical association of the traditional diet with more hypertension may reflect residual confounding of this dietary pattern with other features of the rural setting, such as the proportionally higher number of undiagnosed hypertensive subjects in the traditional diet/rural cluster than in other diet groups (subjects with a previous diagnosis were not included in the study). Nevertheless, the significant and independent association of the modern diet pattern with higher insulin resistance is of interest and of concern.

A study conducted in Tanzania focused on diet and cardiovascular risk factors in men and women aged 47–57 years in three locations: the capital city, a rural area, and a pastoral population [19]. A FFQ including five selected foods and covering one week was administered. Food consumption (fish, meat, green vegetables, milk, and coconut milk) varied among the three areas. Coconut milk and meat were more frequently consumed in urban than in rural or pastoral groups. Dietary pattern differences were reflected in cardiovascular risk. In men, salt intake (based on urinary sodium) was positively associated with blood pressure, whereas in women salt was not, but coconut milk was. Dietary determinants of total cholesterol were meat (positive) and fish (negative association) in men. In both men and women, green vegetable consumption was associated with lower total serum cholesterol. In a more recent study in Tanzania [20], fish consumption had reportedly declined, owing to industrial fishing of perch in Lake Victoria, at the expense of traditional fishing and local consumption of the small fish. Low fish consumption among men aged 20–50 years was associated with a higher ratio of total cholesterol: high-density lipoprotein (HDL) cholesterol and higher fasting glycaemia. In a previous study by the same team on groups of middle-aged men and women in urban or in rural areas, as well as among Maasai herdsmen [43], higher fish consumption frequency was associated with lower glycated haemoglobin (HbA_{1c}), total cholesterol, and low-density lipoprotein (LDL) cholesterol. This study further illustrates the impact of the global food industry and trade on dietary patterns and health consequences.

The Assessment of Dietary Quality in Sub-Saharan Africa: Methodological Issues and Challenges

Major challenges in assessing dietary quality in Africa, as in other cultures, relate to the use of adapted and validated indexes or scores. There are also methodological issues around the assessment of dietary intakes due to the lack of food composition data on traditional foods, low literacy rates in some settings and, more generally, the limited resources available for this type of studies. The difficulty of estimating individual portions in places where food is eaten from a common pot and the seasonality of dietary patterns are further challenges facing researchers.

Dietary Quality Assessment

Three broad categories of methods are used to assess dietary quality: data-driven dietary patterns, dietary diversity scores, and a priori food- or nutrient-based indexes. Dietary patterns and diversity scores are simple and useful tools that have been widely used in Africa, since quantification of intakes is not required. However, dietary patterns and dietary diversity scores have to be validated against some sort of standard, whether food-based dietary guidelines or recommended nutrient intakes, combinations of these, or else biological or biochemical health markers. The lack of food-based dietary guidelines is a problem in most African countries because their absence not only makes assessing dietary quality more difficult but also impedes communication with the public on nutrition issues.

Whether the assessment of dietary quality is based on data-driven food patterns or on diversity, food grouping is essential. Depending on the context and purpose of the study, the number of food groups varies widely across studies, as shown in Table 19.1. This is, in itself, an impediment to direct comparisons between studies. Dietary diversity scores vary considerably because there is no standard number of food groups, at least for adolescents or adults. Dietary diversity indicators of dietary quality have been developed for infants and children [44] in a large study including ten developing countries.

According to a large study among women in five DCs (including Mali, Burkina Faso, and Mozambique), there is some evidence that increasing the number of food groups improved performance of food group diversity as an indicator of micronutrient adequacy assessed on the basis of 24-h recalls using the probability approach to adequacy [30–32] (see Table 19.3). Among urban women of Burkina Faso, a diversity score based on 22 food groups was positively associated with socioeconomic status variables, while the score based on nine food groups was not [28].

The reference period for assessing dietary diversity is also an issue. Most studies assessed food frequency over a period of one month or one week, while others used 24-h recalls. In areas with marked seasonality of food supply and patterns, and particularly in rural areas, dietary diversity would have to be measured at different periods of the year [45]. Another issue with dietary diversity is that it may be more closely connected with the adequacy dimension of dietary quality than with its moderation or prevention dimension, unless foods are specifically grouped to identify both adequate and prudent aspects of dietary quality. In the Benin study, as well as in a prior study in Oaxaca, Mexico [46], we found that more diversified diets were also less preventive of cardiometabolic risk. In urban Burkina Faso women, a higher diversity score also meant higher consumption of 'unhealthy' foods such as sugar and fats, as well as of snacks [28]. However, dietary diversity was not associated with the anthropometric status of those women. This suggests that dietary diversity may not capture the differential risk of inadequate intake or of an unbalanced, atherogenic diet.

When assessing dietary patterns or diversity in a nutrition transition context, consideration could be given to integrating into food grouping the notion of extent and purpose of processing. The dietary quality problem nowadays, according to Monteiro [47], lies in the excessive proportion of ultraprocessed items in the diets, a trend also gaining ground in Africa and which should be countered by promoting local, traditional foods, which are usually little processed, healthier, and more beneficial to local economies than imported foods.

Dietary Intake Assessment

Several studies in Africa have used 24-h recalls and FFQ with or without estimated quantities. The FFQ is a useful tool, but prior modification is required to adapt it to the local food culture by adding and deleting items and modifying the questions themselves. A methodological study in South Africa on the use of a quantitative FFQ among adolescents [48] could also inspire studies among adults. Respondents were asked to group food photos into three piles: one for foods and drinks not consumed, a second one for items consumed occasionally, and a third pile for items consumed on a regular basis, at least once a week. Portion sizes were then estimated only for the items in the last pile, using local utensils. Additionally, foods eaten together were grouped together in the FFQ, for easier recall and quantification.

Conclusions

Until recently, the main dietary concerns in Africa were deficient intakes of macro- and micronutrients usually associated with food insecurity. While undernutrition persists, particularly among the poor, nutrition-related NCDs are increasingly prevalent among the poor and the non-poor, primarily in cities. The transition towards food and lifestyle patterns conducive to obesity is a major contributor to escalating rates of NCDs, notably in sub-Saharan Africa. Therefore, the assessment of dietary quality cannot be dissociated from the nutrition transition in Africa.

Dietary transition and quality have been assessed in Africa primarily using data-driven eating patterns and dietary diversity. In both cases, food groups have to be defined, and this continues to be an issue. More research is needed to validate dietary diversity and dietary patterns as indicators of dietary transition stage and dietary quality. Additionally, meal patterns, eating away from home, snacking, and consumption of highly processed foods would need to be integrated into the assessment tools in order to fully assess the 'healthfulness' of diets. Up to now, on the basis of available evidence in Africa, dietary diversity appears to be better suited for assessing the adequacy dimension of dietary quality than the moderation or preventive dimensions. In a nutrition transition context, concerns regarding dietary quality shift from how much food to how well diversified and to how much processed.

The dietary transition is heterogeneous. While considered predominantly negative, the transition towards western dietary patterns has some positive aspects, as shown in Mauritius, where western foods include healthy food choices such as low-fat dairy products, whole-grain cereals and bread, and salad vegetables.

Eating patterns and practices typical of advanced stages of dietary transition are by and large determined by the global forces of food industry and trade. Policy-makers need to be aware of the potentially negative impact of dietary transition fuelled and accelerated by trade liberalization and globalization. It is necessary to analyze their impact on local food systems, directly and indirectly, because they influence the eating patterns of diverse segments of the population [4, 15]. As recommended by Hawkes [15], food and health policy-makers should pay more attention to global economic policies in order to address some of the structural causes of obesity and other nutrition-related NCDs, which are progressively shifting to lower socioeconomic groups, notably in Africa.

To reorient the dietary transition, one essential strategy is the rehabilitation of traditional foods and food practices. Minor improvements would still be required, however, to increase micronutrient adequacy in African settings. Promoting the production and consumption of fruits and vegetables, and even subsidizing these [49], are other means of reorienting the dietary transition. Thus, efforts have to go beyond communication for behavioural change, although this communication is crucial, notably at school age, in order to impact on the food supply. Promoting healthier diets that are both culturally relevant and affordable is a challenge in any setting. Public health messages formulated in accordance with culture-specific dietary patterns are likely to be more user-friendly than generic recommendations, and to this end, research on dietary patterns is directly relevant for action.

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20 Diet Quality in Peri-urban Settlements: South African Aspects

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Key Points

- Food and nutrient intakes and selected socioeconomic variables (poverty, poor education, and unemployment) relate to diet quality and dietary diversity in impoverished women from peri-urban areas in South Africa (SA).
- Dietary quality in terms of diversity and nutrient adequacy is central in finding resolutions to address the coexistence of under- and overnutrition found in South Africa.
- Accurate and efficient measurements of diet quality are complex and often compromised by the methodology used and the difficulty in data analyses, especially in poverty-stricken and/or low-income and illiterate communities.
- Simple, inexpensive, and easy-to-use measuring instruments that are valid and reliable should be used to assess diet quality and its indicators.
- Focusing only on selected indicators such as either food group diversity or individual food variety instead of a combination may result in a skewed picture.
- Food group diversity scores in the peri-urban areas indicated high dietary diversity while food variety scores indicated low dietary diversity.

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V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health, DOI 10.1007/978-1-4614-7315-2_20,

- Women in both peri-urban areas were impoverished, poorly educated, and unemployed, with low income, all of which contributed to diet quality.
- Very little data are available about diet quality/dietary diversity in peri-urban communities in South Africa, apart from this précis.
- Further investigations regarding dietary variety and its determinants are needed to find resolutions in the South African context.

Keywords
Diet quality • Dietary diversity • Women • Peri-urban • Nutrient adequacy

Abbreviations

AI	Adequate intake
AIDS	Acquired immunodeficiency syndrome
DDS	Dietary diversity score
DRI	Dietary reference intakes
EAR	Estimated average requirement
EER	Estimated energy requirement
FAO	United Nations Food and Agriculture Organization
FFQ	Food frequency questionnaire
FGDS	Food group diversity score
FVS	Food variety score
g	Gram
GP	Gauteng Province
HIV	Human immunodeficiency virus
kJ	Kilojoules
M	Million
MAR	Mean adequacy ratio
mg	Milligram
NAR	Nutrient adequacy ratio
NCD	Noncommunicable disease
OR	Odds ratio
p	Statistical significance
RDA	Recommended daily allowances
RSA	Republic of South Africa
SA	South Africa
SAHR	South African Health Review
SD	Standard deviation
US$	United States dollar
ZAR	South African rand

Introduction

Nutrition in Transition

Urban populations are growing [1] as people move closer to cities, many living in informal dwellings in closer proximity to cities. These peri-urban communities being established on the urban fringes are steadily increasing, resulting in a variety of changes in lifestyle and circumstances. A country whose people are undergoing these changes is referred to as a nation in transition [2] and includes nutrition transition, which describes shifts in diet, physical activity, lifestyle, health, and nutritional aspects that are linked with higher incomes and are affected by food marketing and availability [3]. People move closer to cities in the hope of securing work and income, while living in areas with poor urban infrastructure, lacking the most basic amenities for decent living standards [4]. According to Garrett [1], the people resident in developing countries will grow rapidly over the next 10 years, with a 90 % increase in expanding towns and cities. It is speculated that more than half of the populations of both Africa and Asia will be living in urban areas by 2020 [1].

This scenario is evident in South Africa, as many people have informal housing in the vicinity of the major centers or cities [2]. According to the South African Health Review (SAHR) of

2008 [5], the total population of South Africa at that time was 48.5 million (M), with the largest groups living in Gauteng Province (GP) (10.5 M) and KwaZulu-Natal Province (10.3 M). In GP, a large percentage is urbanized (97.2 %) and half of the population is female. Also, the black population group predominates (78.9 %) over all other South African population sub-categories [5]. Peri-urban black women are particularly prone to poverty and low income, accompanied by poor socioeconomic circumstances, limited access to services, and also food insecurity—all major determinants of the health and nutrition outcomes evident in these areas [1].

Prevalence of Malnutrition in South Africa

In South Africa, the face of malnutrition is changing together with the increase in nutrition transition. In the recent 2007 health survey, it was found that underweight in men and women is not common, with only 4.6 % of women and 8 % of men with a BMI of <18.5. The SAHR [5] clearly reveals that, in contrast, 50 % of young women and 30 % of young men (aged 16–35 years) are either overweight or obese. The problem is severe in urban areas [5].

Research has proved that both hunger and obesity are often present within the same household [6], especially in low-income households as in these peri-urban areas. Higher obesity rates are, furthermore, associated with low income and education levels, mainly among women [7]. An explanation for this may be the effect of price and income on food choices and thus also diet quality. The consumption of energy-dense foods and/or diets is one of the main coping strategies used by low-income women to extend the household food budget. Limited economic resources may thus result in energy-dense diet choices as these foods provide maximum energy for the least quantity and cost [8].

The effects of these factors are evident in the quadruple burden of disease in South Africa: poverty-related infectious disease, lifestyle-related noncommunicable disease (NCD), violence-related trauma, and the human immunodeficiency virus (HIV) and acquired immunodeficiency syndrome (AIDS) epidemic [2].

The stage of nutrition transition is dependent on the level of change in shifting from the rural diet to the westernized diet in conjunction with changes in physical activity levels and body composition [3]. This type of change in diet composition is related to the level of urbanization that comes with westernization. Diets become higher in fat and saturated fat (from animal products), salt, sugar, and refined carbohydrates and are subsequently too low in fiber, fruit, and vegetables [5]. Newly arrived migrants in Cape Town (South Africa) typically have poor education, live in informal housing, and have poor diets that are low in micronutrients and are associated with poor dietary diversity [9]. Bourne and coauthors reported that those who are more educated, urbanized, and living in formal housing have diets of better quality. On the other hand, an improvement in socioeconomic status does not necessarily result in improved nutritional status, but may rather lead to poor dietary habits and/or food consumption patterns [2]. Consuming an unhealthy diet is at present one of the most important causes of chronic diseases, especially when combined with a lack of exercise and using tobacco products over the long term. Currently, smoking is the third leading cause of premature loss of life years (quality of life years), especially in the age group 35–64 years [5]. Owing to the fast rate of epidemiological transition, the poor are becoming susceptible victims of these poor dietary habits and, consequently, NCDs [5].

According to the SAHR [5], the nutritional status of South Africans has not improved since the first democratic elections in 1994. This is mainly due to complex multiple factors such as dietary intake, diseases, environmental quality, caring practices, food security, education, and poverty. In children, chronic mild undernutrition persists, while in adults (especially women) the increasing coexistence of overweight and undernutrition in terms of micronutrient deficiencies is exacerbated by poor choices in diet and physical inactivity in all groups, regardless of age, gender, and socioeconomic circumstances. Except for optimal folate and iodine status, the biochemical micronutrient status (particularly vitamin A and iron) has worsened significantly since 1994.

Dietary quality in terms of diversity and nutrient adequacy is central in finding solutions to address the coexistence of under- and overnutrition. In a recent South African survey, it was found that dietary variety was compromised, particularly in low-income and black households. This is a cause for serious concern. Further investigations regarding dietary variety and its determinants are needed to find solutions in the South African context [10].

Definitions

For the purpose of this chapter, diet quality, dietary diversity, and nutrient adequacy are defined as follows:

Diet quality is "the assessment of both quality and variety of the entire diet, enabling examination of associations between whole foods and health status, rather than just nutrients" [11]. Human diets are complex and multidimensional as a result of many nutrient-to-nutrient and food-to-nutrient interactions. Focusing on the consumption of a single food, nutrient, or dietary component when evaluating specific health outcomes may result in invalid and unreliable conclusions. It is thus important to consider a number of related aspects of dietary intake simultaneously to assess diet quality [12, 13]. Examining diet quality and variety concurrently, in association with health outcomes in cross-sectional studies, is recommended to make longitudinal predictions for the development of targeted nutrition interventions [11].

Dietary diversity is used as a measure of diet quality and refers to a diet consisting of a number of different foods and is quantified in terms of food groups compared with the number of different food items consumed. Healthy diets are considered those most varied in terms of individual foods across and within food groups and have been shown to protect against chronic diseases [14–16]. Dietary variety is considered as a synonym for dietary diversity [16].

Nutrient adequacy indicates the attainment of recommended daily macro- and micronutrient and energy intakes as measured by 24-h recall, quantified food frequency questionnaire (FFQ), and weighed food records [16].

Review Methodology

Literature Search Strategy

A search of electronic databases for diet quality in South Africa was carried out between 2002 and 2012. The databases searched were MEDLINE (PubMed), ScienceDirect, Scopus, Scirus, EBSCOhost, Springer Link, Web of Science, and Sabinet. The keywords used were "diet quality," "dietary diversity," "peri-urban," "women," "South Africa," "food variety," and "dietary variety" for a thorough search on studies conducted in South Africa specifically during this period. The focus of this review was diet quality/dietary diversity in peri-urban areas in South Africa, a developing country; therefore, articles for developed countries and urban and rural areas were excluded in the evaluation of diet quality. However, for the methods used to measure diet quality, the articles focusing on similar studies in African countries were assessed. All the references were downloaded into the bibliographic software program called EndNote, version X2. Only five articles [10, 17–20], focusing on diet quality/dietary diversity in South Africa, were found. Of these, only three [17, 19, 20] focused on peri-urban areas in South Africa. As a result of the paucity of published data and to improve the quality of the chapter, the authors included unpublished original data recently collected for this chapter. The data of the three articles published earlier were included in this data set. Low-income Sotho-speaking women were the focus of this chapter. A sample size of 722 women for the Vaal region, selected from four peri-urban settlements, namely, Boipatong, Bophelong, Eatonside, and Sharpeville, were included. The three published articles reported on Sharpeville and Eatonside. Thus, Bophelong and Boipatong were added to the database of the Vaal region.

The Vaal region (in the GP) has a population of 794,599 people. The Vaal region is characterized by a 47.9 % unemployment rate and 46.1 % of households are living under the breadline (in poverty) [21]. In addition, Qwa-Qwa data were added from 395 women who were selected from three tribes in Qwa-Qwa, forming part of the peri-urban Thabo Mofutsanyana district, the largest in the Free State Province with a population of 766,754. This district is severely impoverished, with 73 % of its population living below the poverty line for South Africa [22]. Most of the people living in the Vaal region and Qwa-Qwa are Sotho-speaking Africans.

Therefore, the data for this chapter formed part of a cross-sectional survey in four informal settlements in the peri-urban Vaal region and among three tribes in peri-urban Qwa-Qwa. The aim of this chapter was to investigate the food and nutrient intakes and selected socioeconomic variables in relation to diet quality and dietary diversity in women residing in peri-urban areas in two of the nine provinces of South Africa.

Measuring Diet Quality/Dietary Diversity

In earlier studies, to determine associations between nutritional adequacy and dietary diversity in developing countries, 24-h recall questionnaires, FFQs, or weighed food records were used [16]. The limitations of using these methods include memory lapses, portion size estimations, respondent compliance, and specialized software programs for analyses. Furthermore, trained interviewers are needed for data collection, and it is time consuming to conduct studies and to analyze the data. It often results in a long lapse of time between data collection and availability of results [23]. Quick decisions can thus not be made in communities where appropriate interventions are required the most.

Accurate and efficient measurements of diet quality are thus complex and further compromized by the methodology used and the difficulty in data analyses. This is exacerbated in poverty-stricken/low-income and illiterate communities. Therefore, simple, inexpensive, and easy-to-use measuring instruments that are valid and reliable are needed [16].

Single food or food group counts have been mostly used in developing countries to overcome the mentioned challenges. A list of food items frequently consumed by a community can be determined by means of focus group discussions or any previous dietary assessment conducted in a community. This is simply a list of food items consumed by a person in a specified reference period. This dietary diversity tool is quick and easy to use as respondents are required to indicate, with a simple yes or no answer, only those food items consumed during a reference period reflecting usual food intake. Data capturing and analyses are also straightforward, and analyses do not require any specialized software programs that are usually based on country-specific food composition tables. The different dietary diversity measures include:

- Overall variety score (simple count of food items)
- Variety score across all (nine) food groups
- Variety score within every food group [15]

The different dietary diversity scores (DDSs) are usually calculated for a reference period [16] that can range from one to three and even up to 15 days, although 7 days are most commonly used. The nine nutritious food groups recommended by the United Nations Food and Agriculture Organization (FAO) have been used to classify food intakes [10, 17–20]; however, 8 [15], 11 [24], and 13 [25] groups have also been used in other studies conducted in African countries. For the purpose of this chapter, one to three groups consumed in a reference period of 7 days indicated low dietary diversity, four to five groups medium, and six to nine groups high dietary diversity. Fewer than 30 foods consumed in a reference period of 7 days indicated low food variety, while 30–60 foods and more than 60 foods indicated medium and high food variety, respectively [26].

Even though this approach seems simplistic, it has been validated against dietary intake assessment methods and nutrient adequacy ratios (NARs) in many studies but has also been done in the previously published South African studies

[10, 17–20]. The dietary intake data are used for calculating the NAR, by dividing the actual daily nutrient intake by the current dietary reference intakes (DRI) for each nutrient [27]. The mean adequacy ratio (MAR %) is calculated by the sum of NAR (truncated at 100 %) for all nutrients, divided by the number of nutrients used. A value of 100 % for both NAR and MAR indicates that the dietary intake is equal to the nutrient requirement [2], thus serving as a measure of overall diet adequacy.

Food variety and dietary diversity have been proven to be good indicators of dietary adequacy and showed that dietary diversity is an easy but effective tool to identify communities at risk of food and nutrition insecurity and its subsequent effects on health. It could thus successfully replace the traditional dietary assessment tools in screening for dietary profiles. This is especially useful in low-income, illiterate peri-urban communities such as the Vaal region and Qwa-Qwa in South Africa [17]. The same approach was used in the South African studies reviewed [10, 17–20] and for the data analyses reported in this chapter.

Diet Quality in the Peri-urban Vaal Region and Qwa-Qwa, South Africa

Studies have shown that poor dietary quality and diversity, evidenced by suboptimal food and nutrient intakes, is a feature of many developing countries, including South Africa. In the absence of a National Nutrition Surveillance Program in South Africa, limited recent data are available on diet quality and dietary diversity in women, and it has been recommended that future research should focus on black adults and impoverished population groups, among others [28]. Few studies focused on the association between food variety and household socioeconomic factors, specifically in peri-urban areas [29, 30]. In this chapter the aim was to report on the findings of investigating how the food and nutrient intakes and selected socioeconomic variables relate to diet quality and dietary diversity in impoverished women living in the peri-urban areas of the Vaal region and Qwa-Qwa in South Africa. Food variety and dietary diversity were used as indicators of dietary quality as recommended by other researchers for use in developing countries [29–31].

Peri-urban Socioeconomic Descriptors

The mean ± SD age of the women was 46 ± 12 years in the Vaal region and 42 ± 12 years in Qwa-Qwa. In both areas the majority of the women had a primary school education (77.3 % in the Vaal and 55.9 % in Qwa-Qwa), and 78.0 % and 82.8 % were unemployed in the Vaal region and Qwa-Qwa, respectively. The mean ± SD monthly household income was ZAR885.15 (US$118) in the Vaal region and ZAR1024.35 (US$136.60) in Qwa-Qwa. The socioeconomic indicators showed that the women in both areas were impoverished, based on the high unemployment and low household income levels. The unemployment rate of these women was much higher than the South African unemployment rate of 36.4 % for black women [32]. A contributing factor to unemployment and poverty could include the low percentage of women with education levels higher than primary school (22.7 % and 44.1 % in the Vaal region and Qwa-Qwa, respectively). The international poverty line indicator is US$1 (ZAR7.50) per day [33]. The women in Qwa-Qwa reported a mean monthly income of ZAR1024.35 (US$136.60), which equals US$0.9 per household member (assuming five household members), compared with US$0.79 in the Vaal region. A further interesting finding revealed that 91.3 % of the women in Qwa-Qwa cultivated vegetable gardens and 84.7 % used these vegetables for household food consumption. This was not observed in the Vaal region.

Nutrient Intake and Adequacy

Black South Africans in the low-income bracket have been proven to have poor nutrient intakes and low dietary variety [10]. This was mirrored in these peri-urban areas. The energy intakes of the women in both areas were very low and did not meet even 50 % of the estimated energy requirements (EERs). This was supported by the low NAR for energy of 0.48 and 0.46 for the two regions (Table 20.2). When considering the South African food balance sheets, 12,536 kJ is available per capita [34]; however, even though this is available in the country, it cannot be assumed that all people have equal access to food, as poverty may result in people not having enough money to buy nutritious foods. The same is true for protein intakes of 40 and 42 g (NAR 0.87 and 0.92) in the Vaal region and Qwa-Qwa, respectively, in comparison with the 81 g of protein per capita available in SA [34].

Dietary intakes (Table 20.1) were poor in both areas. In terms of micronutrient intakes, neither group achieved the estimated average requirement (EAR) for the majority of vitamins and minerals. In the Vaal region, the EARs were not met for the mean intakes of all nutrients except carbohydrates, phosphorus, vitamin B12, and vitamin K. Despite adequate mean intakes of these four nutrients, 20.3 %, 55.1 %, 91.8 %, and 65.6 % of the women respectively did not meet 100 % of the EAR for these nutrients. A similar trend was observed in Qwa-Qwa, where the EAR was not met for the mean intakes of all nutrients except carbohydrates, chromium, selenium, and vitamin B12. Although many of these intakes were suboptimal, statistically significant higher mean intakes were found in Qwa-Qwa for total dietary fiber ($p=0.033$), iron ($p=0.000$), copper ($p=0.015$), chromium ($p=0.000$), selenium ($p=0.000$), vitamin B2 ($p=0.000$), vitamin B3 ($p=0.001$), vitamin B5 ($p=0.014$), vitamin B6 ($p=0.000$), vitamin C ($p=0.000$), and folate ($p=0.000$). This was confirmed by the individual NARs (Table 20.2). A significant difference in micronutrient intakes can be seen between the women of the two areas. The ideal cutoff for mean adequacy ratio should be 1, which means that the intake of all nutrients would be adequate. In neither of the two areas did the women reach this cutoff (0.7 and 0.9), indicating nutrient inadequacy. The MAR for Qwa-Qwa (0.9 ± 0.9) was significantly better than the MAR for the Vaal region (0.7 ± 0.7) (Table 20.1). Although Qwa-Qwa women reported a significantly higher MAR than the women in the Vaal region, the dietary adequacy was still suboptimal. These findings were consistent with results in other South African studies [17, 19, 35].

Food Variety

A nutritionally adequate diet should meet both macronutrient and micronutrient requirements. In these areas this was clearly not achieved. An evaluation of the food variety and food group diversity scores (FGDSs) indicated low dietary diversity, thus supporting inadequate nutrient intakes of the women in these peri-urban areas. The majority of women in both areas had a low food variety score (FVS) (19.6 and 21.3) despite the relatively high food variety (>60 individual foods consumed in 7 days) [26] reflected in the total number of individual food items consumed in 7 days (Table 20.1). Although 117 and 94 different food items were mentioned by all the women in the Vaal region and Qwa-Qwa, respectively, this was not a mean intake value, but meant that several different combinations of the individual food items were consumed by the women. Although the total number of food items consumed indicated high food variety in both groups, this is not a true reflection of the actual variety of foods consumed by the majority of the women, as only 1.9 % and 0.8 % of the women in the Vaal region and Qwa-Qwa respectively consumed more than 60 individual food items. In Fig. 20.1 it is shown that 78.8 % of the women in the Vaal region consumed a range of only zero to 30 nutritious food items (low food variety) [3] for the 7-day period. A similar trend (82.0 %) was observed among the Qwa-Qwa women. It was interesting that 38.2 % of the women in the Vaal region, as against 7.8 % in Qwa-Qwa, consumed only a very limited variety of zero to ten individual foods in the reference period. This was also reflected in the low FVS of 19.6 ± 15.1 for the Vaal region and 21.3 ± 11.2 for Qwa-Qwa (Table 20.1).

The other South African studies reported the opposite where a low FVS was restricted to a relatively narrow range of food items [2, 17, 19, 36].

Table 20.1 Analysis of 24-h recalls: mean daily intakes of the Vaal region ($n=722$) and Qwa-Qwa ($n=395$) women analyzed by independent t-tests

Nutrient	Vaal region Total group (mean ± SD) ($n=722$)	Vaal region Total group (%) <100 % of EAR	Qwa-Qwa Total group (mean ± SD) ($n=395$)	Qwa-Qwa Total group (%) <100 % of EAR	EAR	Significant difference between Vaal region and Qwa-Qwa at 5 % (two tailed)
Energy (kJ)	4,827 ± 2,161	98.0	4,648 ± 2,789	96.2	10093.0^	0.235
Total protein (g)	40 ± 25	67.1	42 ± 27	65.0	46.0	0.138
Plant protein (g)	19 ± 10		19 ± 16			0.992
Animal protein (g)	21 ± 23		23 ± 22			0.064
Total fat (g)	29 ± 28		32 ± 25			0.085
Carbohydrates (g)	169 ± 75	20.3	149 ± 103	32.1	100.0	0.000*
Total dietary fiber (g)	11 ± 6	97.3	12 ± 9	95.1	25.0#	0.033*
Calcium (mg)	200.0 ± 211.1	98.7	219.8 ± 197.9	99.7	1000.0#	0.126
Iron (mg)	5.5 ± 1.2	82.6	6.8 ± 4.5	76.7	8.1	0.000*
Magnesium (mg)	193.4 ± 92.0	80.3	173.6 ± 106.7	89.3	265.0	0.001*
Phosphorus (mg)	594.2 ± 303.9	55.1	548.0 ± 330.4	66.0	580.0	0.019*
Zinc (mg)	5.3 ± 3.7	80.0	5.2 ± 3.3	86.5	8.1	0.705
Copper (mg)	0.6 ± 0.7		0.7 ± 0.7			0.015*
Chromium (μg)	20.7 ± 27.6	72.5	32.8 ± 61.8	67.3	25.0#	0.000*
Selenium (μg)	18.2 ± 24.8	88.3	53.3 ± 179.0	73.9	45.0	0.000*
Iodine (μg)	15.3 ± 21.9	99.0	16.6 ± 17.4	99.4	95.0	0.317
Vitamin A (μg RE)	456.1 ± 1726.4	83.3	431.3 ± 1141.2	75.1	500.0	0.798
Thiamin (mg)	0.7 ± 0.4	71.7	0.7 ± 0.5	78.2	0.9	0.742
Riboflavin (mg)	0.6 ± 0.8	86.0	0.9 ± 1.8	77.4	0.9	0.000*
Niacin (mg)	8.9 ± 8.9	72.5	10.8 ± 9.3	65.5	11.0	0.001*
Vitamin B6 (mg)	0.6 ± 0.6	85.7	2.2 ± 10.2	68.6	1.1	0.000*
Folate (μg)	148.3 ± 201.3	88.6	213.5 ± 187.2	43.2	320.0	0.000*
Vitamin B12 (μg)	3.2 ± 15.1	73.5	2.3 ± 10.0	71.8	2.0	0.295
Pantothenate (mg)	3.1 ± 3.7	80.7	3.9 ± 4.2	75.1	5.0#	0.003*
Biotin (μg)	20.0 ± 41.9	91.8	14.7 ± 13.2	94.9	30.0#	0.014*
Vitamin C (mg)	20.1 ± 33.7	95.0	28.5 ± 43.2	90.3	60.0	0.000*
Vitamin D (μg)	1.6 ± 2.9	88.9	1.4 ± 2.2	94.1	5.0#	0.388
Vitamin E (mg)	4.2 ± 6.6	94.7	4.2 ± 4.2	93.6	12.0	0.904
Vitamin K (μg)	113.6 ± 192.5	65.6	2.1 ± 4.2	60.5	90.0#	0.000*
FVS	19.6 ± 15.1		21.3 ± 11.2			0.042*
DDS	6.4 ± 2.4		7.4 ± 1.4			0.000*
MAR	0.7 ± 0.7		0.9 ± 0.9			0.000*

This table shows the mean ± SD nutrient intakes and significant differences between the intakes of the 722 and 395 women in the Vaal region and Qwa-Qwa, respectively. The mean nutrient intakes are compared to the dietary reference intake, specifically the EAR and AI. These data have not been published before

*Statistically significant difference between the Vaal region and Qwa-Qwa at $p \leq 0.05$ (independent t-test for equality of variances)

Dietary reference intakes as represented by the estimated average requirement for females aged 31–50 years old and adequate intake (AI)# where no EAR is available [40]

^Estimated energy requirement (EER)

Food Group Variety

The FGDSs of 6.4 ± 2.4 (Vaal region) and 7.4 ± 1.4 (Qwa-Qwa) of both groups indicated high dietary diversity (6–9 food groups consumed in 7 days) [26] (Table 20.1). The FGDSs are further clarified in Fig. 20.2, where the number of food groups consumed is shown. The majority (92.9 %) of the Qwa-Qwa women had high FGDSs, and very few had medium (4.0 %) or low (3.1 %) scores.

Table 20.2 Nutrition adequacy measured by 24-h recall and analyzed by independent *t*-tests

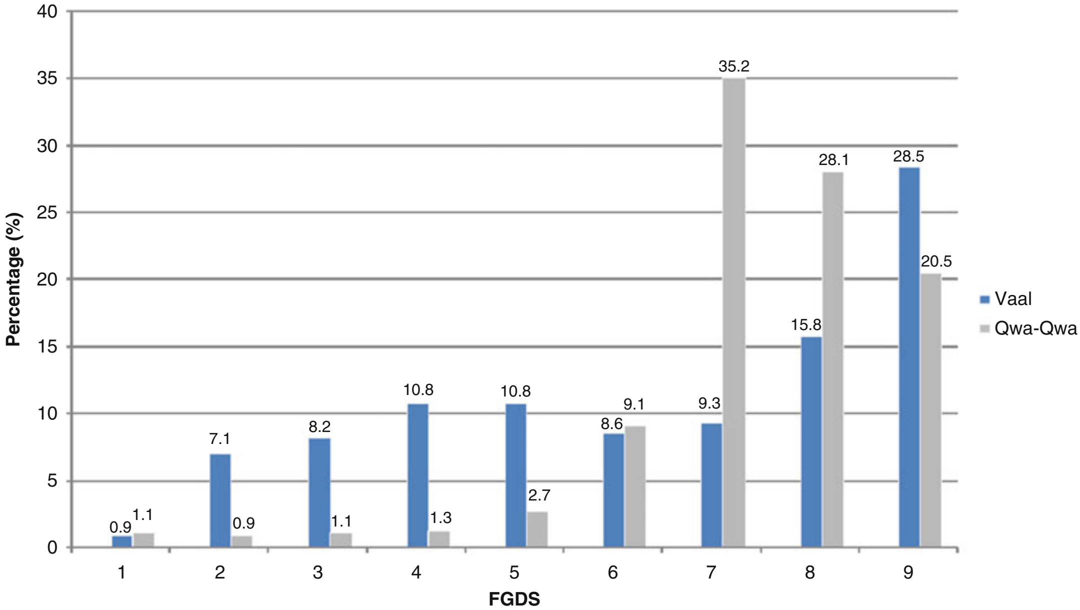
Nutrient	Vaal region (n=722)		Qwa-Qwa (n=395)		Significant difference between Vaal region and Qwa-Qwa at 5 % (two tailed)
	NAR (mean ± SD)	Range of nutrient intake	NAR (mean ± SD)	Range of nutrient intake	
Energy	0.48 ± 0.21	428–14,447	0.46 ± 0.28	615–19,526	0.235
Total protein	0.87 ± 0.55	3–195	0.92 ± 0.59	2–156	0.138
Carbohydrates	1.69 ± 0.75	0–454	1.49 ± 1.03	17–733	0.000*
Total dietary fiber	0.44 ± 0.27	0–45	0.48 ± 0.38	0–83	0.051
Calcium	0.19 ± 0.20	0.0–1293.3	0.21 ± 0.19	0.0–1251.9	0.087
Iron	0.80 ± 0.70	0.2–38.5	0.94 ± 0.64	0.0–41.8	0.000*
Magnesium	0.73 ± 0.35	19.2–1060.5	0.66 ± 0.40	0.1–986.6	0.001*
Phosphorus	1.02 ± 0.52	44.0–1858.5	0.94 ± 0.57	0.2–2677.7	0.019*
Zinc	0.78 ± 0.54	0.2–30.5	0.77 ± 0.48	0.1–22.0	0.707
Chromium	0.87 ± 1.14	0.0–181.1	1.34 ± 2.48	0.0–484.8	0.000*
Selenium	0.40 ± 0.55	0.0–152.6	1.18 ± 3.98	0.0–2143.0	0.000*
Iodine	0.16 ± 0.23	0–301.2	0.17 ± 0.18	0.0–141.0	0.317
Vitamin A	0.91 ± 3.45	0–2690.9	0.86 ± 2.28	0.0–17327.3	0.798
Thiamin	0.82 ± 0.43	0.1–4.1	0.81 ± 0.58	0.0–4.6	0.742
Riboflavin	0.64 ± 0.85	0.0–10.5	0.98 ± 2.04	0.0–18.4	0.000*
Niacin	0.81 ± 0.81	0.2–74.1	0.98 ± 0.84	0.1–68.1	0.001*
Vitamin B6	0.52 ± 0.51	0.0–5.4	1.96 ± 9.05	0.0–117.6	0.000*
Folate	0.46 ± 0.63	3.0–1971.5	0.67 ± 0.58	0.2–1455.5	0.000*
Vitamin B12	1.58 ± 7.54	0.0–280.0	1.14 ± 5.02	0.0–178.9	0.295
Pantothenate	0.63 ± 0.75	0.1–38.6	0.78 ± 0.84	0.2–25.7	0.002*
Biotin	0.67 ± 1.40	0.8–514.5	0.49 ± 0.44	0.0–133.7	0.014*
Vitamin C	0.34 ± 0.56	0.0–401.0	0.48 ± 0.72	0.0–341.0	0.000*
Vitamin D	0.29 ± 0.56	0.0–25.0	0.26 ± 0.41	0.0–20.5	0.320
Vitamin E	0.35 ± 0.55	0.0–127.8	0.35 ± 0.35	0.0–30.2	0.904
Vitamin K	1.27 ± 2.15	0.0–2241.0	2.06 ± 0.04	0.0–4482.0	0.000*

The table shows the mean ± SD of the nutrient adequacy ratios for 25 nutrients and significant differences between the Vaal region and Qwa-Qwa. These data have not been published before

*At a 5 % level of significance (two tailed), there is a statistical significant difference between baseline and follow-up measurements (independent t-test for equality of variances)

In contrast, 62.2 %, 21.6 %, and 16.2 % of the women in the Vaal region had high, medium, and low FGDSs, respectively.

Low dietary variety is associated with low-income black South Africans [10]. However, the DDS of both peri-urban areas indicated high dietary diversity (6–9 food groups consumed in 7 days) [1]. This is interesting because the women of Qwa-Qwa mostly had high DDSs, but the women in the Vaal region had a combination of, and were spread equally among, the high, medium, and low scores. This is further supported by the statistically significant (p=0.000) higher DDS in Qwa-Qwa. Both these regions obtained higher DDSs than the mean DDS of 4.02 for South Africa [10]. Furthermore, the tribal areas of Qwa-Qwa had a significantly higher DDS than the Vaal region. The agricultural activities in Qwa-Qwa may have contributed to this. However, in other tribal areas in South Africa, the lowest DDSs were found compared with the rural and urban areas [10]. This could possibly be attributed to differences in methodology used to investigate dietary diversity.



Low = 0-3 food groups, Medium = 4-5 food groups, High = 6-9 food groups [26]

Fig. 20.1 Comparison of food group diversity scores. A comparison of the prevalence (%) of 722 and 395 women in the Vaal region and Qwa-Qwa respectively using the number of food groups for the 7-day reference period is shown. These data have not been published before

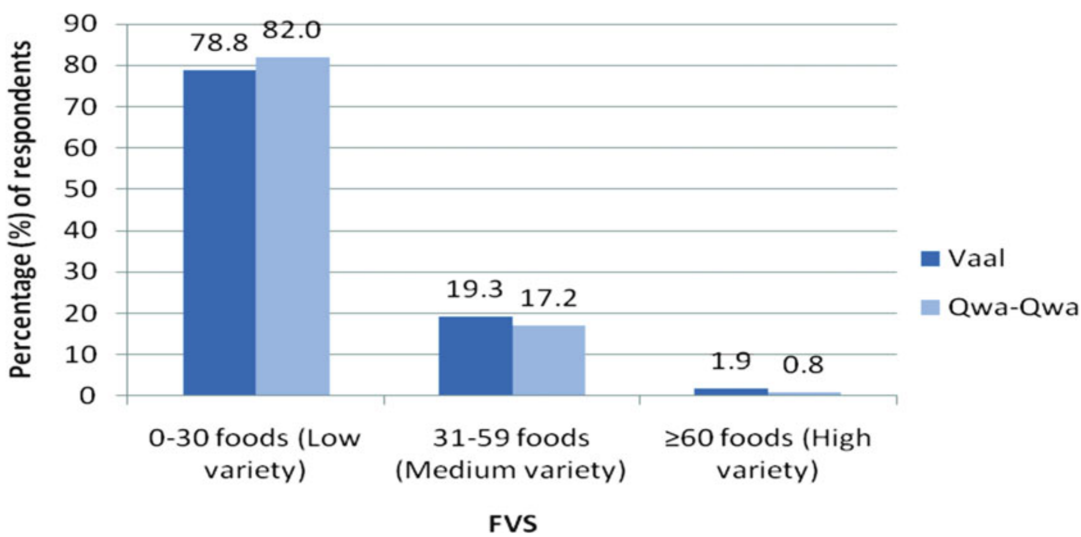


Fig. 20.2 Comparison of food variety scores (FVSs). A comparison of the percentage of 722 and 395 women in the Vaal region and Qwa-Qwa respectively with low, medium, and high FVSs is shown. These data have not been published before

Table 20.3 Summary of the food variety within the food groups

Food group	Vaal region ($n=722$) Mean	SD	Range of scores[a]	Qwa-Qwa ($n=395$) Mean	SD	Range of scores[a]	Significant difference between Vaal region and Qwa-Qwa at 5 % (two tailed)
Cereals, roots, and tubers	5.48	3.55	0–17	5.27	2.81	0–15	0.000
Other vegetables	3.07	2.74	0–27	3.62	2.21	0–12	0.000
Vitamin A-rich fruit and vegetables	1.94	1.91	0–11	2.78	1.41	0–08	0.000
Flesh foods (meat, poultry, fish)	3.30	2.63	0–12	3.31	2.34	0–11	0.000
Fats and oils	1.48	1.15	0–5	1.44	0.80	0–05	0.000
Dairy	1.31	1.54	0–09	1.34	1.53	0–07	0.000
Other fruit	1.55	2.58	0–17	1.76	2.11	0–13	0.000
Legumes and nuts	0.92	1.08	0–04	1.20	1.06	0–09	0.000
Eggs	1.00	0.00	0–01	0.62	0.49	0–01	0.000
Total food items (FVS)	19.57	15.06	0–97	21.33	11.17	0–72	0.000

This table shows the summary of the mean ± SD food variety as well as the range of foods consumed within each of the nine nutritious food groups and the significant differences between the Vaal region and Qwa-Qwa. These data have not been published before

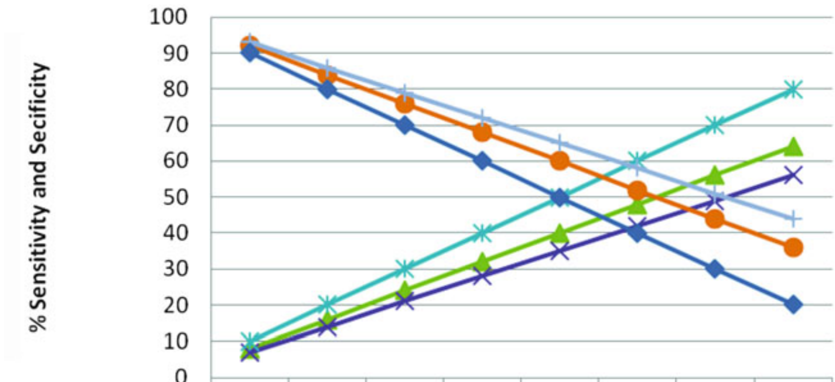
[a]The range of scores indicates the range of individual food items consumed within each group

Household food variety within each of the food groups is presented in Table 20.3. The food group with the most variety in both areas was the cereal group, with 5.48 ± 3.55 for the Vaal region and 5.27 ± 2.81 for Qwa-Qwa, which was consistent with the adequate mean carbohydrate intakes in excess of 100 % of EAR in both groups, but also with the staple-based diet typically consumed by black South Africans [37].

In the Vaal region, the cereal group was followed consecutively by the flesh, other vegetables, vitamin A-rich fruit and vegetables, and other fruit groups. The same top food group order was observed in Qwa-Qwa except for the flesh and other vegetable groups exchanging places.

In these peri-urban areas, the food groups with the most variety within the group were the vegetable, fruit, flesh, and cereal groups, with 27, 20, 20, and 19 food items respectively in the Vaal region. However, a large number of women did not consume any food items at all from the vegetable ($n = 122$, 17 %), fruit ($n = 365$, 51 %), flesh ($n = 98$, 14 %), legume and nut ($n = 347$, 48 %), egg ($n = 335$, 46 %), and dairy ($n = 247$, 34 %) groups during the 7-day period. A similar trend was observed in Qwa-Qwa, with 18, 17, 17, and 14 food items in the vegetable, fruit, cereal, and flesh groups, respectively. This is in line with South African food consumption patterns, as 40 % and 70 % of adults apparently do not regularly consume vegetables and fruit, respectively, and only 15 % eat legumes. Furthermore, dairy and eggs are consumed by only 48 % and 18 %, respectively [38]. The food groups with the least variety within the group in both areas are eggs, legumes and nuts, as well as dairy. This is evident in the nutrient intakes indicating deficient protein, energy, and micronutrient intakes. The most neglected food groups in the other South African report included the vitamin A and legumes and nuts groups [10].

The FVSs within the food groups were significantly higher in Qwa-Qwa for other vegetables, vitamin A-rich fruit and vegetables, flesh foods, dairy, other fruit, and the legume and nut group.



	1	2	3	4	5	6	7	8
MAR (50%)S	8	16	24	32	40	48	56	64
MAR (60)S	7	14	21	28	35	42	49	56
MAR (70)S	10	20	30	40	50	60	70	80
MAR (50%)SP	92	84	76	68	60	52	44	36
MAR (60)SP	93	86	79	72	65	58	51	44
MAR (70)SP	90	80	70	60	50	40	30	20

Fig. 20.3 Sensitivity and specificity (%) of different cut-off points for FVS with cutoff points of mean adequacy ratio (MAR) ranging from 0.50 to 0.70 in Qwa-Qwa. The sensitivity and specificity percentage of different cutoff points for the FVS with cutoff points of the mean adequacy ratio ranging from 0.50 to 0.70 for the 395 women in Qwa-Qwa is shown. This gives an indication of the number of food groups to be consumed to reach nutritional adequacy. These data have not been published before

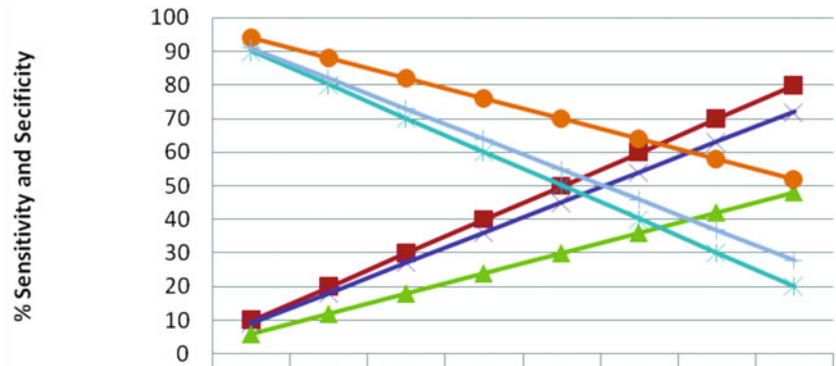
In these groups, a mean adequacy ratio of 0.7 was used as a cutoff point for nutrient adequacy. For DDS, a cut point of 0.7 was used to assess nutrient adequacy (Fig. 20.3) in Qwa-Qwa. To reach nutrient adequacy >50 %, the DDS was 5, indicating that 50 % of the group had inadequate diets if they used foods from only five groups. The inversely related specificity of <50 % indicated that 50 % of the group had adequate intakes (AIs) when using more than five groups. A cut point of 5 for DDS will have a sensitivity of >50 % and a specificity of <50 %, and a score of 7 will give a sensitivity of >70 % and specificity of <30 %. In the Vaal region, to reach nutrient adequacy of >50 %, the DDS was also 5, indicating that 45 % of the group had inadequate diets if they used foods from only five groups. The inversely related specificity of <50 % indicated that 55 % of the group had AIs when using more than five groups, while a score of 7 will give a sensitivity of >63 % and specificity of <37 % (Fig. 20.4).

Nutrient Adequacy

A trend was observed that with higher food variety and DDSs, a better mean adequacy ratio was reached in these low-income groups of peri-urban women. To reach a mean adequacy ratio higher than 70 %, a DDS of five nutritional food groups is needed. Higher food variety and DDSs resulted in higher mean adequacy ratios, indicating that with better food choices and more varied intakes, a better quality diet can be achieved. It appears that with intakes of seven food groups, it would be possible for 63–70 % of all the women in both peri-urban areas to reach 70 % nutritional adequacy.

Influence of Sociodemographic Factors on Dietary Diversity

In Table 20.4, selected socioeconomic factors that may be associated with dietary intakes and



	1	2	3	4	5	6	7	8
MAR (50%)S	10	20	30	40	50	60	70	80
MAR (60)S	6	12	18	24	30	36	42	48
MAR (70)S	9	18	27	36	45	54	63	72
MAR (50%)SP	90	80	70	60	50	40	30	20
MAR (60)SP	94	88	82	76	70	64	58	52
MAR (70)SP	91	82	73	64	55	46	37	28

Fig. 20.4 Sensitivity and specificity (%) of different cutoff points for FVS with cutoff points of MAR ranging from 0.50 to 0.70 for the Vaal region. The sensitivity and specificity percentage of different cutoff points for the FVS with cutoff points of the mean adequacy ratio ranging from 0.50 to 0.70 for the 722 women in the Vaal region is shown. This gives an indication of the number of food groups to be consumed to reach nutritional adequacy. These data have not been published before

diversity are presented. In the Vaal region, it is clear that inadequate energy intakes were significantly higher among the women who had lower education ($p=0.015$), lower income ($p=0.028$), and were unemployed ($p=0.015$). The same trend was observed with the FGDS; however, no significant difference was observed between the lower-income and higher-income groups. None of these were significant in the Qwa-Qwa women (Table 20.5).

Many other factors, such as poverty, lack of resources, and education, also impact on food choices and food preparation methods. Odds ratios of the selected socioeconomic factors with a DDS of <6 showed that the relative odds of having a DDS <6 compared with a DDS of ≥6 was the highest under the following conditions in the Vaal region: no or primary education (OR 4.307), unemployment (OR 3.187), and household income <ZAR2,000 (US$267) (OR 1.571). In contrast, the relative odds of having a DDS <6 compared with a DDS of ≥6 was highest for household income ZAR2,000 (US$267) (OR 2.697), employment (OR 1.825), and secondary and tertiary education (OR 1.246) in Qwa-Qwa (Table 20.6).

All these factors had an impact on macronutrient intakes and dietary diversity in the Vaal region. Similar trends were observed in the Qwa-Qwa women, although these were not significant. It is well known that lower socioeconomic groups consume diets of lower quality and that the converse is also true, with diets of higher quality being consumed by affluent and better educated people [39].

Conclusions

It can be concluded that most of the women in both peri-urban areas were impoverished, poorly educated, and unemployed, with low income. All these factors contributed to their diet quality.

Table 20.4 Prevalence of inadequate nutrient intake according to the educational level, income, and employment status of women in the Vaal region ($n=722$)

Nutrient/dietary diversity score	No or primary school education ($n=569$) (%)	Secondary and tertiary education ($n=153$) (%)	p	Income < ZAR2,000 per month ($n=708$) (%)	Income ≥ ZAR2,000 per month ($n=14$) (%)	p	Employed ($n=53$) (%)	Unemployed ($n=669$) (%)	p
Energy	98.8	95.4	0.015	98.3	85.7	0.028	92.5	98.5	0.015
Total protein	64.9	75.8	0.012	67.5	50.0	0.248	69.8	67.0	0.762
Carbohydrates	22.0	14.4	0.042	20.5	14.3	0.746	11.3	21.1	0.110
Total dietary fiber	96.1	96.7	1.000	96.2	100.0	1.000	96.2	96.3	1.000
Calcium	98.6	100.0	0.214	99.0	92.9	0.146	100.0	98.8	1.000
Iron	78.4	82.4	0.313	79.7	57.1	0.050	77.4	79.4	0.726
Magnesium	80.5	79.7	0.820	80.5	71.4	0.493	71.7	81.0	0.107
Phosphorus	53.4	62.1	0.067	55.4	50.0	0.789	50.9	55.6	0.567
Zinc	73.3	75.2	0.680	74.3	42.9	0.013	69.8	74.0	0.518
Chromium	68.2	74.5	0.139	69.9	50.0	0.141	58.5	70.4	0.087
Selenium	87.5	91.5	0.202	88.6	78.6	0.216	83.0	88.8	0.262
Iodine	99.3	98.0	0.168	99.0	100.0	1.000	98.1	99.1	0.415
Vitamin A	82.1	88.2	0.086	83.5	78.6	0.714	88.7	83.0	0.341
Thiamin	73.3	66.0	0.086	71.8	71.4	1.000	49.1	73.5	0.000
Riboflavin	85.6	87.6	0.600	86.3	71.4	0.119	86.8	85.9	1.000
Niacin	6.0	3.3	0.230	5.5	0.0	1.000	1.9	5.7	0.351
Vitamin B6	88.2	87.6	0.888	88.3	78.6	0.227	86.8	88.2	0.825
Folate	87.9	91.5	0.251	88.8	78.6	0.206	86.8	88.8	0.652
Vitamin B12	73.6	73.2	0.918	73.9	57.1	0.217	69.8	73.8	0.520
Pantothenate	79.1	86.9	0.028	80.8	78.6	0.739	90.6	80.0	0.069
Biotin	92.1	90.2	0.509	91.8	85.7	0.327	92.5	91.6	1.000
Vitamin C	94.9	95.4	1.000	95.1	92.9	0.515	96.2	94.9	1.000
Vitamin D	89.6	92.1	0.444	90.2	85.7	0.640	92.5	90.0	0.810
Vitamin E	95.1	93.5	0.418	94.8	92.9	0.534	90.6	95.1	0.189
Vitamin K	66.8	61.4	0.250	65.7	64.3	1.000	50.9	66.8	0.024
DDS	45.0	11.1	0.000	38.0	28.6	0.585	17.0	39.5	0.001
FVS	98.2	97.4	0.510	98.0	100.0	1.000	98.1	98.1	1.000

This table shows the prevalence (%) of inadequate nutrient intake for 25 nutrients according to the educational levels, income, and employment status of the 722 women in the Vaal region. These data have not been published before

Table 20.5 Prevalence of inadequate nutrient intake according to the educational level, income, and employment status of women in Qwa-Qwa ($n = 395$)

Nutrient/dietary diversity score	No or primary school education ($n = 246$) (%)	Secondary and tertiary education ($n = 149$) (%)	p	Income < ZAR2,000 per month ($n = 380$) (%)	Income ≥ ZAR2,000 per month ($n = 15$) (%)	p	Employed ($n = 43$) (%)	Unemployed ($n = 352$) (%)	p
Energy	94.3	98.0	0.123	95.8	93.3	0.489	95.2	100.0	0.237
Total protein	61.1	70.3	0.082	64.5	66.7	1.000	63.6	73.2	0.301
Carbohydrates	29.5	37.0	0.146	32.3	33.3	1.000	30.9	43.9	0.112
Total dietary fiber	93.5	92.6	0.837	94.2	66.7	0.002	92.9	95.1	1.000
Calcium	99.2	99.3	1.000	99.2	100.0	1.000	99.2	100.0	1.000
Iron	71.3	63.5	0.118	69.7	33.3	0.008	69.2	61.0	0.291
Magnesium	89.9	87.2	0.413	89.5	73.3	0.073	88.7	90.2	1.000
Phosphorus	64.0	68.2	0.444	65.5	66.7	1.000	65.0	70.7	0.494
Zinc	74.1	79.7	0.223	76.1	80.0	1.000	76.0	78.0	0.849
Chromium	57.9	79.1	0.000	65.3	80.0	0.281	65.5	68.3	0.862
Selenium	67.2	85.1	0.000	73.2	93.3	0.130	72.6	85.4	0.091
Iodine	98.4	100.0	0.302	98.9	100.0	1.000	98.9	100.0	1.000
Vitamin A	79.4	67.6	0.012	75.5	60.0	0.221	74.3	80.5	0.451
Thiamin	74.9	82.4	0.104	78.2	66.7	0.340	77.1	82.9	0.552
Riboflavin	78.9	74.3	0.322	76.8	86.7	0.536	77.7	73.2	0.555
Niacin	65.2	64.9	1.000	65.3	60.0	0.784	64.7	68.3	0.731
Vitamin B6	68.0	74.3	0.211	70.0	80.0	0.568	70.3	70.2	1.000
Folate	81.8	85.8	0.331	83.7	73.3	0.291	82.2	92.7	0.120
Vitamin B12	72.1	71.6	1.000	71.1	93.3	0.077	71.5	75.6	0.714
Pantothenate	74.9	74.3	0.905	75.3	60.0	0.224	74.3	78.0	0.706
Biotin	93.5	95.9	0.370	94.5	93.3	0.583	97.6	94.1	0.715
Vitamin C	89.1	91.2	0.606	90.0	86.7	0.656	89.3	95.1	0.408
Vitamin D	97.2	91.9	0.027	95.0	100.0	1.000	95.5	92.7	0.432
Vitamin E	15.4	17.6	0.575	16.3	13.3	1.000	16.1	17.1	0.825
Vitamin K	66.4	50.7	0.003	60.8	53.3	0.597	59.6	68.3	0.315
DDS	6.1	7.5	0.676	6.9	0.0	0.612	7.1	2.4	0.501
FVS	100.0	98.0	0.052	99.2	100.0	1.000	99.4	97.6	0.282

This table shows the prevalence (%) of inadequate nutrient intake for 25 nutrients according to the educational levels, income, and employment status of the 395 women in Qwa-Qwa. These data have not been published before

Table 20.6 Odds ratios of socioeconomic factors associated with a dietary diversity score <6

	Vaal region		Qwa-Qwa	
	Odds ratio	95 % confidence interval	Odds ratio	95 % confidence interval
No or primary education	4.307	2.822–6.575	1.103	0.627–1.943
Secondary and tertiary education	0.153	0.090–0.260	1.246	0.556–2.790
Household income <R2,000 per month	1.571	0.521–4.736	2.694	0.348–20.868
Household income ≥R2,000 per month	0.653	0.203–2.102	1.074	1.045–1.104
Employed	0.314	0.162–0.607	1.825	0.626–5.317
Unemployed	3.187	1.530–6.637	0.327	0.043–2.479

This table shows the odds ratios of the socioeconomic factors associated with a low/medium dietary diversity score (<6) for the 722 women in the Vaal region and the 395 women in Qwa-Qwa. These data have not been published before

The assessments of diet quality revealed contradictions in that the DDSs indicated high dietary diversity and the FVS indicated low dietary diversity. This indicates that although most food groups were consumed by the women, only a few foods from each group were included. Consuming one or two foods from each of the nine groups does not, therefore, constitute a varied intake. In addition, the relatively high NARs also showed AIs; however, these were based on the micronutrient intakes only and did not consider energy or other macronutrients. In contrast to the relatively high mean adequacy ratio of 0.7 and 0.9, the total energy intakes in most women were very low (NAR 0.46 and 0.48). A key component of dietary adequacy is the consumption of a wide variety of foods, which in turn determines dietary diversity, a widely recognized indicator of diet quality. These outcomes proved the importance of focusing not only on food group variety but also on the variety of foods across and within the nutritious food groups. Focusing on either food groups or individual food variety only may result in a skewed picture. It is essential to use the appropriate methodology with a combination of dietary diversity assessment scoring techniques in order to make appropriate assessments and recommendations for future interventions. Owing to the paucity of data regarding South African dietary diversity, more research is recommended in various settings (rural, peri-urban, urban) and target groups (all age groups, genders, living standards measures, and socioeconomic factors) across South Africa. Very little information is available on the association between diet quality and household socioeconomic characteristics, and researchers should address these issues in all related research studies in South Africa.

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Part IV

Methods, Indexes and Scoring Systems: Applications and Analysis

The 'Diet Quality Index' and Its Applications

21

Inge Huybrechts, Carine Vereecken, Krishna Vyncke, Lea Maes, Nadia Slimani, and Stefaan De Henauw

Key Points

- The original Diet Quality Index (DQI) was developed for the US population and included food- and nutrient-based recommendations.
- An adapted version, existing out of four subscores (dietary diversity, quality, equilibrium and meal index), was exclusively based on Food Based Dietary Guidelines (FBDG) and was designed for use in Flemish preschoolers.
- This FBDG-based DQI for Flemish preschoolers has also been applied in European adolescents and Belgian adults.
- An important advantage of this latter DQI is the fact that no linking with food composition tables is required which is time saving and also avoids extra bias due to errors in food composition.
- Evaluation and validation studies of the FBDG-based DQI score and its subscores revealed good reproducibility and validity of the concepts in different populations.
- This FBDG-based DQI was shown to be applicable on different dietary assessment instruments (e.g. short FFQs and dietary records).
- Although the FBDG-based DQI was designed to compare and monitor dietary changes in populations rather than individuals, it could also serve as an effective evaluation tool for intervention studies or clinical trials.

Keywords

Diet quality index • Validity • Evaluation • Applications • Dietary diversity • Quality • Equilibrium • Meal index

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V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health, DOI 10.1007/978-1-4614-7315-2_21, © Springer Science+Business Media New York 2013

Abbreviations

C-DQI	Children's Diet Quality Index
CVD	Cardiovascular diseases
DQI	Diet Quality Index
DQI-A	Diet Quality Index for Adolescents
DQI-R	Diet Quality Index-Revised
FBDG	Food based dietary guidelines
FFQ	Food frequency questionnaire
RDA	Recommended dietary allowances

Introduction

The gaps in human diets have mainly been discussed by comparing nutrient intakes with age- and gender-specific recommended dietary allowances (RDA) for nutrients [1] or by comparing food intakes with Food Based Dietary Guidelines (FBDG). A complementary approach to assessing compliance with nutrition and food guidelines consists of obtaining an overall dietary index, which has the added value of considering the complexity of food consumption patterns and their multidimensional nature [2–5]. In this respect, indices based on nutrients, foods and a combination of both have been proposed [3, 5–9]. Some of these indices have shown an association with mortality risk, cardiovascular diseases (CVD) and some types of cancer, of greater magnitude than that observed for any nutrient or food at an individual level [10, 11].

Although different indices have been developed to capture multidimensional dietary behaviours (e.g. fruit and vegetable intake vs. energy-dense and low-nutritious foods, in one single index), this chapter will focus on the development of the Diet Quality Index (DQI) and its past, current and future applications. The original DQI was based upon the US dietary recommendations from the 1989 National Academy of Sciences publication Diet and Health that focused mainly on the prevention of deficiencies. This DQI included measures of eight food group- and nutrient-based recommendations (total fat, saturated fat, cholesterol, fruit and vegetables, grains and legumes, protein, sodium and calcium). These dietary recommendations were stratified into three levels of intake for scoring individuals. Those who met a dietary goal were given a score of zero. Those who did not meet a goal, but had a fair diet, were given one point, and those who had a poor diet were given two points. These points were summed across eight diet variables to score the index from zero (excellent diet) to 16 (poor diet). An evaluation study of this DQI revealed that lower index scores were positively associated with high intakes of other important measures of diet quality (e.g. fibre, vitamin C), while single nutrients or DQI components (such as dietary fat) were not necessarily associated with other measures of diet quality [5].

The original DQI was revised to reflect renewed US dietary guidelines to incorporate improved methods of estimating food servings and to include measures of dietary variety and moderation [12]. The scoring of the original scale was reversed in direction to improve interpretability (low scores reflect poorer achievement of dietary recommendations and higher scores better diet quality) and expanded to a 100-point scale. This revised Diet Quality Index (DQI-R) reflects ten dietary characteristics, including both foods and nutrients. An evaluation study revealed a statistically significant quantitative and qualitative improvement in all components of the DQI-R as one moves from the lowest grouping of scores to the highest. For example, persons with DQI-R scores less than 40 consumed 43.9 % of energy from fat, 72 % of the adequate intake for calcium and 6.7 % of the recommended servings of fruit per day. In contrast, those with DQI-R scores greater than 80 consumed 24.2 % of energy from fat, 101 % of the adequate intake for calcium and 137 % of the recommended servings of fruit per day. From this evaluation study, it could be concluded that the DQI-R reflects the dietary guidance principles of macronutrient distribution, moderation, variety and proportionality [6]. More recently, this DQI-R was utilised as a framework for delivering and evaluating an intervention to improve overall diet quality among older cancer survivors. This evaluation study concluded that the DQI-R could serve as an effective guide and evaluation tool for diet-related randomised controlled trials [13].

The DQI and DQI-R were not designed to include recommendations for children younger than 18 years. Therefore, the Children's Diet Quality Index (C-DQI) [14] was developed based on the dietary intake recommendations provided by the Food Guide Pyramid for Children from 1998 [15]. However, children consuming more food, and thus more total energy, were more likely to meet the intake recommendations for food groups and nutrients compared with children who ate less. In an effort to reduce the childhood obesity epidemic, a component to represent energy balance of children's dietary intake was included in the revised Children's Diet Quality Index (RC-DQI) that was developed for use in 2–5-year-old American preschoolers. This latter index was based on more recent intake recommendations regarding not only nutrients/foods at risk for deficiency but also items of excessive intake to prevent childhood obesity. An evaluation study revealed that the RC-DQI can be used to determine diet quality in groups of preschool-aged children [14]. This index successfully differentiated diets by level of diet quality and higher scores were associated with lower consumption of added sugar and juices and higher intakes of fibre, essential fatty acids, fruits and vegetables.

All the abovementioned diet quality indices were assessed by means of detailed dietary intake assessment methods like 24-h recalls or dietary records to allow the calculation of nutrient intakes which are principal components of these diet quality indices. While detailed and labour-intensive dietary assessment methods like dietary records or recalls are required for accurately measuring different nutrient intakes [16], quick and easy methods like a brief FFQ are more appropriate for assessing the intake of foods and/or food groups only [17]. Since FBDG are based on nutrient recommendations, a person complying with the FBDG could be assumed to comply better with nutrient recommendations in comparison with people not meeting the FBDG. Consequently, a FFQ assessing the intake of foods and/or food groups might be a useful alternative for estimating usual diet quality when diet records or recalls are not feasible for the study [17, 18].

Hence, a 47-item FFQ was used to develop a DQI for preschool children as a tool for assessing in a quick and accurate way the compliance of Flemish preschoolers with the Flemish FBDG [19]. The basic principles of a healthy diet in the Flemish FBDG include 'equilibrium (adequacy and moderation)' and 'variation/diversity'. Additional guidelines concern the 'meal pattern' (which should include at least three main courses (breakfast, lunch and dinner)) and the 'quality of the food items' consumed. The FBDG-based DQI for preschool children considered these four basic principles for a healthy diet and did not consider any nutrient recommendations. Afterwards, this DQI for preschoolers has been adapted for use in adult and adolescent populations and by means of different dietary intake assessment methods (e.g. 24-h recalls). In addition the inclusion of an extra component evaluating the physical activity level of the individuals was evaluated.

This chapter gives a *description of the FBDG-based DQI* for preschoolers and its adapted versions that were used and evaluated in adult and adolescent populations. Furthermore, this chapter will discuss the *different evaluation studies* that were performed to investigate the validity of this DQI score for use in different populations and when being assessed via different dietary intake assessment methods. At last this chapter gives an overview of the *current and possible applications of this DQI* score.

Concepts and Design of FBDG-Based Diet Quality Indices

Development of the FBDG-Based Diet Quality Index for Flemish Preschoolers

The DQI for preschool children was designed for assessing the compliance with the FBDG (Fig. 21.1) [19] by means of a semi-quantitative FFQ. This FFQ contained questions on the average consumption of 47 food items during the past year. The contents and relative validity of this FFQ

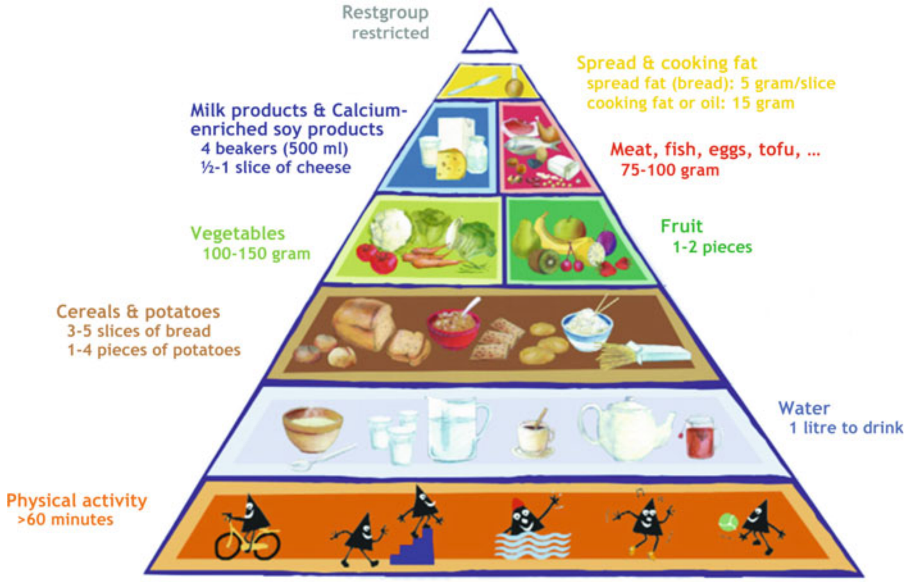

Fig. 21.1 The Flemish food based dietary guidelines (food triangle) for Flemish preschoolers [19] (source: adapted from the Flemish institute for Health promotion (Vlaams Instituut voor Gezondheidspromotie en Ziektepreventie vzw), Belgium: http://www.vigez.be)

have been described elsewhere [20]. In summary, the parents were asked to indicate their answers in a list of frequencies: every day, 5–6 days/week, 2–4 days/week, 1 day/week, 1–3 days/month, never or <1 day/month. The questionnaire also contained three or four portion-size categories per food item and a list of common standard measures as examples. Parents were asked to indicate the portion-size category that best fitted the daily portion of their child. Dietary data from the FFQ were converted to average daily intake values (e.g. 1 serving/week = 0.14 serving/day). To validate this FFQ-based DQI, parents were also asked to complete a 3-day dietary record for their child. The DQI was also calculated by means of this 3-day dietary record and was compared with the FFQ approach [21]. In total, 510 preschool children (2.5–6.5 years old) could be included in this validation study of the FFQ-based DQI for preschool children. In addition, the reproducibility of the FFQ-based DQI was evaluated in another sample of 58 preschool children for whom the parents completed the FFQ on two nonconsecutive days at least 5 weeks apart.

The DQI for preschool children was developed based on the Flemish FBDG [19]. The major components of this DQI are dietary diversity, dietary quality, dietary equilibrium and meal patterns. Although a brief description of the major components of the DQI for Flemish preschoolers is given below, a more in-depth description of this DQI is given in Huybrechts et al. [21].

Dietary Diversity

While the value of increased food variety in either ensuring essential nutrient adequacy or decreasing the risk of food toxicity has been understood for some time, using food variety as a predictor of health outcome is a relatively recent approach [22, 23]. However, enough evidence is available to justify promoting food variety through FBDG as a technique to reduce morbidity and mortality while awaiting further scientific studies on how exactly it operates. Therefore, dietary guidelines almost universally list consumption of a variety of foods as the number one recommendation. Hence, the consumption of at least one serving of food per day from each of the eight recommended food groups illustrated in the Flemish active food triangle [19] is the first dietary guideline.

Dietary Quality

Within each food group, food items differ in nutrient and energy density. When developing FBDG, it is important to recommend high nutritious food items (with high nutrient density for the essential micronutrients) and to discourage a daily use of energy-dense and low-nutritious food items [22]. A representative group of Flemish dieticians and nutritionists discussed the different options for categorising the different food items within a certain food group according to their nutrient and energy density. The consensus of these experts was to categorise products within a food group into three subgroups in the Flemish FBDG: food items that are preferred in the 'preference group' (e.g. fresh fruit, cereal/brown bread), food items that may be consumed in the 'intermediate group' (formerly also called 'moderation group') (e.g. white bread) and food items that should be avoided in the 'low-nutritious, energy-dense group' (e.g. soft drinks and sweet snacks). If a child consumes one portion from each food group, he or she will have the maximum diversity score. However, this does not necessarily imply that this child has made the optimal quality food choices within each food group. Therefore, the 'dietary quality' component was introduced in the DQI scoring system for preschool children.

Dietary Equilibrium: Adequacy and Excess

Dietary guidelines stress an adequate intake of key foods such as fruits and vegetables, but also encourage moderation, especially in intakes of nutrient-poor energy-dense foods. A diet is in balance when an adequate but moderate intake of each element of the FBDG is reassured. Therefore, the dietary equilibrium factor is disaggregated into 'adequacy' and 'excess'. The adequacy score investigates to what extent the daily intake of the different food groups reach the minimum recommendation provided in the food triangle, while the excess score investigates to what extent the daily intake of the different food groups exceed the maximum recommendation. These distinctive categories help users to readily identify dietary aspects that need to be improved most. The equilibrium score is calculated by subtracting the excess from the dietary adequacy score.

Meal Index

A healthy diet implies also the consumption of a certain number of meals per day. Although children are recommended to have smaller but more frequent meals (up to 6/day), only the three major meals (breakfast, lunch and dinner) were assessed in the FFQ. Evidence shows an important influence of meals on individuals' health. Skipping breakfast was found being associated with higher risk for obesity [24] and lower attention or concentration capacities [25–27]. In addition, low meal frequencies and a high-calorie late-evening dinner were found to be associated with overweight and obesity [28, 29]. Therefore, this fourth component was added to the DQI for preschool children. This meal index was calculated from the frequency variables 'breakfast', 'lunch' and 'dinner', representing the number of days per week that these meals were consumed.

To compute the overall DQI for preschool children, the scores of the four major categories were summed and divided by four, resulting in total scores ranging from –25 to 100 %, as only negative values could be obtained with the diet quality component. Although a child theoretically can reach a DQI score below zero, negative scores can only be achieved when a child only consumed food items from the group of low-nutritious, energy-dense foods (e.g. soft drinks and candies). The better a child complies with the FBDG, the higher the total DQI with a maximum of 100 %.

It is noteworthy that despite the inclusion of a physical activity layer in the Flemish food triangle, no physical activity index could be calculated from this preschool dietary survey as insufficient information on the children's physical activity level had been collected in this survey. However, one could envisage the inclusion of such physical activity component in future studies. More details about the technical aspects of the DQI and its different components are given in Table 21.2.

FBDG-Based DQI Adapted for Belgian Adults and Assessed by Means of a Short FFQ

The DQI for preschoolers was adapted for use in adults in the frame of the Belgian Asklepios Study [30, 31]. The Asklepios Study is a longitudinal population study focusing on the interplay between ageing, cardiovascular (CV) haemodynamics and inflammation in (preclinical) CVD. At baseline in October 2002, 2,524 healthy volunteers aged 35–55 years were recruited. The participants were asked to complete a semi-quantitative FFQ that was specifically designed to assess adherence to the Flemish FBDG. This FFQ included questions on the habitual daily consumption of 25 food items during the past year. The participants were asked to indicate how often they consumed each item in a list of frequencies: every day, 5–6 days per week, 2–4 days per week, 1 day per week, 1–3 times per month, never or less than once a month. In addition, the FFQ contained three daily portion-size categories per food item and a list of common standard measures as examples.

Based upon the original DQI for Flemish preschoolers, a dietary index consisting of three subscores (dietary quality, diversity and equilibrium) was calculated to measure adherence to the Flemish FBDG among adults, using data from the semi-quantitative food frequency questionnaire (FFQ). The lower and upper recommended daily food intakes for preschoolers were converted to the recommendations for adults using the food triangle for adults (same concept as the food triangle for children presented in Fig. 21.1 but with different recommended portion sizes) [32]. In this adapted index, the meal index was omitted because it was shown in the validation study among preschoolers that this meal index decreased the variation in the total DQI.

FBDG-Based DQI Adapted for European Adolescents and Assessed by Means of Repeated 24-h Recalls

More recently, the original DQI for Flemish preschoolers has also been adapted for use in European adolescents from the 'Healthy Lifestyle in Europe by Nutrition in Adolescence—Cross-Sectional Study' (HELENA-CSS). HELENA is a population-based multicentre investigation of the nutritional and lifestyle status of adolescents, carried out in ten European cities (Vienna in Austria, Ghent in Belgium, Lille in France, Dortmund in Germany, Athens and Heraklion in Greece, Pécs in Hungary, Rome in Italy, Zaragoza in Spain and Stockholm in Sweden). Data were collected from October 2006 till December 2007 [33]. Dietary intake was assessed by two nonconsecutive 24-h recalls [34], comprising both weekdays and weekend days, though not necessarily including a week and weekend day for each individual. The 24-h recalls were collected by use of a computer-based self-administered tool, the HELENA-Dietary Intake Assessment Tool (HELENA-DIAT). This tool was adapted from a previous version developed and validated for Flemish adolescents [35]. This assessment tool is based on six meal occasions (breakfast, morning snacks, lunch, afternoon snacks, evening meal, evening snacks) referring to the previous day. Trained dieticians assisted the adolescents to complete the 24-h recalls when needed. Adolescents selected autonomously all the consumed foods and beverages from a standardised food list in the HELENA-DIAT [36]. Items not available in the list could be added by the participant. The Flemish FBDGs for adults are also applicable for adolescents and were therefore also used as a basis for the Diet Quality Index for Adolescents (DQI-A).

In the frame of the HELENA study, the added value of the meal index component and a physical activity component were investigated. The DQI-AM (Diet Quality Index for Adolescents with Meal Index) included the four different components (dietary diversity, quality, equilibrium and meal index) that were also included in the FBDG-based DQI for Flemish preschoolers. The DQI-AP (Diet Quality Index for Adolescents with Physical Activity component) included a new component, namely, the physical activity index. Finally, also an index combining all scores was investigated, namely, the DQI-AMP score (Table 21.1).

The International Physical Activity Questionnaire for Adolescents (IPAQ-A) was used to assess the physical activity among the

Table 21.1 Overview of the different Diet Quality Indices and their components, developed and validated in the frame of the HELENA project [37]

DQI type	DQI components							
	Dietary diversity	Dietary quality	Dietary adequacy	Dietary moderation	Dietary equilibrium	Meal index	PA index	Total DQI
DQI-A	X	X	X	X	X			
DQI-AM	X	X	X	X	X	X		
DQI-AP	X	X	X	X	X		X	
DQI-AMP	X	X	X	X	X	X	X	
Theoretical minimum (%)	0	−100	0	0	0	0	0	−20
Theoretical maximum	100	100	100	100	100	100	100	100

adolescents. This questionnaire has first been developed as an instrument for adults and later adapted and validated for the HELENA population [37]. Participants were classified in low, moderate, high and vigorous physical activity categories according to the guidelines for data processing and analyses of IPAQ (http://www.ipaq.ki.se/ipaq.htm). The physical activity level of the adolescents was compared with the recommendation that states that adolescents should spend at least 60 min in moderate to vigorous physical activities per day [38]. Therefore, the total time spent (min) in moderate to vigorous physical activities per day was divided by 60 and multiplied with 100 to obtain a percentage expressing the compliance with the physical activity recommendation. Values higher than 100 were truncated at 100 to obtain a score between 0 % (0 min in moderate or vigorous physical activity) and 100 % (at least 60 min per day in moderate or vigorous physical activity). More details about the technical aspects of this DQI are given in Table 21.2.

Evaluation of FBDG-Based Diet Quality Indices

The DQI for Flemish preschoolers has been evaluated in different ways. First, it was investigated whether this DQI for preschool children was able to measure what it was intended to measure (namely, the quality of the diet) by comparing the DQI scores derived from 3d records with nutrient intake profiles also derived from these 3d records. Second, the validity of FFQ-based DQI scores (FFQ-DQI) for preschool children was assessed by comparing the results of the FFQ-based DQI with a 3d record-based approach [21].

Total DQI scores and its subscores calculated from 3d records were correlated with most nutrients in the expected direction [21]. So were increasing DQI scores for preschool children associated with decreasing consumption of simple carbohydrates and increasing intakes of fibre, water, calcium and most of the micronutrients. Also the dietary diversity and dietary equilibrium scores were positively associated with fibre, water and most of the micronutrient intakes. Although the positive correlation between SFA and DQI scores for preschool children might be unexpected, from previous analyses it could be concluded that the dairy intakes in accordance with the recommendations for preschool children are mainly responsible for these high SFA intakes. Interesting was the fact that the DQI for preschool children was inversely associated with energy intake, assuming that not only large food intakes reassured high diet quality in preschoolers. This latter finding is in contrast with other DQI validation studies where children consuming more food, and thus more total energy, were shown having higher DQI scores since they are more likely to meet the intake recommendations compared with children who eat less [14, 39]. The limited level of misclassification when using tertiles reveals that the FFQ-based DQI is a useful tool for categorising children in groups according to diet quality [21].

Although in a reproducibility study, mean DQI test and retest scores and subscores were not significantly different, important differences

Table 21.2 Description of the FBDG-based Dietary Quality Index (DQI) and its optional index components

Dietary diversity
Expresses the degree of variation in the diet (whether the subject used foods from the different food groups (FG) recommended in the FBDG)
=(# different FG from main FG from which at least one serving was consumed)/total # main FG × 100 %
Dietary quality
Expresses whether the subject made the optimal food quality choices
All food amounts were multiplied with a factor
1 for items of the 'preference' food category
0 for items to be consumed with moderation from the 'intermediate' food category
−1 for items from 'low-nutritious, energy-dense group' (↑ caloric, but ↓ nutrient density)
Then they were summed and divided by the total food amount consumed: $\sum$ (factor food item × food quantity food item)/$\sum$ food quantity food item
Dietary equilibrium
Expresses the equilibrium/balance of food intakes
$=\sum_1^{\#FG}$(dietary adequacy FG—dietary excess FG)/# different FG × 100 % (see rules in adequacy and excess score below)
Dietary adequacy
Expresses the percentage of the minimum recommended food intake actually consumed for all main FG
$=\sum_1^{\#FG}$(actual intake FG/min recommendation FG)/# different FG × 100 %
With the actual intake being truncated to the minimum recommended intake if exceeding the minimum recommended intake
Dietary excess
Expresses the percentage of intake exceeding the upper level of the recommendation[a]
$=\sum_1^{\#FG}$ ((actual intake FG—upper level FG)/upper level FG)/# different FG × 100 %
With the excess of a FG being truncated at 100 % when exceeding 100 % and at 0 when below 0 %
Meal index
Expresses frequency of consumption of a breakfast, lunch and dinner per week
(frequency breakfast/week + frequency lunch/week + frequency dinner/week)/3 × 100 %
Physical activity index (PA index)
Expresses the compliance with the physical activity recommendation (e.g. 60 min in moderate to vigorous physical activity per day)
(total time spent in moderate to vigorous physical activity per day)/60 × 100 %
With the PA index being truncated at 100 % when exceeding 100 %
Total DQI = (dietary diversity score + dietary quality score + dietary equilibrium score + meal index + PA index)/5
Expresses the compliance of the subject with the FBDG (higher compliance gives higher DQI score)
Variations to this total DQI are possible depending on
The information available in the FBDG where the DQI is based upon
The information available in the survey in which the data for calculating the DQI have been collected
Example: $DQI_{\text{without meal and PA index}}$ = (dietary diversity score + dietary quality score + dietary equilibrium score)/3

Main/essential food groups (FG) included in the FBDG are beverages (non-sugared and no milk); bread and cereals; potatoes and grains (no crisps); vegetables (no juices and soups); fruit (no juices); milk products; cheese; meat, game, poultry, fish and meat replacements; and fat and oils

FBDG food based dietary guidelines

[a]For dietary excess, three additional food groups that are not included in the essential food groups are considered: snacks, sugared drinks (soft drinks) and fruit juice

were found between the mean DQI estimated from the FFQ and 3d records (FFQ values were always higher than diet record values for both the total DQI and its components) [21]. These significant differences in mean DQI scores might indicate limited usefulness of the absolute values of the DQI scores. However, the main purpose of our FFQ-based DQI is to rank individuals according to their DQI score. The Pearson correlation coefficient for the total DQI score was high in comparison with other DQI validation studies [12], showing good correlation between respectively the FFQ and 3d record-based approach for this newly developed DQI for preschool children. The weak validity correlation for meal index (which was about half the correlation of the other components) may have been due to limited variation in meal pattern, because most preschoolers met the goal for three meals daily according to both FFQ and diet records. Also the low standard deviations found for the DQI scores and subscores (except for the diet quality subscore) might possibly be explained by low between-individual variation in preschool-aged children's diet [40]. Because of this low variation in meal pattern among preschool-aged children, it would be better to exclude this meal component from the total DQI score calculation when using it in preschool-aged children.

As explained in the previous sections, the DQI for Flemish preschoolers has been adapted for use in adults participating in the Asklepios Study. A study investigating the relationship between diet and subclinical atherosclerosis in the Asklepios Study showed that better adherence to the Flemish FBDG, using the DQI as a surrogate marker, was associated with a better CV risk profile and less inflammation [30].

Also the DQI, combining different components, was investigated in European adolescents in the frame of the HELENA study. In this study the different DQIs have been evaluated in comparison with nutrient intakes and nutritional biomarkers. However, the DQI-A was found to be the best index for use in European adolescents because of its stronger associations with nutrient intakes and nutritional biomarkers and because of its higher ability to discriminate between the high and low compliers with the FBDG [41]. DQI-A scores were associated with food intake in the expected direction: higher intakes of nutrient-dense food items, such as fruits and vegetables, and inverse associations with energy-dense and low-nutritious foods. On the nutrient level, the DQI-A was positively related to the intake of water, fibre and most minerals and vitamins. No association was found between the DQI-A and total fat intake. Furthermore, a positive association was observed with 25(OH) vitamin D, holo-transcobalamin and ω-3 fatty acids serum levels [41]. Therefore, this study has shown good validity of the DQI-A by confirming the expected associations with food and nutrient intakes and some concentration biomarkers in blood.

From these evaluation studies in Flemish preschoolers, Belgian adults and European adolescents, it can be concluded that this convenient DQI which is based upon FBDG only (without considering nutrient intakes) is a useful and valid tool to compare the general compliance with FBDG between population groups and individuals. This DQI has not only been applied in different population groups, but it has also been calculated from different dietary intake assessment methods, including short and long FFQs, 24-h recalls and food diaries indicating the multifunctional use of this DQI.

Methodological Considerations of the FBDG-Based Diet Quality Index

In contrast with many other diet quality indices, the DQI for preschool children was not based on nutrient intakes. Although calculations of nutrient intakes are necessary in order to estimate nutrient inadequacies, one can assume that an individual following the FBDG should have an adequate intake of most nutrients, given the fact that FBDG are supposed to be based on nutrient recommendation. From the evaluation studies described above, it could be concluded that except from a positive correlation found with SFA intakes, the correlations found between the DQI and most other nutrients were in line with the expectations for a DQI that is supposed to reflect an optimal diet quality. An important advantage of a score only based on FBDG and not on nutrients is that no food composition data need to be used, which is also likely to include a certain bias. In addition, this DQI can be calculated from simple dietary intake assessment methods that do not allow/aim at nutrient intake calculations.

It is important to note that the impact of the different subscores on health is unknown. Therefore, the authors did not include weighing factors for the subscores when calculating the total DQI score.

As mentioned before, variation in our diet is one of the most important universally listed dietary guidelines [22]. Although it is recommended to use food items from all eight food groups recommended in the food triangle on a daily basis, it is further recommended to increase the variation of food items within each group of the food guide triangle. It is, for instance, recommended to vary between different fruit types in order to foresee in a broad range of micronutrients of which the nutrient-specific density differs importantly from fruit type to fruit type. Although it would be better to include more food groups in the dietary diversity score, the limited number of food categories in some FFQs forced us to limit the diversity score to the minimum recommended dietary diversity presented by the different food groups recommended in the food triangle. However, when the DQI is calculated from 24-h recalls and dietary records, a more in-depth food categorisation can be applied to increase the variation in the dietary diversity score between individuals.

At last it should be noted that an index that is based on current guidelines may become outdated as nutrition science evolves. DQI, then, is only as good as the components on which it is based; hence, it inevitably must be revised if it is truly to reflect the latest nutrition science and guidelines.

Applications of the FBDG-Based Diet Quality Index

All the DQI indices discussed in this chapter are designed to be used for the examination of diet quality in population groups. Because the scoring criteria are based on population-level adequate intake recommendations, they cannot be used to determine an individual's diet quality. Although the DQI was designed to monitor dietary changes in populations rather than individuals, each index component reflects an aspect of dietary guidance. As such, calculation of DQI scores for an individual could provide an estimate of diet quality relative to national guidelines, and differences in scores over time could suggest improvement or decline in overall diet quality. Therefore, the DQI could also serve as an effective evaluation tool for intervention studies or clinical trials.

An important advantage of this continuous DQI score is the fact that it can easily be used as an indicator for compliance with the FBDG in different types of statistical analyses (e.g. regression analyses and cluster analyses) as outcome, predictor or confounding variable rather than using multiple variables that express the compliance with one specific dietary recommendation (e.g. fruit intake). Furthermore, this DQI was shown to be applicable in different population groups, including children, adolescents and adults, and using different dietary intake assessment methodologies like short FFQs, 24-h recalls or dietary records.

A theoretical example of a FBDG-based DQI has been worked out in Table 21.3. Although this example included all five components described in this chapter (dietary diversity, quality, equilibrium, meal index and physical activity index), the index can also be calculated with less components when whatever component cannot be calculated (e.g. when no physical activity information is available). However, at least the dietary diversity, quality and equilibrium score have been included in all validation studies described in this chapter.

Depending on the FBDG available for the region under study, this FBDG-based DQI can be adapted to reflect the local guidelines. As dietary diversity can be considered as a global guideline that should be part of all FBDG [22], this diversity index will most likely need to be part of all FBDG-based Diet Quality Indices. The theoretical concepts given in Table 21.2 can be used to adapt this FBDG-based DQI to other FBDG and considering the methods used in the study of interest. Although the 24-h dietary recall and the dietary record methods should provide sufficient details to calculate these FBDG-based Diet Quality Indices, when using a FFQ, one should make sure that at least all food groups that are distinguished in the FBDG of interest are also included in the FFQ.

At last it should be underlined that it is mandatory to validate the adapted DQI for use in its population of interest.

Table 21.3 A theoretical example of the Diet Quality Index (DQI) calculations, including all the different components described in this chapter: dietary diversity, dietary quality, dietary equilibrium, meal index and physical activity index

Food based dietary guidelines (FBDG)	Recommendation	Theoretical example	DQI-components							
			Dietary diversity	Dietary quality	Dietary excess	Dietary adequacy	Dietary equilibrium	Meal index	PA index	Total DQI
Main food groups (#=9 FG)								=((5×breakfast/7) +(7×lunch/7) +(7×dinner/7))/ 3×100 %	=((20 min))/ 60×100 %	
Beverages (total)[a]	1,500–2,250 mL	1 bottle water of 0.5 L	1	1×500	0	(500/1500)=0.3	(0.3–0)=0.3			
Bread and cereals	150–360 g	150 g white bread	1	0×150	0	(150/150)=1	(1–0)=1			
Potatoes and grains (no crisps)	210–350 g	210 g potatoes	1	1×210	0	(210/210)=1	(1–0)=1			
Vegetables (no juices and soups)	300–450 g	240 g tomatoes	1	1×240	0	(240/300)=0.8	(0.8–0)=0.8			
Fruit (no juices)	250–375 g	220 g apple	1	1×220	0	(220/250)=0.9	(0.9–0)=0.9			
Milk products[b]	450–600 mL	–	0		0	(0/450)=0	(0–0)=0			
Cheese	20–40 g	–	0		0	(0/20)=0	(0–0)=0			
Meat, game, poultry, fish and meat replacements	75–100 g	75 g lean meat	1	1×75	0	(75/75)=1	(1–0)=1			
Fat and oils	10–15 g	18 g butter	1	−1×18	(18–15)/ 15=0.2	(18/10)= truncated to 1	(1–0.2)=0.8			
Restgroups (#=2 FG included in calculation moderation and equilibrium score)										
Snacks[c]	Restricted (<50 g/day)	1 large candy bar (105 g)		−1×55	(90–50)/ 50=0.8		(0–0.8)=−0.			
Sugared drinks and fruit juice[d]	Restricted (<300 mL/day)	1/2 bottle lemonade (500 mL)		−1×330	(500–300)/ 300=0.7		(0–0.7)=−0.			
			∑=7	∑=842	∑=1.7	∑=6	∑=4.3			
Dietary score of example			∑/#FG	∑/∑quant. foods	(#FG+ ∑)/#FG	∑/#FG	∑/#FG			(78+47+36+9 0+33)/5=57 %
			7/9×100 % =78 %	842/1,798× 100 %=47 %	1.7/12×100 % =14 %	6/9×100 % =67 %	4.3/12×100 % =36 %	90 %	33 %	

(continued)

Table 21.3 (continued)

Food based dietary guidelines (FBDG)	Recommendation	Theoretical example	DQI-components							
			Dietary diversity	Dietary quality	Dietary excess	Dietary adequacy	Dietary equilibrium	Meal index	PA index	Total DQI
Theoretical minimum			0 %	−100 %	0 %	0 %	0 %	0 %	0 %	−20 %
Theoretical maximum			100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %

PA index = physical activity index

[a]All drinks (but no milk products and no drinks from the "low-nutritious, energy-dense group").

[b]Milk, sugared milk drinks, yoghurt, milk deserts, and calcium enriched soy drinks.

[c]Sweet snacks, salty snacks (e.g. chips), chocolate and brioches, sweet deserts (e.g. ice cream, chocolate mousse), upper limit set at 50 g/day

[d]Sugared drinks (e.g. tea with sugar added), soft drinks, and fruit juices, upper limit set at 300 mL/day

Conclusions

The DQI that is based on FBDG only (without considering nutrient intakes) was shown to be a useful tool for assessing compliance with FBDG in different population groups (e.g. children, adolescents and adults) and when using different dietary intake assessment methods (e.g. FFQ, 24-h recalls or dietary records). The rather simple FFQ-based DQI for preschool children showed good reproducibility and validity when compared with 3d diet records. Although FFQ are not as accurate in assessing absolute intakes as are multiple diet records, the reasonable correlations observed indicate that children can be ranked with sufficient accuracy with respect to diet quality. Also the adapted FFQ-based DQI that was used in adults revealed that higher DQI scores were associated with a better CV risk profile and less inflammation, which is in line with our expectations that a diet in accordance with the guidelines should lead to better health outcomes. Furthermore, the evaluation of the DQI-A that was used among European adolescents showed good validity of the DQI-A by confirming the expected associations with food and nutrient intakes and some concentration biomarkers in blood. Although the DQI was designed to monitor dietary changes in populations rather than individuals, it could also serve as an effective evaluation tool for intervention studies or clinical trials. However, it should be noted that the DQI is only as good as the components on which it are based; hence, it inevitably must be revised if it is truly to reflect the latest nutrition science and guidelines.

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Diet Quality Assessed with the "Framingham Nutritional Risk Score"

22

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Key Points

- Diet quality indices and dietary patterns, rather than single foods and nutrients, are the currently preferred dietary exposures.
- The Framingham Nutritional Risk Score predicts weight change, overweight and obesity, abdominal obesity, and metabolic syndrome.
- The Framingham Nutritional Risk Score performs as well as other global indices of diet quality and is stable over long term.
- The performance and stability of the Framingham Nutritional Risk Score supports the utility of diet quality indices in nutritional epidemiology and in guiding nutrition policy.
- Diet quality indices afford opportunities to enhance the nutrient quality of habitual dietary patterns.

Keywords

Diet quality • Dietary pattern • Metabolic syndrome • Obesity • Weight change • Prevention

Abbreviations

CVD	Cardiovascular disease
DASH	Dietary Approaches to Stop Hypertension
FFQ	Food frequency questionnaire
FHS	Framingham Heart Study
FNRS	Framingham Nutritional Risk Score
FNS	Framingham Nutrition Studies
FOS	Framingham Offspring/Spouse Study
ICC	Intra-class correlation
MetS	Metabolic syndrome

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V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health,
DOI 10.1007/978-1-4614-7315-2_22, © Springer Science+Business Media New York 2013

MSDPS	Mediterranean-style dietary pattern score
NCEP ATP III	National Cholesterol Education Program Adult Treatment Panel III
US	United States

Introduction

Research into methods of dietary exposure assessment and the application of these techniques to population-based research has become a prolific area of investigation since the field of nutrition epidemiology emerged as a recognized domain in the 1980s [1, 2]. Prior to that time, the tools available to the assess food and nutrient intakes were much more limited in number, including, in particular, the dietary history, 24-h recall, and multiple-day dietary records; they were also highly labor intensive and had only limited application in population studies [3]. Indeed ongoing surveillance of the food and nutrient behaviors at an individual level in the United States (US) and the international setting were not yet firmly established as central features of public health policy and population health monitoring. In addition, the assessment of dietary quality was largely limited to the comparison of the individual's intake of single nutrients to expert standards such as the US National Academy of Sciences Recommended Dietary Allowances [4].

In the past 2 decades, nutrition epidemiology has expanded tremendously as new tools for assessing the dietary behavior of individuals have been developed and validated, and as advanced statistical techniques have been applied in innovative ways to characterize population dietary patterns and to distinguish alternative methods for evaluating diet quality [1, 5]. The importance of these advances in nutrition epidemiological methods is multifold. They have provided researchers with new techniques for assessing dietary exposures at the individual level such as using age-, ethnicity-, and disease-specific long- and short-form food frequency questionnaires (FFQ) and qualitative dietary behavioral instruments. New ways to approach the collection and interpretation of traditional dietary assessment methods have also been developed. For example, 24-h recalls can now be conducted face-to-face or with telephone or web-based multi-pass interviewing systems, and dietary records can be collected using paper and pencil or automated online systems or with other electronic (telephone- and photo-assisted) technologies. Advances in database content and format have also yielded applications to enable real-time web-based dietary data interpretation and reporting. As well, dietary quality assessment has advanced. Not only have expert standards been updated to evaluate the adequacy of an individual's intake of specific nutrients (including the Institute of Medicine's Dietary Reference Intakes) [4], but researchers have also developed and demonstrated the evidence basis for new approaches of evaluating *overall* diet quality. New composite indices of diet quality (also referred to as a priori patterns) typically incorporate both macro- and micronutrients and, in some cases, foods; these include the Healthy Eating Index, the Mediterranean Diet Score, the Framingham Nutritional Risk Score (FNRS), and the Obesity-Specific Nutritional Risk Score to mention a few [6–10].

The availability of new and relatively cost-efficient techniques of dietary assessment has enabled their widespread applications in population-based research. Their availability and application has also led to the creation of new methods for evaluating habitual dietary patterns of populations and their sex, age, or ethnicity or other subgroups (also termed a posteriori patterns). Thus, there has emerged the concept of a habitual "Western" dietary pattern characterized by low nutrient density and high energy density and the higher consumption of fat meat products, higher-fat dairy foods, refined grains, and sugar-containing beverages and food; a "Prudent"/"[Heart] Healthy" pattern that is lower in total and saturated fat, higher in complex carbohydrates and such foods (including fruits, vegetables, and grains), and more limited in refined carbohydrates; and a "Mediterranean" (or Mediterranean-style) pattern that is low to moderate in total fat, higher in polyunsaturated fats, higher in monounsaturated fats from plant sources (olive and other oils as well as tree nuts), moderate in alcohol (particularly wine), and higher in fruits, (root) vegetables, and whole grains [1, 2, 7, 11]. In addition, distinct non-overlapping habitual dietary patterns of younger and older adult men and women have been identified in certain populations including the USA [8, 9, 11–13].

Each of these methods of characterizing dietary patterns of individuals and populations has been evaluated in terms of diet quality (macro- and micronutrient intakes) and assessed in terms of its relationship to various dimensions of health and disease risk in various populations [1, 14, 15]. In addition, recent randomized clinical trials have also taken this evidence basis and demonstrated that dietary patterns can be constructed based upon their food and nutrient profiles to enhance diet quality (a priori patterns) and to study it in terms of its metabolic and health consequences. For example, the Dietary Approaches to Stop Hypertension (DASH) dietary pattern was designed to be lower in total and saturated fat and sodium, higher in polyunsaturated fat and targeted micronutrients (calcium and magnesium in particular), and higher in fruits, vegetables, and whole grains. When consumed in a controlled setting, the DASH-like dietary pattern was demonstrated effective in lowering blood pressure and improving cardiovascular disease (CVD) risk profiles of adult men and women and to be particularly effective in improved metabolic and health outcomes in those at higher risk of hypertension [16]. In addition, the application of various calorie-restricted dietary patterns to weight loss and obesity risk reduction (including the Mediterranean-style diet, the DASH-like pattern (lower-fat dairy and micronutrient rich), and low-fat National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) diet) has been compared and found to produce similar impact on weight loss and obesity risk reduction [17]. Thus, what appears to be emerging from this combined literature is that a dietary pattern approach is important to consider in both research and practice. Today, there is less emphasis on single foods and nutrients as dietary exposures in favor of diet defined in terms of habitual patterns and diet quality. Researchers urge that these approaches minimize confounding inherent in research that typifies dietary exposures based upon single foods or nutrients.

The following section discusses the Framingham Nutrition Studies (FNS) and their contributions to work on composite epidemiological measures for understanding dietary patterns and overall diet quality. We compare them to other research in the field and conclude with implications and future research.

The Framingham Nutrition Studies

The Framingham Heart Study (FHS) has investigated CVD and other health outcomes among Framingham residents in Massachusetts since 1948 [18]. A second-generation cohort of 5,124 FHS offspring and their spouses was enrolled in 1971 and comprises the Framingham Offspring/Spouse Study (FOS). Members of the FOS cohort participate in standardized clinical assessments approximately every 4 years [19]. The FNS were initiated in order to reintroduce studies of nutritional risk exposures into the FHS investigations. During Examination three of the FOS cohort in 1984–1988, all men and women ($n=3{,}729$; 96 %) who participated in testing ($n=3{,}873$) completed the Framingham FFQ, a single 24-h recall, and a nutrition behavior questionnaire; two-thirds of these participants also completed 3-day dietary records. The FNS have been in the forefront in developing nutritional epidemiological methods including a posteriori dietary patterns and diet quality indices as assessed by the FNRS [8, 9, 11, 12].

Dietary Patterns of the FNS Cohort

Five unique a posteriori dietary patterns of men and women have been defined and validated in the FNS cohort [8, 9, 12, 20]. The distinct sex-specific patterns were derived by cluster analysis, which was applied to the 145-item Framingham FFQ and were based upon similarities in the frequency of the subjects' consumption of the specific food items.

The dietary patterns of FNS women include *Heart Healthier*, *Lighter Eating*, *Wine and Moderate Eating*, *Higher Fat*, and *Empty Calorie*. The *Empty Calorie* pattern (higher in energy, total and saturated fat, sweetened beverages, and desserts and lower in micronutrients) has higher overall nutritional risk compared to the other clusters and is associated with a higher risk for adverse health outcomes including subclinical heart disease as well as overweight and obesity [8, 9, 21, 22].

The dietary patterns of FNS men include *Transition to Heart Healthy*, *Higher Starch*, *Average Male*, *Lower Variety*, and *Empty Calorie*. All dietary patterns are associated with a relatively high nutritional risk although intakes of men in the *Transition to Heart Healthy* pattern are somewhat more favorable [12].

Framingham Nutritional Risk Score

The FNRS is a validated 19-nutrient index for evaluating diet quality [8, 9]. The index was developed specifically to assess CVD, which is a focus of the FHS [18]. The constituent nutrients were, as such, originally selected for their relation to CVD but the majority are also associated with other major chronic diseases, and the FNRS is consistent with *Dietary Guidelines for Americans* recommendations [23].

FNRS nutrients were chosen according to three categories: selected macronutrients (energy, protein, monounsaturated fat, polyunsaturated fat), risk-related nutrients (total fat, saturated fat, alcohol, cholesterol, sodium), and protective nutrients (carbohydrate, dietary fiber, calcium, selenium, vitamin C, vitamin B6, vitamin B12, folate, vitamin E, beta-carotene). Nutrient intake levels as estimated from multiple-day dietary records were ranked from lowest to highest. Ranks were assigned such that a desirable intake level (polyunsaturated fat, carbohydrate, dietary fiber, and micronutrients) received a lower rank, whereas a less desirable intake level (energy, protein, monounsaturated fat, total fat, saturated fat, alcohol, cholesterol, sodium) got a higher rank. Macronutrients and alcohol were expressed as a percentage of total energy, while cholesterol, fiber, and micronutrients were calculated as consumption units per 1,000 cal. The FNRS was computed from the sum of the mean scores of the 19 individual nutrients [8, 9, 12]. In the 1980s, the FNS cohort derived monounsaturated fat mainly from animal sources (e.g., beef fat) rather than vegetable sources (e.g., olive oil); hence, it received a higher rating (Table 22.1).

Table 22.1 Component nutrients of the Framingham Nutritional Risk Score

Nutrient	Units
Selected macronutrients	
Energy	kcal
Protein	% Energy
Monounsaturated fat	% Energy
Polyunsaturated fat	% Energy
Risk-related nutrients	
Total fat	% Energy
Saturated fat	% Energy
Cholesterol	mg/1,000 kcal
Alcohol	% Energy
Sodium	mg/1,000 kcal
Protective nutrients	
Carbohydrate	% Energy
Dietary fiber	g/1,000 kcal
Calcium	mg/1,000 kcal
Selenium	μg/1,000 kcal
Vitamin C	g/1,000 kcal
Vitamin B6	g/1,000 kcal
Vitamin B12	μg/1,000 kcal
Folate	μg/1,000 kcal
Vitamin E	g/1,000 kcal
β-Carotene	μg/1,000 kcal

[a]Overall nutrient risk score based on the consumption of 19 cardiovascular disease-related nutrients, obtained by ranking the nutrient intake levels for each woman or man in the cohort: a lower rank for a desirable intake level (e.g., lower fat or higher micronutrient intake) and a higher rank for a less desirable intake level (e.g., higher fat or lower micronutrient intake). For "risk nutrients," energy, protein, and monounsaturated fat, intakes were ranked from lowest to highest. For "protective nutrients" and polyunsaturated fat, intakes were ranked in the reverse order, from highest to lowest. Monounsaturated fat was not considered protective since it was derived mainly from animal products. The overall mean score was then computed from the sum of the mean scores of the 19 nutrients for each woman and man [8, 9, 12]

Reproducibility and Stability of the FNRS

Diet quality indices can change over time due to variation in individuals' diets or dietary assessment methods [1, 3]. Hence, assessing stability of the indices is vital in order to ascertain their utility in epidemiological studies and ultimately better inform formulation of nutrition policies.

Despite the long usage of diet quality indices [14, 15], published literature on their stability, in particular longer-term stability, is limited. Reproducibility of the Diet Quality Index-Revised was examined in the Health Professionals Follow-up Study. One-year correlations for the index ($r=0.72$) and component nutrients ($r=0.41$ to $r=0.69$) were moderate to strong [24]. Short-term stability (1 year) of the glycemic index was also assessed in the European Prospective Investigation into Cancer and Nutrition study [25] as well as among Swedish men [26] and Japanese adults [27]. Stability coefficients in these three studies were similarly moderate to strong (intra-class correlations [ICCs], 0.40–0.78). However, the FNRS is the only diet quality index that has been evaluated for long-term stability [28]. Over 8 years of follow-up (1984–1988 to 1992–1996), the FNRS and its component nutrients remained relatively stable. Modest changes (≤15 %) that were consistent with those seen in the general US population during the time frame were observed in the intakes of most of the 19 nutrients. The FNRS exhibited stronger stability than its constituent nutrients. In both men and women, the index changed the least (3 %). Notably, stability coefficients of the FNRS (women, ICC = 0.49; men, ICC = 0.46) were higher than those of individual nutrients (ICC ≥ 0.3), except for alcohol, and were comparable to those of the previously discussed glycemic indices [25–27] despite the longer follow-up (Tables 22.2 and 22.3). Additionally, more than half of women and men (58 %) remained in the same or contiguous baseline and follow-up quartile of the FNRS, and few (women, 3 %; men, 4 %) shifted to extreme quartiles [28]. The relatively stronger stability of the FNRS in comparison to its constituent nutrients indicates that the dietary pattern approach may be more suitable for evaluating diet-disease relationships than the conventional single nutrient/food method.

Studies on the Association of the FNRS and Weight-Related Outcomes

Most of the research involving the FNRS in the FOS cohort has focused on weight-related outcomes as determinants of CVD. The FNRS has been related to weight change, overweight and obesity, abdominal obesity, and metabolic syndrome (MetS).

Significant findings have been observed in women only. During a 16-year duration, lower diet quality (higher intakes of dietary lipids and alcohol, and lower consumption of carbohydrate, fiber, and micronutrients), compared to higher diet quality, was associated with greater likelihood of developing overweight and obesity (BMI ≥ 25 kg/m [2]) [29]. Lower diet quality likewise conferred a higher risk for MetS and abdominal obesity in women over a 12-year period [30]. Lower diet quality was also associated with greater weight gain among formerly smoking women [31] (Table 22.4).

The lack of association between diet quality and weight-related outcomes in men may be attributable to the little variation in FNS men's diet [12]. Furthermore, sex differences that relate to obesity, fat distribution, and energy metabolism [32, 33] as well as MetS epidemiology [33–35] have been demonstrated. Our findings thus harmonize with proposals by experts for sex-specific research to enable study of targeted management of women and men in relation to health outcomes [32, 33, 36].

Comparison of the FNRS and Other Diet Quality Indices

The FNRS compares favorably with other diet quality indices that have been derived in the FHS on weight-related outcomes in prospective studies (Table 22.5).

Table 22.2 Raw means, mean changes, Bland-Altman limits of agreement, and ICC for the FNRS and nutrient intakes for Framingham Offspring/Spouse Study women at baseline (1984–1988) and follow-up (1992–1996) ($n=949$)[a]

Framingham Nutritional Risk Score and its nutrient components	Baseline (1984–1988)	Follow-up (1992–1996)	Mean ± SD of difference	Limits of agreement	ICC
	Mean ± SD				
Framingham Nutritional Risk Score	661.5 ± 140.3	678.1 ± 145.3	16.6 ± 143.9*	–271.2, 304.5	0.49**
Energy (kJ)***	6,588.3 ± 1,986.3	6,949.2 ± 2,029.8	360.8 ± 2,031.5**	–884.5, 1,056.9	0.48**
Protein (% energy)	17.4 ± 4.2	17.5 ± 3.9	0.2 ± 4.6	–9.1, 9.4	0.34**
Total fat (% energy)	36.5 ± 6.9	31.6 ± 7.2	–4.9 ± 8.2**	–21.2, 11.5	0.19**
Monounsaturated fat (% energy)	13.2 ± 2.9	11.8 ± 3.0	–1.4 ± 3.5**	–8.4, 5.5	0.23**
Polyunsaturated fat (% energy)	7.7 ± 2.7	6.9 ± 2.4	–0.8 ± 3.2**	–7.3, 5.6	0.18**
Saturated fat (% energy)	12.7 ± 3.2	10.4 ± 3.2	–2.3 ± 3.7**	–9.6, 5.0	0.21**
Carbohydrate (% energy)	44.8 ± 8.4	50.3 ± 8.7	5.5 ± 9.3**	–13.1, 24.0	0.29*
Dietary fiber (g/4.186 kJ)	13.1 ± 5.4	16.0 ± 6.7	2.9 ± 6.4**	–9.8, 15.6	0.38**
Alcohol (% energy) median IQR	0.05 (0, 4.3)	0.02 (0, 3.0)	–0.6 ± 4.0**	–8.6, 7.4	0.62**
Cholesterol (mg/4.186 kJ)	229.4 ± 110.5	202.1 ± 103.6	–27.3 ± 128.0**	–283.3, 228.7	0.27**
Sodium (mg/4.186 kJ)	2,503.6 ± 899.2	2,678.6 ± 997.5	175.0 ± 1,068.3**	–1,961.6, 2,311.7	0.36**
Calcium (mg/4.186 kJ)	628.1 ± 275.7	676.0 ± 310.2	47.9 ± 302.2**	–556.4, 652.2	0.46**
Selenium (μg/4.186 kJ)	98.6 ± 34.2	105.5 ± 33.9	6.9 ± 41.1**	–75.3, 89.2	0.26**
Vitamin C (mg/4.186 kJ)	93.9 ± 59.0	113.4 ± 69.3	19.5 ± 70.1**	–120.7, 159.7	0.38**
Vitamin B6 (mg/4.186 kJ)	1.4 ± 0.6	1.7 ± 0.7	0.3 ± 0.7**	–1.2, 1.8	0.31**
Vitamin B12 (μg/4.186 kJ) median IQR	3.7 (2.6, 5.3)	3.6 (2.4, 5.5)	–0.1 ± 14.5	–29.1, 28.8	0.02
Folate (μg/4.186 kJ)	225.9 ± 114.2	271.5 ± 136.0	45.7 ± 139.4**	–233.1, 324.4	0.34**
Vitamin E (mg/4.186 kJ)	7.9 ± 4.2	8.9 ± 5.1	1.0 ± 5.8**	–10.5, 12.6	0.22**
β-Carotene (μg/4.186 kJ) median IQR	2,108.9 (1,003.9, 4,319.7)	2,859.9 (1,425.4, 5,605.8)	994.7 ± 5 024.8**	–9,054.9, 11,044.4	0.15**

FNRS Framingham Nutritional Risk Score, *ICC* intra-class correlation
[a]Bland-Altman limits of agreement between baseline and follow-up FNRS and nutrient intakes were calculated as mean difference ± 2 SD. Stability of the FNRS and nutrient intakes was evaluated using ICC
[b]To convert kJ to kcal, divide by 4.186 [28]
*$P<0.05$; **$P<0.01$; ***$P<0.0001$

The Obesity-Specific Nutritional Risk Score is an 11-nutrient index that was developed to assess weight-related outcomes. The component nutrients include energy, energy density, carbohydrate, protein, total fat, monounsaturated fat, polyunsaturated fat, saturated fat, fiber, calcium, and alcohol. The index was associated with abdominal obesity during a follow-up of 12 years, and findings are consistent with those of the FNRS; women with lower diet quality had a twofold higher risk of developing abdominal obesity than those with higher diet quality [10].

The Diet Quality Index is based on the 1995 *Dietary Guidelines for Americans* and comprises five nutrients: total fat, saturated fat, cholesterol, sodium, and carbohydrate. Lower diet quality as assessed by the index also predicted greater weight gain among women, similar to the FNRS, over an 8-year duration; however, unlike the FNRS, lower diet quality was associated with greater weight gain in men as well [37].

Incidence of MetS was highest among women and men with lower diet quality as evaluated by the Mediterranean-style dietary pattern score

Table 22.3 Raw means, mean changes, Bland-Altman limits of agreement, and ICC for the FNRS and nutrient intakes for Framingham Offspring/Spouse Study men at baseline (1984–1988) and follow-up (1992–1996) (n=785)[a]

Framingham Nutritional Risk Score and its nutrient components	Baseline (1984–1988) Mean ± SD	Follow-up (1992–1996)	Mean ± SD of difference	Limits of agreement	ICC
Framingham Nutritional Risk Score	578.0 ± 119.3	560.8 ± 119.0	−17.2 ± 122.8*	−262.9, 228.4	0.46*
Energy (kJ)*	9,025.4 ± 2,590.7	9,301.3 ± 2,740.2	275.9 ± 2,849.4**	−1,295.5, 1,427.3	0.43*
Protein (% energy)	16.6 ± 3.5	16.9 ± 3.8	0.3 ± 4.2***	−8.1, 8.8	0.32*
Total fat (% energy)	36.0 ± 7.0	32.7 ± 7.3	−3.3 ± 8.5*	−20.3, 13.8	0.23*
Monounsaturated fat (% energy)	13.5 ± 3.0	12.4 ± 3.1	−1.1 ± 3.8*	−8.7, 6.5	0.20*
Polyunsaturated fat (% energy)	7.2 ± 2.7	6.7 ± 2.2	−0.5 ± 3.2*	−7.0, 5.9	0.13*
Saturated fat (% energy)	12.5 ± 3.2	11.0 ± 3.3	−1.5 ± 3.6*	−8.7, 5.8	0.31*
Carbohydrate (% energy)	43.5 ± 8.9	48.2 ± 8.9	4.7 ± 9.5*	−14.3, 23.7	0.34*
Dietary fiber (g/4.186 kJ)	16.7 ± 6.8	19.3 ± 8.6	2.6 ± 8.1*	−13.7, 18.8	0.41*
Alcohol (% energy) median IQR	2.7 (0, 8.1)	1.4 (0, 5.5)	−1.6 ± 5.9*	−13.4, 10.2	0.50*
Cholesterol (mg/4.186 kJ)	305.2 ± 143.1	282.4 ± 135.4	−22.8 ± 161.9*	−346.6, 301.0	0.32*
Sodium (mg/4.186 kJ)	3,379.4 ± 1,216.8	3,544.7 ± 1,267.5	165.3 ± 1,470.0**	−2,774.7, 3,105.2	0.29*
Calcium (mg/4.186 kJ)	769.3 ± 353.4	829.3 ± 370.5	60.0 ± 384.1*	−708.3, 828.2	0.43*
Selenium (μg/4.186 kJ)	132.3 ± 41.9	138.5 ± 45.7	6.1 ± 53.4**	−100.7, 113.0	0.25*
Vitamin C (mg/4.186 kJ)	108.8 ± 74.6	120.3 ± 78.7	11.5 ± 83.3*	−155.1, 178.0	0.40*
Vitamin B6 (mg/4.186 kJ)	2.0 ± 0.8	2.2 ± 1.0	0.3 ± 1.0*	−1.7, 2.3	0.36*
Vitamin B12 (μg/4.186 kJ) median IQR	5.2 (3.6, 7.8)	4.8 (3.2, 7.2)	−1.6 ± 16.8**	−35.2, 32.0	0.02
Folate (μg/4.186 kJ)	287.3 ± 147.2	329.6 ± 172.8	42.4 ± 176.6*	−310.9, 395.6	0.37*
Vitamin E (mg/4.186 kJ)	10.2 ± 5.9	10.9 ± 6.6	0.7 ± 7.9**	−15.0, 16.5	0.21*
β-Carotene (μg/4.186 kJ) median IQR	2,147.8 (1,178.7, 4,504.4)	2,618.7 (1,264.9, 5,178.0)	485.3 ± 4,666**	−8,846.7, 9,817.3	0.22*

FNRS Framingham Nutritional Risk Score, *ICC* intra-class correlation
[a]Bland-Altman limits of agreement between baseline and follow-up FNRS and nutrient intakes were calculated as mean difference ± 2 SD. Stability of the FNRS and nutrient intakes was evaluated using ICC
[b]To convert kJ to kcal, divide by 4.186 [28]
*P < 0.0001; **P < 0.01; ***P < 0.05

(MSDPS), similar to the FNRS. Whereas the FNRS was associated with abdominal obesity only of the MetS components, mean levels of waist circumference, glucose, and triglycerides were highest and mean HDL-cholesterol level was lowest among adults with a lower MSDPS score [38].

Dietary factors included in the FNRS, the Obesity-Specific Nutritional Risk Score, the Diet Quality Index, and the MSDPS varied as did the dietary recommendations/guidelines considered. Additionally, scoring methods and cutoff points as well as the disease focus differed; these factors may account for some of the differences observed in the findings [1, 15].

Studies that have prospectively examined associations of the Healthy Eating Index and overweight or obesity [39] as well as the relationships between the Mediterranean Dietary Score and weight change [40, 41], overweight and obesity, [40] and MetS [42] in other cohorts have obtained findings consistent with those of the FNRS; higher diet quality is beneficial, while lower diet quality is detrimental.

Table 22.4 Associations between the Framingham Nutritional Risk Score and weight-related outcomes in prospective studies

Reference	Study population	Sample size	Sex (%)	Age (years)	Follow-up (years)	Outcome	Results
Wolongevicz et al. (2010) [29]	FOS cohort	590 women	F: 100	25–69	16	Overweight or obesity	Tertile 3 vs. tertile 1
							OR: 1.8 (95 % CI: 1.2–2.7)
Millen et al. (2006) [30]	FOS cohort	300 women	F: 100	30–69	12	MetS and MetS components	Tertile 3 vs. tertile 1
							OR (95 % CI)
							MetS: 3.0 (1.2–7.6)
							Abdominal obesity: 2.3 (1.2–4.3)
Kimokoti et al. (2010) [31]	FOS cohort	1,515 men and women	F: 54.5	≥30	16	Weight change	*Women*: *former smokers*
			M: 45.5				Weight gain: tertile 3 vs. tertile 1
							8.1 kg vs. 2.9 kg (*P*-trend: 0.06)
							Weight gain: tertiles 2 and 3 vs. 1
							7.5 kg vs. 2.9 kg ($P<0.05$)

FOS Framingham Offspring/Spouse Study, *MetS* metabolic syndrome

Table 22.5 Associations between other diet quality indices of the Framingham Offspring/Spouse Study cohort and weight-related outcomes in prospective studies

Reference	Study population	Sample size	Sex (%)	Age	Follow-up (years)	Outcome	Results
Obesity-Specific Nutritional Risk Score							
Wolongevicz et al. (2010) [10]	FOS cohort	288 women	F: 100	30–69 years	12	Abdominal obesity	Tertile 3 vs. tertile 1
							OR: 2.4 (95 % CI: 1.3–4.4)
Diet Quality Index							
Quatromoni et al. (2006) [37]	FOS cohort	2,245 men and women	F: 56	49–56 years	8	Weight change	β (SE) for a 1-unit increase in DQI score
			M: 44				Men: –0.48 (0.21); $P<0.05$
							Women: –0.60 (0.23); $P<0.05$
Mediterranean-style dietary patterns score							
Rumawas et al. (2009) [38]	FOS cohort[d]	2,730 men and women	M: 45	Median age 54 years	7	MetS and MetS components	Quintile 5 vs. quintile 1
			F: 55				*MetS incidence*
							30.1 % vs. 38.5 % ($P=0.01$)
							Mean MetS traits
							Lower waist circumference, glucose, and triglycerides and higher HDL cholesterol (All *P*-trend <0.05)

FOS Framingham Offspring/Spouse Study, *MetS* metabolic syndrome

Comparison of the FNRS and A Posteriori Dietary Patterns of the FNS Cohort on Weight-Related Outcomes

The relationship between dietary patterns of the FNS cohort and weight-related outcomes has also been examined in several studies. The Empty Calorie pattern (which is comparable to lower diet quality as assessed by the FNRS) was associated with a higher risk for overweight and obesity in comparison to the Heart Healthier pattern (intake similar to higher diet quality) over 12 years of follow-up among FNS women in age-adjusted analysis; however, this relationship was attenuated in the multivariable-adjusted model [22]. In a study that examined the association of dietary patterns and incident MetS over a mean 7-year follow-up, results were suggestive of an inverse association between the Heart Healthier, Lighter Eating, Wine and Moderate Eating, and Higher Fat clusters and MetS compared to the Empty Calorie pattern, but the relationship did not attain statistical significance ($P \geq 0.05$). Women in the Higher Fat (higher consumption of vegetable fats, soft margarine, oils, and refined grains and lower intakes of high-fat dairy and snack foods) and Wine and Moderate Eating (higher wine consumption and lower intakes of sweetened beverages and desserts) patterns, relative to those in the Empty Calorie pattern, were less likely to develop abdominal obesity. BMI, however, somewhat attenuated these findings [43] (Table 22.6).

It is noteworthy that whereas higher diet quality (as assessed by the FNRS) protected against overweight/obesity and MetS [29, 30], the Heart Healthier pattern was not associated with these outcomes over longer term. Therefore, while higher diet quality regardless of habitual dietary pattern is associated with MetS, obesity, and abdominal obesity, it is less clear that the Heart Healthier pattern confers protective benefits unless the nutrient quality of the intake is relatively high. Since empirical patterns reflect habitual eating patterns, they may not be optimal for disease prevention. Our findings also show that no dietary pattern is entirely protective or detrimental and that there can be more than one "healthy" pattern. These findings considered in parallel with those on diet quality indices would suggest that behavioral intervention planning might focus on improving the nutrient profile and overall quality of habitual eating patterns in order to lower disease risk and promote population health.

Conclusions

With the emergence of new methods for assessing composite dietary behaviors and advances in our understanding of the importance of habitual and modified dietary patterns and overall diet quality, fundamental changes have also occurred in nutrition epidemiological research. Most epidemiological investigations now evaluate dietary exposures with consideration of dietary patterns and/or comprehensive diet quality indices. Recent prospective research demonstrates that certain eating patterns (e.g., those that are more "Heart Healthy," "Mediterranean," or higher in lower-fat foods and higher in nutrient-dense foods, including those more DASH-like in nature) are beneficial in lowering risks associated with a wide variety of health and disease outcomes.

The FNRS has been shown to predict weight change, overweight and obesity, abdominal obesity, and MetS. The index performs as well as other global indices of diet quality. This supports the use of diet quality indices in evaluating associations of diet and health outcomes and consequently guiding nutrition programming and policy. Moreover, the FNRS is the only index that has shown long-term stability further validating the utility of diet quality indices nutritional epidemiology.

The FNS have demonstrated that habitual dietary patterns vary in diet quality in women and to a lesser extent in men. All patterns have some level of nutritional risk, and all are characterized by habitual intakes of certain food groups that might be encouraged in order to enhance overall nutrient profile and diet quality. Thus, these data combined with the available epidemiological and

Table 22.6 Associations between dietary patterns of the Framingham Offspring/Spouse Nutrition Study cohort and weight-related outcomes in prospective studies

Reference	Study population	Sample size	Sex (%)	Age (years)	Follow-up (years)	Outcome	Results
Quatromoni et al. (2002) [22]	FOS cohort	737 women	F: 100	≥30	12	Overweight or obesity	Empty Calorie vs. Heart Healthier
							Age adjusted
							RR: 1.6 (95 % CI: 1.0–2.5)
							Multivariable adjusted
							RR: 1.4 (95 % CI: 0.9–2.2)
Kimokoti et al. (2012) [43]	FOS cohort	1,146 women	F: 100	25–77	7	MetS and MetS components	Abdominal obesity
							Higher Fat vs. Empty Calorie
							OR: 0.3 (95 % CI: 0.2–0.8)
							OR: 0.4 (95 % CI: 0.2–1.0) after adjustment for BMI
							Wine and Moderate Eating vs. Empty Calorie
							OR: 0.2 (95 % CI: 0.1–0.7)
							OR: 0.3 (95 % CI: 0.1–1.0) after adjustment for BMI

FOS Framingham Offspring/Spouse Study, *MetS* metabolic syndrome

clinical trial research literature suggest that diet quality indices and dietary patterns offer new opportunities to customize intakes to enhance the overall healthfulness of the individual's habitual eating in order to achieve favorable health outcomes. Individuals might be guided toward personalized, targeted changes in their habitual eating practices to induce specific metabolic changes that promote disease prevention and risk reduction. This approach is markedly different from the "one-size" fits "all" dietary prescription that has been the focus of clinical practice for many years. Such innovation, brought forth in large part by several things, translation to clinical research of advances in dietary assessment, a greater understanding of habitual dietary patterns and their quality, and the emergence of models from randomized clinical trials, offers new opportunities for clinical practice and population public health education. Important breakthroughs have already occurred in approaches to behavioral lifestyle intervention to suggest that translational innovations offer real opportunities for future research and practice.

Future research will help determine the best methods to assess dietary behaviors and model optimal eating practices and what applications from such research evidence offer the greatest promise. The overall goals of such research will be to promote improvement in habitual dietary patterns that optimize diet quality and are most effective in achieving long-term behavior change for health and wellness promotion and disease prevention at the individual and population levels.

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23 The Overall Nutritional Quality Index (ONQI™): Derivation, Validation, and Application

David L. Katz, Lauren Q. Rhee, and Valentine Yanchou Njike

Key Points

- Diet is a cornerstone of health.
- Variation in the quality of diet thus has major implications for variation in the quality of health.
- People choose foods, snacks, and meals—but are only very rarely in a position to choose an entire diet.
- Nutrition profiling systems measure nutritional quality of food products to inform such selection.
- The Overall Nutritional Quality Index (ONQI™) is one such metric and the first to be correlated directly with health outcomes in a large population study.

Keywords

Diet, Nutrition profiling • Nutritional quality • Overall Nutritional Quality Index • Derivation • Validation • Application

Introduction

Dietary pattern has been linked to health for centuries [1, 2]. Clinical trials have demonstrated the powerful influence of dietary pattern on chronic disease risk and mortality [3–8]. A body of research dating back roughly 20 years establishes diets at odds with prevailing recommendations as a leading cause of premature mortality and chronic morbidity [9]. A recent addition to the relevant evidence is the fast-growing literature demonstrating the capacity for dietary pattern, and lifestyle practices in general, to extend their influence from physiology to gene expression [10, 11].

The theme of healthful eating, and variations on that theme, are relatively well established and beneficiaries of more consensus than debate [12]. Translating such patterns into an objective scale that reliably predicts health outcomes is an ongoing challenge, albeit one that the best measures have met.

On a daily basis, individual decision making, with the rare exception of individuals who choose and purchase a comprehensive meal plan, involves foods, snacks, and meals, not diets. Measures of diet quality and expansive

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V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health,
DOI 10.1007/978-1-4614-7315-2_23,

advice about dietary pattern do not inform such decisions.

The time-honored approach to informed food selection is the provision of compositional details on the product package. Ingredient lists and nutrition facts panels have been required on packaged foods in the United States since 1994 [13]. The nutrition facts panel, potentially due for an overhaul in the near future, achieved its current form in 2006 [14].

Research generally suggests, however, that limited use is made of the nutrition information on food products. For one thing, food selections are made in just several seconds on average, and interpretation of ingredients and nutrient details can take longer than that. For another, such back-of-pack details compete with front-of-pack marketing collateral which often expresses something related to nutritional quality. The banner on the front of pack, which may preferentially highlight only one or several nutrient properties, is designed to persuade, and presumably often does so.

Finally, even if consumers were to routinely ignore the marketing material on the front of pack and scrutinize the objective details on the back, they might still be left unable to answer the relevant point-of-purchase decision: which product is better? Not only do nutrition facts fail to answer this question, they can befuddle even highly sophisticated shoppers [15]. Factual information on display is not the same as true knowledge. Knowledge—and the power we contend it connotes—requires actionable information. Nutrition facts often fail to deliver.

It is in response to this challenge—and the development of a modern food supply spanning literally hundreds of thousands of foods, the overwhelming majority of which come in bags, boxes, bottles, jars, and cans—that nutrient profiling systems have proliferated [16]. The extant systems vary widely in the nutrients they include or exclude, the means by which they measure nutrient density, the groups responsible for them, the expanse of the food supply to which they pertain, and the science on which they are based.

The Overall Nutritional Quality Index (ONQI™) is one such system. The ONQI™ algorithm is used in the NuVal® Nutritional Scoring System, which at the time of writing is in roughly 1,650 supermarkets throughout the United States from coast to coast and reaching nearly 30 million consumers. The origins, validation, and applications of the ONQI™ are detailed in this chapter.

Origins and Derivation of the ONQI™

The remote origins of the ONQI™ reaching back 15 years or more reside with the frustrations of a clinician committed to dietary counseling. Clinical experience demonstrated vividly, intimately, and abundantly the capacity of Madison Avenue to manipulate even consumers armed with good advice from a physician about food. Interactions with patients, the public, media audiences, and even family [17] consistently indicated that simple advice about nutrition was insufficient to overcome a cacophony of marketing messages.

The frustration that nurtured the thinking that gave rise to the ONQI™ was temporarily relieved in 2003. At that time the US Food and Drug Administration (FDA) had convened an obesity working group [18] to develop strategies suitable for federal action to control and reverse trends in obesity and related chronic disease. Tommy Thompson, then US Secretary of Health and Human Services, convened small groups from different sectors around a conference table in Washington, DC, for concise ideas to be shared with him and FDA Commissioner, Mark McClellan. The author was privileged to participate in the academic group [19].

The meeting allowed each of approximately 15 participants a single, 3 min turn to convey a single, actionable idea. The development of what would later be called the ONQI™ and then NuVal® was proposed by the author.

Specifically, the challenges related to the identification and selection of nutritious foods were chronicled. The need to express nutritional quality in holistic terms, given a history of dietary boondoggle related to one-nutrient-at-a-time approaches (e.g., low fat, low carb, added oat bran), was also emphasized. The proposal was made that the US Department of Health and Human Services could, and should, commission the Institute of Medicine and/or FDA to engage and support a multidisciplinary panel of leading experts in nutrition and public health to convert the ability to gauge nutritional quality into a guidance system accessible to all. The intention was to place symbols interpretable at a glance by all, such as A–B–C, 1–2–3, or green–yellow–red, in front of every item in the food supply and make every shopper a nutrition expert.

The relief was short-lived, and the frustration resurgent when nearly 2 years passed and no federal action was taken. In late 2005, eager to operationalize this languishing initiative, the author proposed it to the administration of Griffin Hospital, in Derby, Connecticut. Griffin is a Yale University-affiliated, not-for-profit community hospital. It is also the global headquarters for Planetree, an international alliance of health care entities committed to patient-centered care. As such, Griffin has an unusually global vision and an unusually strong commitment to empowering consumers to achieve health. Finally, Griffin is the primary physical home to Yale University's Prevention Research Center [20].

The project was approved by the Griffin Hospital administration in the final quarter of 2005, and the project began in earnest in early 2006. The ONQI™ project was established to address the following objectives: (1) to develop a (the) definitive algorithm to stratify food items within any category, and across food categories, based on overall nutrition quality; (2) to develop a novel metric for the nutritional quality of individual foods based on the relationship among nutrients in foods, the overall quality of the diet, and associations with health outcomes; (3) to place the ability of top nutrition experts to discriminate among food choices on the basis of nutrition into the hands of every consumer; and (4) to provide the public a powerful and empowering means to improve dietary intake patterns, and thereby health, one food choice at a time.

The ONQI™ project was initiated in an explicit effort to satisfy the criteria proposed to the US Secretary of Health in 2003 and to replicate, to the extent possible, the very process that the FDA or IOM "would have" applied. The salient elements in such a process include those specified in Table 23.1.

The ONQI™ project was implemented in satisfaction of these principles. The sequence of methodological steps was approximately:

1. A review of literature pertaining to nutrition guidance and nutrient profiling from both the USA and abroad by staff at the Prevention Research Center (PRC).
2. From a master list of thought leaders in nutrition science and public health, 16 potential members of the ONQI™ Scientific Expert Panel (SEP) were invited and the final composition of 11 consultants represented fields from nutritional biochemistry to chronic disease epidemiology, pediatric endocrinology, to behavior modification. Their identities were kept in confidence to avoid any outside influence. While compensated for their time, the consultants did not have any financial interest in the final product.
3. Beginning in early 2006, a draft of the ONQI™ algorithm and its justifications were circulated to panel members for review and critique. The basic formula is based on the Dietary Reference Intakes (DRIs); Food and Drug Administration (FDA) Nutrition Facts Panel; US Department of Agriculture (USDA) MyPyramid and the Dietary Guidelines for Americans, 2005; and relevant international standards.
4. An iterative process of editing took place based on feedback from panel members via e-mail and at regularly scheduled conference calls, with process oversight and logistical support rendered by the PRC staff.
5. Once an initial, consensus-based version of the ONQI™ formula was in circulation, validation testing was initiated. Consensus approval of the form of the algorithm was deemed commensurate with face validity [21–23].
6. Content validity testing was conducted (see below).
7. The initial working version of the ONQI™ algorithm (ONQI™ 1.0) was finalized in July 2007.

Table 23.1 Criteria for an optimal nutrient profiling system, per the ONQI™ Scientific Advisory Board

Criterion	Explanation
Adaptable	While dietary guidelines are generated for the population at large, they are adjusted for subpopulations with or at risk for an array of health conditions. An optimal nutrient profiling system should similarly be designed so that derivatives for specific subpopulations (e.g., diabetics) may readily be constructed. This requires the inclusion of epidemiologic considerations (i.e., now nutrient properties relate to actual health effects).
Comprehensive	An optimal system of nutrient profiling should incorporate all aspects of nutritional composition that contribute meaningfully to "overall" nutritional quality.
Generalizable	An optimal nutrient profiling system should generate scores for all foods, including branded items, commodity items, recipes, and meals; should allow for comparison on a single, universal scale both within and across food categories; and should offer sufficiently fine discrimination to provide meaningful guidance among the choices in any food category.
Impartial	A nutrient profiling system should be free of conflicts of interest, developed and maintained by entities uninvolved in the manufacture or sale of specific food products.
Simple	Nutrient profiling should be clear, unambiguous, and interpretable at a glance by virtually any consumer.
Sophisticated	The modern food supply is not simple, containing natural and highly processed foods, foods with intrinsic nutrients and foods fortified with nutrients, macronutrient food substitutes, etc. A nutrient profiling system suitable to apply a common metric to the whole food supply must address these complexities.
Summative	A useful nutrient profiling system should generate a single, aggregated measure of the various inputs so that a summary measure of overall nutritional quality is produced.
Timely	A useful nutrient profiling system must be updated, in an impartial manner, at suitable intervals to keep it current with regard to changes in nutrition science, the food supply, and/or the prevailing epidemiology.
Transparent	The methods, measures, and assumptions on which a nutrient profiling system is based should be sufficiently transparent to the scientific community and consumers alike that a clear understanding of how the algorithm works is attained.

Content and Composition of the ONQI™

Consumer research suggests that the average shopper spends roughly 2 s to scan each product label [19]. A clear, simple nutrition scoring system that consumers can understand at a glance to determine which foods in any given category are the more nutritious choices overall is urgently needed and of enormous potential value to the public health.

The ONQI™ is predicated on a novel, patent-pending concept called the "trajectory score." The ONQI™ defines the nutritional quality of foods based on the influence they have on overall dietary goals and thus avoids entirely any "good food/bad food" controversy. The ONQI™ indicates the relative contributions foods in any given product category make to the quality of the overall diet.

Nutrient Input

The development of the algorithm began with the selection of nutrients (see Table 23.2), based on existing literature evidence supporting their public health implications. In each case, nutrient selection addressed whether the nutrient was generally regarded as making a favorable or unfavorable contribution to health given prevailing dietary and health patterns.

The ONQI™ algorithm is constructed to generate numerical scores representing overall nutritional quality on a scale of relative values, with higher numerical scores representing better overall nutrition. Therefore, nutrients with generally favorable effects on health are placed in the numerator, where higher values increase the ONQI™ score, and nutrients with generally unfavorable effects are placed in the denominator, where higher values decrease the ONQI™ score.

Table 23.2 Nutrient measures selected for inclusion in the ONQI™ algorithm

Numerator nutrients	Denominator nutrients	Universal adjustors
Fiber	Saturated fat	Fat quality
Folate	Trans fat	Protein quality
Vitamin A	Sodium[b]	Energy density
Vitamin C	Sugar (total and added)[b]	Glycemic load[c]
Vitamin D	Cholesterol	
Vitamin E		
Vitamin B_{12}		
Vitamin B_6		
Potassium		
Calcium		
Zinc		
Omega-3 fatty acids		
Total bioflavanoids		
Total carotenoids		
Magnesium		
Iron		
Chromium[a]		
Selenium[a]		

[a]Excluded from the algorithm
[b]Excluded for fruits, vegetables, beans, and legumes
[c]Applied only to grain-containing foods and foods with added sugars

Chromium was excluded because food sources cannot be reliably analyzed due to contamination problems that arise during processing [24], and chromium values are not available in the USDA [25]. Selenium was excluded because the majority of the population is consuming the RDA [26], and the evidence for a direct link to outcomes of public health significance was deemed inadequate at present.

Criteria for Selected Nutrients

Inclusion:

- Establishment of public health importance and relevance to health;
- General consumption below or above recommended levels so that adjusting intake level is a current public health topic of interest;
- A meaningful association with one or more specific health outcomes;
- An interpretable body of relevant scientific literature;
- Availability in standard nutrient databases.

Exclusion:

- Failure to meet all inclusion criteria.

The concentration of any given nutrient in any given food makes a contribution to the trajectory of the diet over the course of that day toward, or away from, a recommended intake level. That is what the trajectory score measures: how the relative concentration of any given nutrient in a food contributes to the trajectory toward or away from a minimum (numerator) or maximum (denominator) recommended intake level over the course of a given day.

The formula for a trajectory score is simply the ratio of the concentration of a given nutrient in a food to the recommended concentration of that nutrient in a healthful diet. Mathematically, that formula is:

$$\frac{\text{Nutrient quantity per serving of food} \,/\, \text{Total calories per serving of food}}{\text{Nutrient quantity recommended over the course of a typical day} \,/\, \text{Total calories representing intake for a typical day}}$$

Threshold Values

The calculation of a trajectory score begins by establishing the recommended concentration of a given nutrient in the overall diet. These **threshold values** are based on the DRIs developed by the Food and Nutrition Board of the Institute of Medicine and the Dietary Guidelines for Americans, 2005.

A trajectory score of 2 for sodium indicates that the food is twice as concentrated in sodium as is recommended for the overall diet. The higher the trajectory score for sodium, or any denominator nutrient, the greater the unfavorable influence on intake trajectory for the nutrient in question and the greater the impact this nutrient will have on lowering the final ONQI™ score for that food. Of course, a food with high sodium content may still have a good ONQI™ score if other nutrient characteristics are compensatory.

Sodium is an essential nutrient and to penalize sodium intake from the first milligram is therefore illogical; some sodium intake is essential, even if too much is clearly bad. Trajectory scores are thus adjusted in specific cases on the basis of ordinal rather than dichotomous threshold values. In the specific case of sodium, when a food is ¼ or less as concentrated in sodium as is recommended for the overall diet, the sodium trajectory score for that food is assigned a null value. Foods that are rather dilute sources of sodium receive no penalty for their modest sodium content.

Weighting Coefficients

The contributions of a nutrient to the "nutritiousness" of a food can be expressed in terms of influences on either vitality or the likelihood of a particular health outcome or both. Therefore, to better characterize the relative importance of each nutrient in the ONQI™, its salient contributions to "health" are reflected in weighting coefficients. Each trajectory score is weighted for three characteristics, one of which pertains only to a health condition and two of which to the association between a nutrient in question and one or more health conditions of interest:

- A weighting coefficient for prevalence adjusts the trajectory score for the percentage of the population with a given health condition of interest in which the given nutrient is thought to be a factor (i.e., the percentage of the population consuming an excess of denominator nutrients or a shortfall of numerator nutrients).
- A weighting coefficient for severity adjusts a trajectory score for the severity of the condition(s) with which a given nutrient is most notably associated.
- A final weighting coefficient adjusts the trajectory score for the relative impact of a given nutrient (i.e., the strength of association) on one or more conditions of public health significance with which it is customarily associated.

The prevalence measures were obtained from the National Health and Nutrition Examination Surveys [27]. The severity and relative impact determinations were made based on evidence from the epidemiologic literature and the consensus-based interpretation of that evidence by the expert panel.

The actual values assigned for each weighting coefficient were determined empirically based on repeated runs of the ONQI™ formula, with examination for appropriate influences when each scale was varied independently of the others. The weighting coefficients are designed to convey synergy between frequency, severity, and relative impact (i.e., $W_P \times W_S \times W_R \times \log\ (1+\text{TS}$ of the nutrient)).

Universal Adjustors

Whereas micronutrient fortification can narrow the gap in nutritional quality between processed and naturally nutrient-rich foods when only micronutrients are considered, such alterations cannot address the macronutrient compositions that similarly distinguish between such foods. To change the macronutrient properties of a processed food requires a significant reformulation.

In addition to the numerator and denominator nutrients, universal adjustors were therefore devised to adjust the nutrition score of a food based on the distribution and "quality" of its macronutrients. These include measures of the **biological quality of protein** (UAp); the **quality/healthfulness of fat** (UAfat); the **glycemic load** (GL), an indicator of carbohydrate "quality" (from the perspective of health implications); and the **energy density** (ED).

The UA coefficients were incorporated to improve the performance of the ONQI™ in stratifying foods on overall nutritional quality and to protect against excessive inflation of ONQI™ scores via additions of micronutrients to processed foods. The UAs would be far more difficult to adjust through fortification than individual trajectory scores and thus serve to protect the ability of the ONQI™ to distinguish between naturally nutritious foods and nutrient-fortified foods of lesser intrinsic nutritional quality.

There are category-specific adjustments to the ONQI™ algorithm to ensure its fidelity both within and across food categories. One example is that numerator nutrients are NOT capped for pure foods but are capped for all processed foods. This prevents artificial inflation of ONQI™ values by micronutrient fortification. Also in unprocessed fruits and vegetables, intrinsic sodium and sugar content are not counted in the ONQI™ denominator. There are other examples precluded here by space constraints.

Dilution Effects

While a food with a low concentration of a given nutrient certainly contributes something toward the recommended daily intake, it does not necessarily have a favorable impact on the trajectory toward that recommended intake. To account for this distinction, the ONQI™ differentiates the contribution between foods that are MORE concentrated in a nutrient than is recommended as the lower limit for the diet overall and foods that, while containing a given nutrient, do so at a concentration lower than is recommended for the diet overall.

The TS is reduced to zero when the TS is ≤0.5. In other words, when a food is less than half as concentrated in a numerator nutrient as is recommended for the diet overall, it is deemed not to be making a favorable impact on the daily intake trajectory for that nutrient; it is neither rewarded nor penalized. The TS is divided by 2 when the TS is >0.5 and <1. In other words, when a food is more than half as concentrated, but less than fully as concentrated, in a nutrient as is recommended for the diet overall, it is deemed to be making a positive, but weakly so, impact on the daily intake trajectory for that nutrient. Therefore, the reward for this contribution is reduced. For all numerator nutrients, the TS is unmodified in this manner whenever it is ≥1, indicating the food is at least as concentrated in the nutrient in question as is recommended for the diet overall.

In the denominator, cholesterol, sodium, and sugar are corrected for dilution effects. The reasoning is similar to the above.

When the TS for cholesterol is ≤0.5, the TS is assigned a null value. In other words, foods with a sodium concentrated less than half that deemed an acceptable upper limit for the diet overall are not penalized for their cholesterol content. When the TS for sodium is ≤0.25, the TS for sodium is assigned a null value. Such foods are dilute sources of sodium, contribute toward the obligatory daily intake of sodium, and are deemed not to have an unfavorable impact on the daily intake trajectory for sodium. The sugar content of foods is similarly exonerated when at ¼ or less the dilution deemed an acceptable upper limit for the diet overall, on the basis of the reason elaborated above.

Handling of Sugar Substitutes/ Artificial Sweeteners

The ONQI™ score is predicated on trajectory scores, which in turn are derived as the ratio of nutrient to calories. Noncaloric sweeteners eliminate (or reduce) calories and thus inflate the ratio of nutrient to calories. A given amount of calcium, for example, in a diet soda will generate a much higher TS than the same amount of calcium in a regular soda, simply because the former is divided by a much smaller number of calories. The discrepancy this created in the ONQI™ scores for diet vs. regular soda was exaggerated relative to the consensus opinion of the panel. The consensus view was that the "diet" or artificially sweetened products deserved to score better than the higher-calorie, sugar-containing counterparts—but only by virtue of the removal of sugar and reduction in calories, not because of their nutrient content.

To narrow this gap between sugar- and nonsugar-sweetened products, a correction factor was established for products sweetened with noncaloric sugar substitutes. This correction factor (*R*) was determined based on obtaining the average ratio of calories in the regular (sugar-sweetened) version of a product to the calories in the corresponding sugar-substituted product counterpart. In each relevant food category, a variety of products were reviewed, and every effort was made to identify product pairs of perfect correspondence; the best match available was used in each instance.

That factor is applied as multiplier to the calories in the sugar-substituted product BEFORE each trajectory score is calculated. The effect of this adjustment is as follows: the reward (numerator) or penalty (denominator) a sugar-substituted food gets in the form of a trajectory score for any given nutrient is WHAT IT WOULD BE IF THE PRODUCT CONTAINED THE SAME CALORIES AS ITS SUGAR-SWEETENED COUNTERPART.

In this manner, products sweetened noncalorically still benefit from reductions in sugar content, glycemic load, and energy density and thus tend to result in higher final ONQI™ scores than their sugar-sweetened counterparts. But these products do NOT receive inflated credit for their nutrient content.

Validation of the ONQI™

Validity testing of the ONQI™ began with assessment of face and content validity by the SEP [28] members. They reviewed and rank-ordered food lists of varying length, e.g., 20–100, and variety on the basis of overall nutritional quality across and within food categories. A mean ranking for the ONQI™ panel was established. The ONQI™ algorithm was then used to rank order the same foods, and correlation analysis was performed. This process was terminated with a food list of roughly 100–120 items and with a correlation coefficient (i.e., $R=0.88$; $R=0.92$) between ONQI™ and expert panel rankings. At that point, the process was reversed where the ONQI™ was used to rank order over 1,000 foods, and the relevant rank-ordered lists were circulated to the SEP for review. Any apparent anomalies identified in the food rankings resulted in scrutiny of the nutrient data entered, and a determination either to acknowledge that the ONQI™ ranking was correct or to adjust the algorithm until no further adjustments were deemed necessary. The final version 1 ONQI™ algorithm correlated highly with the pooled SEP ranking of an initial test list of 21 diverse foods (Spearman rank correlation coefficient 0.92, $p<0.001$). Correlation coefficients for a range of food categories are shown in Table 23.3. Food categories that have been substantially redefined since initial correlation testing was done are excluded from the table.

The next step in construct validity testing was the calculation of a mean ONQI™ score for 7 days of the DASH diet meal plan with comparison to the “typical American diet” using data from NHANES 2003–2006 [27]. Aggregated ONQI™ scores were calculated for the day 1 dietary intake reported in the NHANES 2003–2006 cohort age 4 and older ($n=15{,}900$) and correlated against the Healthy Eating Index 2005 [29]. The aggregate ONQI™ score for 7 days of the DASH meal plan [30] at the 2,300 mg of sodium level was 46 (95 % CI: 40–53). The mean, aggregate score for diets in the NHANES 2003–2006 cohort, representing the “typical American diet,” was 26.5 (95 % CI: 26.2–26.7), thus demonstrating a higher aggregate ONQI™ score for the more nutritious diet ($p<0.05$). The association between raw ONQI™ scores and the adjusted NuVal® scores with quartiles of the Healthy Eating Index 2005 was both highly significant ($p<0.01$).

Table 23.3 ONQI™ 1–100 ranking vs. SEP ranking

Food category	Rho	p-Value
Beverages ($n=12$)	0.24	0.44
Bread and crackers ($n=10$)	0.66	0.04
Cereals and granola bars ($n=10$)	0.89	<0.001
Dairy products ($n=9$)	0.92	<0.001
Dessert ($n=10$)	0.38	0.28
Fat/oil ($n=10$)	0.71	0.02
Fruits ($n=10$)	0.33	0.36
Meat/protein ($n=10$)	0.93	<0.001
Nuts and seeds ($n=6$)	0.12	0.83
Snack foods ($n=9$)	0.93	<0.001
Spreads and condiments ($n=10$)	0.95	<0.001
Vegetables ($n=10$)	0.70	0.02

Concomitantly, consumer testing was conducted to understand consumer response to the concept and to determine how best to communicate the concept. Focus groups and two quantitative studies were conducted, involving about 900 participants. Initially, 3 consumer qualitative focus groups were conducted in October 2007 at a marketing research facility in Chicago, Illinois, and led by a professional moderator. The subjects were female head of households who were interested in making improved food choices. One group included women aged 60–69 with no children at home, and two groups included women aged 35–55 with and without children at home. Each group session lasted approximately 2 h and included 8–10 participants per group. The focus groups followed typical qualitative marketing research protocols by starting with very broad food and shopping behaviors and then narrowed down to specific ONQI™ concepts. The findings were consistent with the majority of respondents reacting favorably to the ONQI™ concept. Participants indicated preference to shop at a grocery store with the rating system and to use the 1–100 scale with the provision of some nutrition education to explain the score.

The next phase included consumer quantitative studies, conducted in November 2007 and March 2008 by the research firm, Affinnova. They were secure Internet-based studies where primary US grocery shoppers who expressed an interest in making better food choices were recruited online. The first study had 454 female respondents, aged 35–64, while the second study had 350 female and male respondents, aged 18–64. Key findings included consumers overwhelmingly confirming the value of a nutritional scoring system where measured scores were extremely strong for interest in the system, appeal, believability, and uniqueness. There was also a direct comparison of the ONQI™ system using a 1–100 scale to a system currently in use by a retailer in the USA that reports nutritional quality using symbols on an ordinal scale with products meeting criteria receiving 3, 2, or 1 star and products not meeting criteria receiving none. A definitive or probable preference for the ONQI™ system was reported by a large majority (75 %) of the respondents. Test respondents were blinded to the test source [31].

The basic form of the final ONQI™ formula is seen in Fig. 23.1. Resultant food and beverage raw scores range from less than 1 to over 8,000 but are converted to a 1–100 scale for consumer use. Conversion to the 1–100 scale compresses the range of raw scores to simplify presentation to consumers, while preserving the exact rank order of all foods. Sample scores can be found at www.nuval.com.

The ONQI™ was tested for correlation with health outcomes in a retrospective cohort study by Chiuve et al. [32] at the Harvard School of Public Health. This group of independent investigators was provided the ONQI™ algorithm under terms of a nondisclosure agreement and received consultative assistance from the Yale-Griffin Prevention Research Center.

The retrospective cohort study followed healthy women from the Nurses' Health Study and healthy men from Health Professionals Follow-Up Study during the period of 1986–2006. Dietary data were collected from baseline food frequency questionnaires, and the ONQI™ algorithm was used to score each food. The average ONQI™ score per participant's diet was then determined to assess association with total chronic disease, defined as cardiovascular disease (CVD), cancer, diabetes, and non-trauma death. The ONQI™ score was inversely associated with risk of total chronic disease, CVD, diabetes, and all-cause mortality (p-trend ≤ 0.01), but not cancer, in both cohorts. Women in the highest compared to lowest quintile of the ONQI™ score had a relative risk (95 % CI) of 0.91 (0.87, 0.95) for chronic disease, 0.79 (0.71, 0.88) for CVD, 0.86 (0.78, 0.96) for diabetes, and 0.90 (0.84, 0.97) for all-cause mortality. Men in the highest compared to lowest quintile of the ONQI™ score had a relative risk of 0.88 (0.83, 0.93) for chronic disease, 0.77 (0.70, 0.85) for CVD, 0.84 (0.73, 0.96) for diabetes, and 0.89 (0.83, 0.97) for all-cause mortality.

Point-of-purchase sales data from NuVal® retailers will further validate the ONQI™. In July 2010, NuVal® LLC submitted commentary in response to FDA's request for information related to point-of-purchase systems [33]. Preliminary 2008–2009 sales results from 2 NuVal® retailers and non-NuVal® area retailers were presented for 3 food categories: cold cereal, fresh bread and

$$\frac{(1+UA_{fat})\times(1+UA_{protein})\times(1+W_{P1}\times W_{S1}\times W_{R1}\times\log(1+TS_1)+ \text{--------------} +W_{P16}\times W_{S16}\times W_{R16}\times\log(1+TS_{16}))}{GL\times ED\times(1+W_{P1}\times W_{S1}\times W_{R1}\times\log(1+TS_1)+ \text{----} +W_{P5}\times W_{S5}\times W_{R5}\times\log(1+TS_5))}$$

Fig. 23.1 Basic construct of the ONQI™ algorithm rolls, and yogurt. Products with NuVal® scores of 50 or greater outperformed products with NuVal® scores from 1 to 49 in sales volume. Specifically, for the cereal category, the percent sales volume changes in products with scores ≥50 were the following: 5 % in NuVal® retailer A vs. −13 % in non-NuVal retailers and −1.63 % in NuVal® retailer B vs. −5.52 % in non-NuVal retailers. For the bread category, the percent sales volume changes were the following: 20 % in NuVal® retailer A vs. 13.8 % in non-NuVal retailers and 11.5 % in NuVal® retailer B vs. −5.5 % in non-NuVal retailers. For the yogurt category, the percent sales volume changes were the following: 29.2 % in NuVal® retailer A vs. 6.8 % in non-NuVal retailers and 18.8 % in NuVal® retailer B vs. 8.7 % in non-NuVal® retailers. These results suggest a positive influence of the NuVal® system on the shoppers' purchasing behavior.

There have been national, as well as international, collaborative project requests from public health researchers for the use of ONQI™ scores and/or the NuVal® system. Topics include the study of purchasing behavior in select populations via brick-and-mortar or online grocery stores, the application of scores to food frequency questionnaire or diet recall data, the evaluation of food categories in relation to consumer welfare and retail competition. An area of considerable interest is the combined effect of NuVal® nutrition guidance and financial incentives on food selection, diet quality, and health outcomes. As of December 2011, one NIH grant application to test the combination has been competitively scored, with a funding decision pending. Pilot testing of the combination is planned, and related grant applications by several groups of investigators are under development. The approach has potentially far-reaching policy implications [34].

The ONQI™ Nutrient Database

ONQI™ nutrient values for foods are calculated using software and databases developed by the Nutrition Coordinating Center (NCC) at the University of Minnesota. Nutrition facts panel and ingredient list data are obtained from retail partners and manufacturers or from direct scanning of product packages. A team of research dietitians at the Griffin Imputation Center in Massachusetts oversee the generation of the ONQI™ nutrient database. Details of the ONQI™ data generation sources have been shared with the US FDA and USDA to ensure they fully conform to standards used in generating federally approved nutrition facts panels. The sources of data used to populate the ONQI™ are in compliance with the FDA's food packaging regulations as outlined in code CFR21 [35]. A schematic of the score generation process is shown in Fig. 23.2.

Applications of the ONQI™

When the ONQI™ algorithm was completed, it was presented to scientists at the US FDA with the hope and intent that the system might be adopted by the federal authorities. When it became clear that bureaucratic impediments were likely to preclude any brisk action by the government, Griffin Hospital decided to pursue an academic/business partnership model that would facilitate getting the ONQI™ into the hands of the shopping public. In partnership with Topco Associates LLC [36], NuVal® LLC was established in 2008 as the sole entity with the rights to license the NuVal® system, based on the ONQI™ algorithm.

NuVal® LLC determined, based on consumer testing, that NuVal® scores were to be offered on a scale from 1 to 100. The ONQI™ algorithm generates raw scores spanning some eight orders of magnitude; these were converted to a 1–100 scale that preserved the rank order.

The principal application of NuVal® is as a shelf-tag system in retail supermarkets. Scores appear with standard iconography on the shelf tag where price is posted [37]. The system is designed to provide a score for virtually every item in the supermarket where over 30 retailers have adopted the system. Also at the time of writing, NuVal® LLC has scored over 100,000 food items matched to product UPC. To the best knowledge of the authors, the NuVal® database is—by a considerable margin—the largest, most detailed, and most current nutrient database in the world.

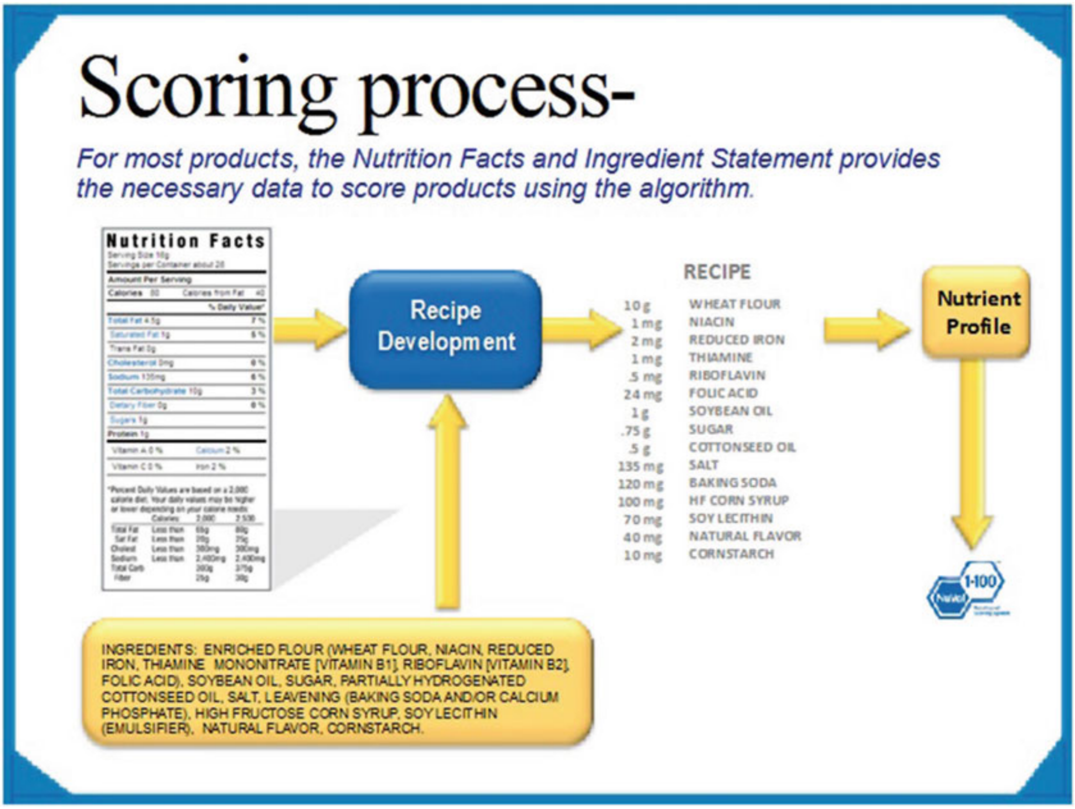

Fig. 23.2 A schematic overview of ONQI™ score generation

In addition to retail application, NuVal® is being implanted in public schools and hospitals where food products in vending machines and cafeteria are scored and displayed individually or in a list format. NuVal® education is then disseminated through brochures, handouts, posters, online videos, and/or local NuVal® retailer involvement. Also, an online health management service provides the NuVal® score database to their members as a nutritional tool for guiding and improving food choices. Further impacting the public and health professional community, NuVal® has a partnership with the American Council on Exercise, the largest nonprofit fitness certification, education, and training organization in the world, to promote a healthier lifestyle to their clientele. The American College of Preventive Medicine, a national professional society for preventive medicine physicians, has officially and independently endorsed the use of the NuVal® system as an evidence-based nutrition guidance system for consumers. Lastly, NuVal® is actively communicating with the public community via social media such as Facebook, Twitter, YouTube, and their own official blogs.

A derivative of the original ONQI™ algorithm for scoring total diet has been developed and undergone initial testing. The method incorporates the ONQI™ to score the quality of individual foods, but then generates a weighted mean score for the total diet, factoring in macronutrient ranges, food variety, the correspondence of servings to recommendations in the Dietary Guidelines for Americans, and total calories. The system, for which patents are pending at this time, has potential application in chronic disease management programs, weight management programs, nutrition research, and Web-based interactive dietary monitoring.

Next Steps and Future Applications

Currently, an informative Web site describing the NuVal® system is available at www.nuval.com. Future Web site enhancements could include a searchable product category database, the ability to perform recipe makeovers using higher scoring foods and customization of a user's dietary profile to include condition-specific guidance. Also, total diet scoring (ONQItds) could be available concurrently with food product scores to enhance the application of ONQI™ while also accompanied by a smart phone application. Given the recent interest from school districts, their food service departments or vendors could partner with NuVal® in the yearly bid selection, scoring, and/or reformulation of their products so that students are exposed to healthier offerings.

Conclusions

Table 23.1 shows a proposed set of criteria by which to judge a nutrition profiling system. The ONQI™ was designed to satisfy these criteria. Objections to a relative lack of transparency have been raised, however. At this time, the ONQI algorithm remains subject to the patent provision process and does incorporate trade secrets. However, the full nutrient contents, if not the mathematical details, of the ONQI™ are in the public domain. The full algorithm has been shared with research scientists and government officials around the world and is generally available for review by any independent party provided NDA protection is in place. All of the fundamentals of the algorithm—its contents and basic approaches—have been openly shared [38].

While a number of nutrition profiling systems are in use to varying degrees and in varying ways around the world [39–42], few satisfy the listed criteria as fully as the ONQI™. There is, in particular, a tendency for entities involved in selling food to generate such systems, a standard which would appear to be impermissible in almost any other industry [43].

In addition, the ONQI™ is the only system with published data demonstrating a direct correlation between score variation and variation in health outcomes—including all-cause mortality. Preliminary data analysis at this time (December 2011) suggests an important influence on point-of-purchase decisions as well, although definitive analysis of such data is ongoing at the time of writing.

There is at present no evidence-based means of determining the best way to express nutrition guidance. Extant systems range from symbols [44–47], to color coding [48], to emphasis on one or more particular product attributes [49–51]. The only way to prove that a given approach is superior is prospective studies that directly compare the systems with regard to consumer influence, change in food choice, change in diet quality, change in health outcomes, ease of use, and perhaps other metrics of interest. At this time, no such studies have been conducted, and they may prove elusive on the basis of logistics. Online simulations of the food shopping experience may offer opportunity in this area.

Relevant in this regard is the fact that a system expressing guidance with a continuous range of scores can be adapted to convey scores in any given ordinal scale as well. Attributes may be highlighted in conjunction with such a system as well. An ordinal scale, however, cannot be converted into a continuous scale and lacks its capacity for fine discrimination. The mathematical properties of a continuous scale are also conductive to a wide array of applications, such as creating a weighted, aggregate score to address recipes, meals, or total diet.

There are two ways to close the gap between how we eat at present and how we should eat for optimal health. One involves a fundamental shift in the pattern of the diet, as reflected in such advice as "eat more fruits and vegetables." The other is one food choice at a time. The range in nutritional quality for every food category represented on supermarket shelves is vast. Choosing the most nutritious offerings in each category offers a powerful means to reduce intake of calories, sodium, added sugar, and harmful fats, while increasing intake of fiber, beneficial nutrients, vitamins, and minerals.

But between the average consumer and those choices is a roiling sea of competing claims, half-truths, marketing hype, and hopeless confusion. Upon those troubled waters, the ONQI™ offers a lighthouse beam, illuminating better choices at glance. The ultimate traction, and public health influence, of the ONQI™ remains to be determined. It seems clear, however, that nutrition profiling is here to stay. May the best system, objectively determined, prevail.

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Mediterranean Diet Quality Index and Albuminuria Levels and Relationship Between Other Physiological Variables

24

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Key Points

- Several observational studies have provided scientific evidence that diets rich in fruit, vegetables, legumes, whole grains, fish, and low-fat dairy products are associated with lower incidence of various chronic diseases, as atherosclerosis, cardiovascular diseases, and cancer.
- In particular Mediterranean diet pattern according to numerous studies has been associated with lower prevalence of ischemic heart disease and lower overall mortality and morbidity.
- The mechanisms through which the Mediterranean diet exerts its beneficial effects on the cardiovascular system are diverse, and a number of plausible explanations have been provided, including management of arterial blood pressure levels, body weight, blood lipid profile, inflammation and coagulation process, and endothelial function.
- Microalbuminuria is an established marker of endothelial dysfunction and cardiovascular disease. Elevated levels of albuminuria serve as independent predictor of cardiovascular events, while in children and adolescents albuminuria is associated with obesity and hypertension. Adherence to Mediterranean diet pattern seems to be associated with the levels of microalbuminuria in children and adolescents but also in the adult population.
- A major nutritional concern in Mediterranean countries is the loss of the Mediterranean diet. Epidemiological evidence suggests that dietary patterns in Mediterranean countries are changing rapidly, with increased consumption of animal products and saturated fat to the detriment of vegetable foodstuffs. This is mainly attributed to the substantial socio-economic changes throughout all of Europe over the past 40 years.

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V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health,
DOI 10.1007/978-1-4614-7315-2_24, © Springer Science+Business Media New York 2013

The alterations in nutritional habits observed in the Mediterranean countries might be accompanied by the loss of the protective effects of Mediterranean diet pattern on health and, consequently, a rise in diet-related diseases in the future, such as cardiovascular disease and cancer.

- The beneficial effect of each of the Mediterranean diet components is well documented. However, the overall adoption of Mediterranean diet pattern is reported to be of a greater importance. Thus, the recent studies are focusing on assessing the adherence to Mediterranean diet pattern and its effects on health. For that different score, tools are proposed and used in several studies, to evaluate the levels of adherence.

Keywords
Mediterranean diet pattern • Albuminuria • Microalbuminuria • KIDMED • MedDietScore • Cancer • Depression • Metabolic syndrome • NIDDM • Cardiovascular disease

Abbreviations

ACR	Albumin to creatinine ratio
GFR	Glomerular filtration ratio
KIDMED	Mediterranean Diet Quality Index
MDP	Mediterranean diet pattern
MS	Metabolic syndrome
TAC	Total antioxidant capacity

Introduction

Although it was first publicized in 1945 by the American doctor Ancel Keys stationed in Salerno, Italy, the Mediterranean diet failed to gain widespread recognition until the early 1990s. The most commonly understood version of the Mediterranean diet was presented, among others, by Dr. Walter Willett of Harvard University's School of Public Health from the mid-1990s including a book for the general public [1]. Based on "food patterns typical of Crete, much of the rest of Greece, and southern Italy in the early 1960s," Mediterranean diet is considered nowadays a modern nutritional recommendation [2, 3].

The typical Mediterranean dietary pattern (MDP) is characterized by a high intake of vegetables, legumes, fruits and nuts, cereals (that in the past were largely unrefined), a high intake of olive oil but a low intake of saturated lipids, a moderately high intake of fish (depending on the proximity to the sea), a low-to-moderate intake of dairy products (and then mostly in the form of cheese or yoghurt), a low intake of meat and poultry, and a regular but moderate intake of alcohol, primarily in the form of wine and generally during meals [4, 5]. Specifically, there is evidence that the antioxidants in olive oil improve cholesterol regulation and LDL cholesterol reduction and that it has other anti-inflammatory and antihypertensive effects [6]. The Mediterranean diet has been associated with better health and improvement in longevity, and it has been promoted as a model for healthy eating [7].

Up to now numerous epidemiological and nutritional studies have shown that Mediterranean countries benefit from lower rates of chronic disease morbidity and higher life expectancy. Thus, the traditional MDP protects against myocardial infarction, some tumors (e.g., breast, colorectal, and prostate), diabetes, incidence of Parkinson's and Alzheimer's disease, and other diseases associated with oxidative stress. It may also contribute to reducing some disease complications, e.g., onset of a second myocardial infarction, risk of coronary heart surgery failure, and diabetic vascular complications.

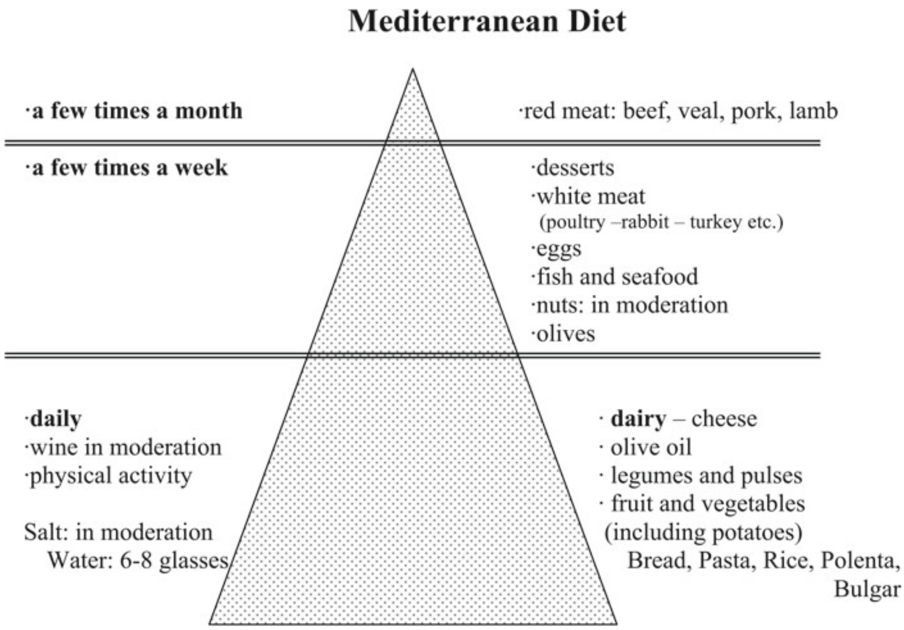

Fig. 24.1 The schematic representation of the Mediterranean diet nutritional pyramid. The pyramid represents the key components of Mediterranean diet

In this chapter, we discuss the scientifically proven beneficial effect of Mediterranean diet and the Mediterranean Diet Quality Index (KIDMED). We also discuss the cardiovascular implications of albuminuria and its relationship to Mediterranean diet and albuminuria.

Key Components of Mediterranean Diet

- Eating primarily plant-based foods, such as fruits and vegetables, whole grains, legumes, and nuts
- Using healthy fats such as olive oil and canola oil instead of butter
- Replacing salt with natural herbs and spices
- Red meat consumption to be limited up to few times monthly
- Moderate consumption of red wine
- Increasing the levels of daily physical activity
- Eating fish at least twice a week (Fig. 24.1)

The main source of fat in MDP is olive oil, which provides monounsaturated fat and has proven antioxidant effects. Further, high consumption of fish is a rich source of omega-3 fatty acids which are associated with decreased levels of triglycerides and decrease cardiovascular risk overall. Grains, vegetables, and fruits should be eaten at most meals, because they are important sources of vitamins, minerals, energy, antioxidants, and fiber. Herbs and spices are beneficial as for replacing salt and because they are also rich in a broad range of health-promoting antioxidants. Finally, daily physical activity, including strenuous exercise like running and aerobics, as well as more leisurely activities such as walking and housework, improves the outcome of Mediterranean diet adoption. Last but not least, the MDP is grounded on the principles of enjoyment and pleasure. Foods, drinks, and meals are best eaten with others, when possible, and savored.

Scientifically Proven Beneficial Effect of Mediterranean Diet

Mediterranean diet (MD) has been associated with a lowered incidence of cardiovascular diseases, metabolic disorders, Parkinson's and Alzheimer's diseases, and several types of cancer [8, 9]. Studies among the elderly in Greece and other European countries showed that the overall Mediterranean dietary pattern was more important for longevity than the single nutrients, and it was associated with increased survival among older people [10].

Recently, it was reported from the Ikaria Study that adoption of Mediterranean diet is beneficial in modifying uric acid levels in elderly individuals with unknown cardiovascular disease [11]. Furthermore, Ikaria Study revealed that Mediterranean diet mediates the adverse effect of depressive symptomatology on short-term outcome in elderly patients surviving from acute coronary syndromes [12].

A recently published meta-analysis suggested that the adherence to MDP is associated with lower prevalence and progression of metabolic syndrome (MS) overall and to a beneficial effect on each of the individual MS components [13]. MDP was also implicated in diabetes type 2. Specifically, it was reported that there is an anti-atherogenetic effect on these patients mainly through the reduced insulin resistance and restored endothelium-dependent vasodilatation induced by monounsaturated diet [14].

Lately the beneficial effect of MDP was associated with arrhythmias protection. It was reported that patients with atrial fibrillation had lower adherence to MDP and lower antioxidant intake compared to control population. Moreover patients with arrhythmia showing a higher MDP score had more probability of a spontaneous conversion of atrial fibrillation [15].

Finally, it was published that the adherence to the MDP may affect the risk not only for Alzheimer's disease but also for predementia syndromes and their progression to overt dementia [16], while the effect of MDP on depression is also implied mainly through reduction of inflammatory, vascular, and metabolic processes that may be involved in the risk of its clinical manifestation [17].

Table 24.1 Mediterranean Diet Quality Index (KIDMED)

KIDMED questions and answers 16 items	Score
Takes a fruit or juice every day	+1
Has a second fruit every day	+1
Has fresh or cooked vegetables regularly once a day	+1
Has fresh or cooked vegetables more than once a day	+1
Consumes fish regularly (at least 2–3 times per week)	+1
Goes more than once a week to a fast-food (hamburger) restaurant	−1
Likes pulses, like beans, peas, and lenses and eats them more than once a week	+1
Consumes pasta or rice almost every day (5 or more times per week)	+1
Has cereals or grains (bread etc.) for breakfast	+1
Consumes nuts regularly (at least 2–3 times per week)	+1
Uses olive oil at home	+1
Skips breakfast	−1
Has a dairy product for breakfast (yoghurt, milk, etc.)	+1
Has commercially baked goods or pastries for breakfast	−1
Takes two yoghurts and/or some cheese (40 g) daily	+1
Takes sweets and candy several times every day	−1

The table represents the quality index that aimed to assess the adherence to Mediterranean diet pattern in schoolchildren and adolescents

Mediterranean Diet Quality Index

The KIDMED was developed by Serra-Majem et al. [18, 19] (Table 24.1) and aimed to assess the adherence to MDP in schoolchildren and adolescents. The need for a quality index was derived from the fact that social changes have led to different levels of adherence to MDP in various countries in the last years. The influence of region on diet quality highlights the importance of considering regional nutrition strategies [20].

Recent changes in the actual Mediterranean diet include a reduction in energy intake and a higher consumption of foods with low nutrient density (e.g., soft drinks, candy, sweets). Children and adolescents are the age groups more prone to deteriorated Mediterranean diet profile, and there is a need for nutrition education programs to be established.

As far as adults are concerned, scale indicating the degree of adherence to the traditional Mediterranean diet was constructed by Trichopoulou et al. [10] and revised to include fish intake [21]. A value of 0 or 1 was assigned to each of nine indicated components with the use of the sex-specific median as the cutoff. For beneficial components (vegetables, legumes, fruits and nuts, cereal, and fish), persons whose consumption was below the median were assigned a value of 0, and persons whose consumption was at or above the median were assigned a value of 1. For components presumed to be detrimental (meat, poultry, and dairy products, which are rarely nonfat or low fat in Greece), persons whose consumption was below the median were assigned a value of 1, and persons whose consumption was at or above the median were assigned a value of 0. For ethanol, a value of 1 was assigned to men who consumed between 10 and 50 g per day and to women who consumed between 5 and 25 g per day. Finally, for fat intake, we used the ratio of monounsaturated lipids to saturated lipids, rather than the ratio of polyunsaturated to saturated lipids, because in Greece, monounsaturated lipids are used in much higher quantities than polyunsaturated lipids. Thus, the total Mediterranean diet score ranged from 0 (minimal adherence to the traditional Mediterranean diet) to 9 (maximal adherence). Based on that scale, it was reported [22] that in the general population a higher score, which reflects the level of adherence to the traditional Mediterranean diet, is associated with a significant and substantial reduction in overall mortality.

Albuminuria: Definition, Causes, and Cardiovascular Implications

Albumin is the predominant protein of human body and its role is to regulate the osmotic pressure of blood. Increased albumin leaking through the kidney is called albuminuria and it is asymptomatic. Albuminuria indicates kidney conditions that affect the glomeruli such as glomerulonephritis, nephrotic syndrome, diabetic nephropathy, and arterial hypertension. Albuminuria may also accompany cardiovascular diseases such as endocarditis and chronic inflammatory diseases such as systematic lupus erythematosus and rheumatoid arthritis. Strenuous physical exercise also can cause transient albuminuria without kidney disease. The definition of microalbuminuria and proteinuria is presented in Table 24.2.

The relationship between albuminuria and renal and cardiovascular disease has been well established. Its association was first described in patients with type 1 diabetes [23, 24]. Several studies followed these initial reports and confirmed the significance of albuminuria in predicting long-term renal prognosis. Guidelines of the American Heart Association and of the National Kidney Foundation include among the risk factors for cardiovascular and renal disease, respectively, both elevation in urinary excretion of albumin—even when of moderate degree, as in the case of microalbuminuria—and elevation in urinary excretion of total protein [25, 26].

Furthermore, microalbuminuria is an established marker of endothelial dysfunction and cardiovascular disease [27, 28] while it serves as an independent predictor of cardiovascular events [29]. Albuminuria was also reported to be a better biomarker in predicting stroke incidence among elderly population [30]. Additionally, albuminuria is relatively common and is closely associated with hypertension and glycemic control in patients with non-insulin-dependent diabetes mellitus, while it is reported that central obesity is an early and independent risk factor for increased albuminuria in normoglycemic subjects [31].

Obesity-related glomerulopathy is a well-known entity. Glomerular hyperfiltration, high protein and salt intake, hypertension, hyperinsulinemia, and increased tubuloglomerular feedback as a result of increased sodium reabsorption, dyslipidemia, inflammation, and elevated leptin levels are implicated in obesity-related glomerulopathy [32, 33]. Obesity-related glomerulopathy

Table 24.2 Definitions of albuminuria and proteinuria

	Urine collection method	Normal	Microalbuminuria	Albuminuria or clinical proteinuria
Total protein	24-h excretion (varies with method)	<300 mg/day	NA	>300 mg/day
	Spot urine dipstick	<30 mg/dL	NA	>30 mg/dL
	Spot urine to creatinine ratio (varies with method)	<200 mg/g	NA	>200 mg/g
Albumin	24-h excretion	<30 mg/day	30–300 mg/day	>300 mg/day
	Spot urine albumin-specific dipstick	<3 mg/dL	>3 mg/dL	NA
	Spot urine albumin to creatinine ratio	<30 mg/g	30–300 mg/g	>300 mg/g
	Spot urine albumin to creatinine ratio (gender-specific definition)[a]	<17 mg/g (men)	17–250 mg/g (men)	>250 mg/g (men)
		<25 mg/g (women)	25–355 mg/g (women)	>355 mg/g (women)

The data shows the definition of albuminuria and proteinuria according to collection status
[a]Use of the same cutoff for men and women leads to higher values of prevalence for women than men

often manifests clinically as albuminuria and is a frequent finding in men than women.

In children and adolescents, the 3L Study revealed a prevalence of microalbuminuria of 12.9 %, while the incidence of childhood hypertension was 5.2 %. The prevalence of overweight status was 25.8 and 5.8 % of the students were classified as obese. Low physical activity was reported by 7 % of boys and girls. Based on the KIDMED score of each student, only 6 % of them were classified as high adherers to a Mediterranean diet, and 41.9 % were classified as having very low diet quality [34].

Mediterranean Diet and Albuminuria

It is clearly demonstrated that the incidence of albuminuria and microalbuminuria is affected by dietary intake. Specifically, it has been reported that higher dietary intake of animal fat and two or more servings per week of red meat may increase risk for microalbuminuria [35]. The Multiethnic Study of Atherosclerosis reported a direct association between each additional serving per day of nondairy animal food intake with albumin to creatinine ratio (ACR) [36].

Adolescents who adhere to the Mediterranean diet exhibit lower levels of albuminuria, independently of demographic and hemodynamic confounders. The inverse relation of KIDMED index with ACR suggests a close link of accelerated vascular damage reflected by albuminuria with low adherence to this favorable diet of the Mediterranean basin [37]. The studies dealing with effects of Mediterranean diet on albuminuria are presented in Table 24.3.

In the 3L Study [34], 498 Greek students were enrolled, their mean age was 14.1 ± 1.6 years, and their dietary habits were assessed. Emphasis was placed on the seasonality of consumption with specific questions to the participants. The main categories (including their subcategories) of the abovementioned foods and beverages consumed were coded as follows: (1) dairy products (all kinds of milk, all types of yoghurt, and all types of cheese); (2) snack food was divided into two main categories, “salty” snacks (e.g., fast-food items such as a hamburger, slice of pizza, a hot dog, a toasted sandwich, a piece of cheese pie, a piece of spinach pie, all kinds of potato chips, savory snacks, popcorn) and “sweet” foods (e.g., ice cream, milk shake, all kinds of chocolates, croissant, cakes, biscuits); (3) all types of soft drinks (still, fizzy, diet, etc.); (4) fruit juices

Table 24.3 Studies on Mediterranean diet and albuminuria

Multiethnic Study of Atherosclerosis. Am J Clin Nutr 2008;87:1825–1836	There is a direct association between each additional serving per day of nondairy animal food intake with ACR
The 3L Study. Eur J Clin Nutr 2011;65:219–225	Adolescents who adhere to the Mediterranean diet exhibit lower levels of albuminuria, independently of demographic and hemodynamic confounders
The GRECO Study. Atherosclerosis. 2011;217:525–530	Children who achieved higher KIDMED score reported healthier diet and higher physical activity levels
The Nurses' Health Study. Clin J Am Soc Nephrol 2010;5: 836–843	Diets lower in animal protein, animal fat, and cholesterol may be protective against microalbuminuria
The Attica Study. J Ren Nutr 2010;20: 176–184	Greater adherence to MDP is independently associated with reduced urea and creatinine and increased creatinine clearance (CCr) among healthy individuals

The table represents the summary of studies that have been conducted regarding Mediterranean diet and albuminuria
The data are unpublished

(fresh or ready to drink, 100 % juice without added sugars); (5) beverages (tea, chamomile tea, etc.); and (6) traditional Greek cooked foods (moussaka, beans, etc.). Based on the answers, the KIDMED index was applied to assess the adherence to Mediterranean diet. In the same study, the prevalence of hypertension and microalbuminuria was also assessed. The average KIDMED score was 4.05 ± 2.2. Based on the KIDMED score of each student, only 6 % of them were classified as high adherers to MDP, 52.1 % showed average values of the index, and 41.9 % were classified as having very low diet quality (Fig. 24.2).

In the same study sample, the prevalence of microalbuminuria was up to 12.9 %, 11 % for boys and 16.3 % for girls, respectively, which is relatively high and implies the effect of dietary habits as well as physical activity level seen in adolescents. The correlations of ACR and KIDMED score in the 3L Study are presented in Table 24.4.

In the recently published GRECO Study [38], which enrolled 4,786 schoolchildren of ten

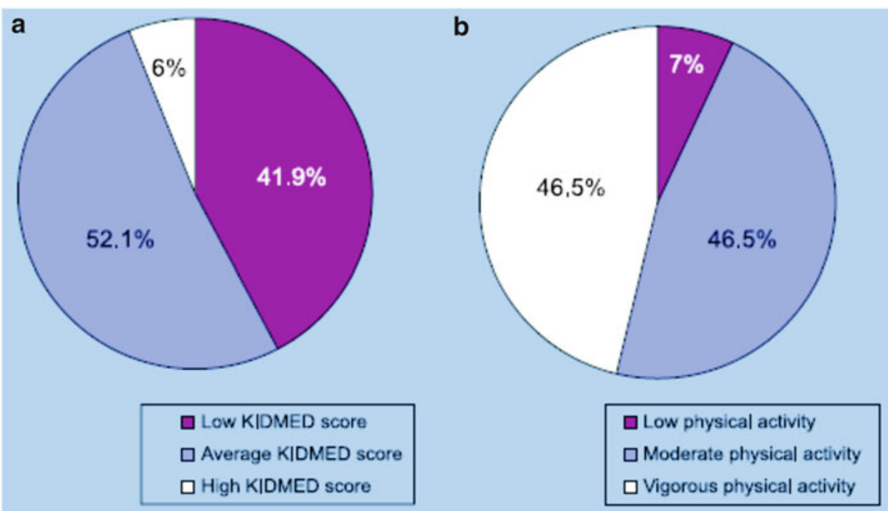

Fig. 24.2 Physical activity levels and adherence to Mediterranean diet in Greek adolescents. Pie charts classifying schoolchildren according to their adherence to Mediterranean diet (**a**) and according to their physical activity level (**b**). The data are unpublished

Table 24.4 Correlation of ACR and KIDMED score

Parameter	ACR	KIDMED score
Age (years)	**r = –0.110, p = 0.044**	*r* = –0.013, *p* = 0.805
Male (%)	**r = 0.16, p = 0.003**	**r = –0.104, p = 0.046**
BMI (kg/m²)	**r = –0.131, p = 0.016**	**r = 0.122, p = 0.020**
Waist circumference (cm)	**r = –0.161, p = 0.003**	**r = 0.118, p = 0.024**
SBP (mmHg)	**r = –0.144, p = 0.008**	**r = 0.119, p = 0.023**
DBP (mmHg)	*r* = –0.045, *p* = 0.415	*r* = 0.051, *p* = 0.333
PP (mmHg)	**r = –0.133, p = 0.015**	**r = 0.121, p = 0.021**
HR (bpm)	*r* = 0.102, *p* = 0.062	*r* = –0.068, *p* = 0.199
ACR (mg/g)	–	**r = –0.111, p = 0.041**
KIDMED score	**r = –0.111, p = 0.041**	–
Watching TV (hours/day)	*r* = 0.048, *p* = 0.382	**r = –0.179, p = 0.001**
Leisure time (hours/day)	*r* = 0.024, *p* = 0.659	*r* = 0.052, *p* = 0.323

The table represents the Pearson correlates of ACR and KIDMED score in the entire population of 3L Study
The statistically significant relationships are presented in bold
ACR albumin to creatinine ratio, *KIDMED* Mediterranean Diet Quality Index in children and adolescents

regions of Greek county, the adherence to MD was also assessed and only 4.3 % of the participants had an optimal KIDMED score. Overweight and obesity prevalence in the same study was 29.9 % and 12.9 % among boys and 29.2 % and 10.6 % among girls, respectively. Children from semi-urban or rural regions had higher scores, while children who achieved higher KIDMED scores reported healthier diet and higher physical activity levels.

Concerning adults, the Nurses' Health Study [35] reported that diets lower in animal protein, animal fat, and cholesterol may be protective against microalbuminuria. Consumption of two or more servings of red or processed meat per day was associated with an approximately 50 % increased odds for microalbuminuria in the same study, while lower sodium and higher carotene intake may be protective against GFR decline. These associations appeared to be stronger when considering cumulative average intake over many years and were similar in nondiabetics and diabetics.

In a study coming from Italy [39], the scientists enrolled 150 participants, 100 healthy and 50 with stage 2 and 3 of chronic kidney disease, and observed the effect of Italian Mediterranean diet consisting of organic vs. conventional food to several factors among which was microalbuminuria levels. The scientists concluded that Italian Mediterranean organic diet, according to the "Nicotera diet," was able to reduce tHcy, phosphorus, microalbuminuria levels, and cardiovascular disease risk in healthy individuals and in chronic kidney disease patients.

It was also reported in a large cohort [40] of 1,514 male and 1,528 females from Greece that greater adherence to MDP is independently associated with reduced urea and creatinine and increased creatinine clearance among those healthy individuals.

Finally, the Multiethnic Study of Atherosclerosis [36] reported that a diet pattern rich in whole grains, fruit, and low-fat dairy foods was associated with lower ACRs. The adherence to Mediterranean diet was not investigated but the diet pattern used is close to MDP dietary habits.

Further investigation needs to be done to enlighten the beneficial effect of MD adoption to several different populations presenting with either microalbuminuria or albuminuria. Given the fact that increase albumin excretion reflects impaired renal function, the importance of prevention is more than prominent. A summary of the abovementioned studies is presented in Table 24.3.

Mediterranean Diet and Other Physiological Variables

Numerous studies coming mostly from Mediterranean countries have reported several different beneficial effects of higher adherence to MD pattern. Research interest in the field, in recent years, has been focused on estimating the adherence to the whole MD pattern rather than in analyzing the individual diet components. Hence, the dietary scores, evaluating the level of MD adoption, were associated with a reduction of overall mortality, cardiovascular mortality, and cancer.

A meta-analysis of 12 studies [41] including a total of 1,574,299 subjects which were followed for a time ranging from 3 to 18 years demonstrated that a two-point increase in the adherence score of MD pattern was associated with a reduced mortality [RR 0.91, 95 % CI 0.89–0.94], while a greater beneficial effect was seen in cardiovascular mortality [RR 0.91, 95 % CI 0.87–0.95], incidence/mortality of cancer [RR 0.94, 95 % CI 0.92–0.96], and incidence of Parkinson's and Alzheimer's disease [RR 0.87, 95 % CI 0.80–0.96]. The results can be considered without a doubt as clinically relevant for primary prevention of major chronic disease.

In the ATTICA Study [42], the total antioxidant capacity (TAC) was evaluated in a random sample of 1,514 males and 1,528 females selected from Attica region, and it was reported that greater TAC was seen in subjects with greater levels of physical activity and increase adherence to MDP.

The Mediterranean diet score [43], which is a score (range 0–55) developed to assess the adherence to MD pattern, was found to have positive predictive values regarding hypertension, dyslipidemia, diabetes, and obesity of 45 % (95 % CI 43–48), 46 % (95 % CI 44–49), 12 % (95 % CI 11–14), and 33 % (95 % CI 30–35), respectively. A 10-unit increase in the diet score is associated with 4 % lower 10-year cardiovascular risk.

A cross-sectional survey in Cyprus [44], conducted between 2004 and 2005, investigated the association of MDP on clinical status of 150 elderly men and women, using the Mediterranean diet score. According to the study, adherence to MDP is associated with reduced odds of having hypertension, dyslipidemia, diabetes, and obesity among elderly.

Due to weekly consumption of fish and almost daily consumption of vegetables, the Mediterranean diet is a pattern that provides adequate consumption of the essential omega-3 fatty acids. Omega-3 fatty acids are mainly found in fish and shellfish, where docosahexaenoic acid (C22:6 omega-3) and eicosapentaenoic acid (C20:5 omega-3) are most abundant. Some omega-3 fatty acids, especially α-linolenic acid (C18:3 omega-3), and omega-6 fatty acids are found mainly in plant oils, as well as certain plants consumed in the traditional Mediterranean diet. A low ratio of omega-6 to omega-3 is beneficial for human health, indicating higher omega-3 fatty acid consumption in the diet. Based on the above knowledge, it was recently published that the Mediterranean diet score is inversely associated with the omega-6/omega-3 ratio [45].

In terms of Ikaria Study [11], it was recently reported that there is an association between Mediterranean diet score and levels of uric acid. Specifically, 281 female and 257 male permanent inhabitants of the island were enrolled, and the prevalence of hyperuricemia was 34 % among males and 25 % among females. The Mediterranean diet score was assessed, and there was an inverse association with uric acid levels independently of several factors such as hypertension, diabetes mellitus, dyslipidemia, physical activity levels, coffee consumption, and creatinine clearance. The association was mostly significant though among males.

According to a meta-analysis published recently [46], MDP in comparison to low-fat diets was associated with more favorable changes in body weight, body mass index, fasting glucose levels, systolic blood pressure and diastolic blood pressure, total cholesterol levels, and CRP. The meta-analysis included six trials and 2,650 participants and the results were obtained post a 2-year follow-up.

The effect of MDP on overall cancer risk has also been assessed. The present study [47] included 9,669 incident cancers in men and 21,062 in women. A lower overall cancer risk was found among individuals with greater adherence to Mediterranean diet for a two-point increment of the Mediterranean diet score. The apparent inverse association was stronger for smoking-related cancers than for cancers not known to be related to tobacco. Furthermore, in the overall population, 4.7 % of cancers among men and 2.4 % in women would have been avoided if study subjects had a greater adherence to Mediterranean dietary pattern.

The beneficial effects of MDP are also identified in mental and psychological disorders. In a prospective study coming from France [48], the association of MD adherence with cognitive performance and risk for dementia in elderly persons was assessed. Cognitive performance was assessed on four neuropsychological tests: the Mini-Mental State Examination, Isaacs Set Test, Benton Visual Retention Test, and Free and Cued Selective Reminding Test. Incident cases of dementia were validated by an independent expert committee of neurologists. The authors concluded that higher adherence to a MDP was associated with slower MMSE cognitive decline but not consistently with other cognitive tests. Higher adherence was not associated with risk for incident dementia though.

In another prospective cohort study of two cohorts comprising 1,880 community-dwelling elders without dementia living in New York, the effect of physical activity levels and adherence to MD pattern was assessed and the association with Alzheimer's disease was evaluated. Authors reported that both higher MDP adherence and higher physical activity were independently associated with reduced risk for Alzheimer's disease.

Finally, in a cross-sectional study [17] from the Seguimiento Universidad de Navarra in which 9,670 participants were recruited, folate intake was inversely associated with depression prevalence among men, especially smokers. Among women, B12 vitamin intake was inversely associated with depression, especially among smokers and physically active women. Thus, it can be concluded that the adherence to a MDP ensures an adequate intake of fruits, nuts, vegetables, cereals, legumes, or fish, important sources of nutrients linked to depression prevention.

Conclusions

The traditional Mediterranean diet is characterized by a high intake of monounsaturated fat, plant proteins, whole grains, and fish; moderate intake of alcohol; and low consumption of red meat, refined grains, and sweets. The MDP has been shown in several prospective studies from around the world to be inversely associated with total and cardiovascular mortality.

Even though MDP is without a doubt one of the most worldwide healthier diet patterns, socioeconomic changes have led to lower adherence, especially in younger ages. Moreover, even though each component of MDP is of great importance, it is prominent that the assessment of MDP as an overall unit is more beneficial. Thus, the development of scores evaluating the adherence to MDP has been developed and used widely by scientists in the recent years.

Microalbuminuria and albuminuria are established markers of cardiovascular disease and renal function and are also associated with all-cause mortality. Accumulating evidence suggests that the levels of albumin excretion are associated with the quality of dietary intake. The role of MDP has been investigated, and the results reported that the higher adherence to MDP is inversely associated with microalbumin levels both in younger ages and also in the adult population. Further studies should be conducted in that field to clarify the mechanisms of that beneficial effect, since it is clearly significant for the community health.

Finally, MDP has been also implicated in beneficial effects in other health conditions apart from cardiovascular disease. Thus, MDP adoption is associated with decrease incidence of depression, dementia, Alzheimer's disease, Parkinson's and inflammatory and autoimmune conditions, and above all cancer risk.

It is therefore more than evident that MDP per se has a beneficial effect in many aspects of human health. Adoption of a healthier nutritional lifestyle may be an easy step to overall health improvement, while its protective effect is of great importance in children and adolescents.

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25 Diet Quality and Use of a Personal Digital Assistant: Transitioning from the Standard Paper Diary to Electronic Diaries

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Key Points

- Self-monitoring is a central behavior change strategy used in behavioral intervention programs.
- Dietary self-monitoring increases an individual's awareness of eating behaviors and food consumed.
- Recent advancements in technology have provided electronic or mobile devices as an alternative to the most commonly used paper diary for dietary self-monitoring.
- Mobile devices might be beneficial tools in easing the task of dietary self-monitoring helping individuals increase awareness of their eating behaviors, develop more healthful behaviors, and improve diet quality.
- Most self-monitoring applications for mobile devices have not been tested empirically thus limiting the evidence base of these applications.
- Future studies are needed to assess patterns of long-term use of mobile devices and diet-related apps and their impact on diet quality and clinical outcomes.

Keywords
Self-monitoring • Dietary self-monitoring • Diet quality • Personal digital assistant (PDA) • Mobile devices • Smartphones • Paper diary

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Abbreviations

apps	Applications
BMI	Body mass index
DMS	Diabetes monitoring system
GI	Glycemic index
GL	Glycemic load
HbA1c	Glycated hemoglobin
NHANES	National health and nutrition examination survey

V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health, DOI 10.1007/978-1-4614-7315-2_25, © Springer Science+Business Media New York 2013

PDA	Personal digital assistant
SBT	Standard behavioral treatment

Introduction

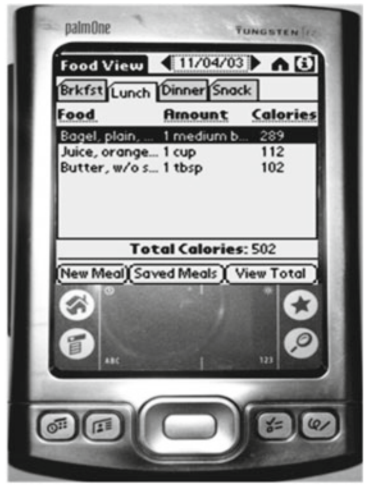
Obesity is a chronic disorder caused by complex interactions among genetic, metabolic, cultural, environmental, and psychosocial factors. The recent 2009–2010 National Health and Nutrition Examination Survey (NHANES) indicated no change in the prevalence rate of obesity among adults from the previous 6 years (2003–2008) with 35.5 % of men and 35.8 % of women being obese (body mass index (BMI) ≥30) [1]. The same survey showed that the prevalence of obesity among children and adolescents was 16.9 % [2] indicating that obesity is still a significant public health problem. Research has demonstrated several health benefits by as little as 5–10 % reduction in excess body weight [3]. Efforts to improve weight loss have focused on standard behavioral treatment (SBT) programs that require lifestyle changes such as adopting healthy eating and exercise habits. A healthy and safe approach to weight loss includes creating a caloric deficit such as a reduction in total caloric intake by 500–1,000 kcal/day, which is expected to result in a weight loss of 1–2 lb per week [4]. Additionally, it is recommended that one engage in a moderate intensity aerobic physical activity program for a minimum of 30 min 5 days per week or vigorous intensity aerobic activity for at least 20 min 3 days per week [5]. The third component of SBT is use of behavior strategies such as goal setting, self-monitoring, and provision of feedback on progress made toward the goals [6]. Despite increasing emphasis on greater dietary intake of vegetables, fruit, and whole grains, intake of these foods is well below the recommended levels [7], and new methods for supporting individuals in making long-term, healthful dietary changes are needed.

Self-monitoring is a behavior change strategy that is central in behavioral weight loss interventions [8]. The use of self-monitoring in behavior change is supported by self-regulation theory, which focuses on the self-management component of the intervention. The process of self-regulation involves self-monitoring, self-evaluation, and self-reinforcement, where self-monitoring occurs first followed by self-evaluation of progress made toward one's goal and self-reinforcement for the progress made [9]. From a practical perspective, self-monitoring consists of identifying a behavior and recording details about its occurrence. It helps individuals learn when and how often a behavior occurs and the circumstances that surround that behavior and the necessary actions to be taken to change desired behaviors [8]. Literature has reported self-monitoring of various behaviors that individuals need to modify, such as coping with pain [10], smoking urges [11], and medication taking [12]. There is a growing body of literature that supports self-monitoring dietary intake and physical activity as a critical element for success in weight loss [6, 13]. Dietary self-monitoring helps improve self-awareness of eating behavior and provides the opportunity for appropriate action to make healthy dietary changes. This chapter reviews dietary self-monitoring and the significance of self-monitoring in the management of successful weight loss and maintenance of the weight lost. Different approaches to dietary self-monitoring and strategies to enhance long-term adherence to dietary self-monitoring to improve diet quality are reviewed.

Different Approaches to Self-Monitoring Eating Behaviors

The purpose of self-monitoring dietary intake is to increase the individual's awareness of eating behaviors and food consumed. The individual is required to record all foods consumed and/or target nutrients; the recording may also include the location when the particular food item or meal was consumed (home vs. away), time of the day, quantity eaten with corresponding number of caloric intake or number of servings, and the target nutrient values (sodium, fat, fiber, etc.) [14]. In an ideal situation, dietary self-monitoring should be performed on a continuous basis such that the person records the food intake as it occurs. This ongoing recording throughout the day

Paper diary



Personal Digital Assistant

Fig. 25.1 Sample of a paper diary and a personal digital assistant (PDA). The photo on the left depicts a standard paper diary in which participants record the location and time of an eating incidence as well as food item(s), portion size, and respective counts for energy and total fat for the consumed portion. The photo on the right shows a PDA with several items entered for the lunch meal. Note that times do not need to be entered using the PDA and calorie counts are summed by the device

allows the person to self assess eating behavior in real time and provides an opportunity to modify food choices for the rest of the day so as not to exceed the daily target, whether it is energy intake, a specific food group, or a particular nutrient [14]. For example, if the person's target nutrient is sodium, recording sodium content of each food consumed helps to assess where the person stands in comparison to the daily goal. Also, depending on the level of current sodium intake, the person can make adjustments in the remaining meals to prevent exceeding the daily goal and also improve the quality of the diet.

The most common method of self-monitoring dietary intake continues to be the paper diary. However, recent advancements in technology have provided electronic diaries or mobile devices as an alternative to using paper diary. Readily available electronic diaries include computers and handheld devices such as smartphones or tablets with wireless connectivity. The personal digital assistant (PDA), which was readily available in the 1990s and early 2000s, is no longer available as a stand-alone device, as it has been incorporated into the smartphone [15]. Figure 25.1 depicts a typical paper diary and a PDA used for dietary self-monitoring in a behavioral weight loss program. All these self-monitoring tools have inherent strengths and limitations as described below. Table 25.1 summarizes the advantages and disadvantages of the paper diary and electronic devices. Figure 25.1 depicts a typical paper diary and a PDA used for dietary self-monitoring.

Paper Diary

The paper diary is inexpensive and readily available in various formats. The use of a paper diary requires little training and is simple to use. However, it may be challenging for individuals with limited literacy or who have illegible handwriting and also requires a high level of subject motivation. Its use can be time consuming and tedious as there is a need to look up nutrition information for the foods consumed when food labels are unavailable; also, one needs to calculate subtotals after each dietary entry to assess diet quality, or at least periodically throughout

Table 25.1 Advantages and disadvantages of using paper diaries and electronic diaries for dietary self-monitoring

Self-monitoring approaches	Advantages	Disadvantages
Paper diary	Simple	Requires literacy and legible handwriting
	Requires less training	Time consuming
	Easy to use	Unease of use in public places
	Little cost	Facilitates only delayed external feedback
	Readily available	
Electronic diaries (personal digital assistant, smartphone with wireless connectivity)	Less burdensome	Costs more than paper diary
	Portable and socially acceptable	Requires literacy
	Provides immediate feedback on screen (current intake: goal)	Requires some training and practice
	Can be password protected	Needs to be charged periodically
	Can be programmed to deliver tailored feedback	
	Additional food items/meals can be added and saved	
	Able to send data via wireless connectivity to provider or researcher	
	Can enter foods with use of bar code scanner	

Pros and cons of using two frequently used methods of self-monitoring food intake

the day to compare intake values to daily goals. Moreover, when using the paper diary, the greater the number of target nutrients, the longer it takes to adequately complete the self-monitoring exercise [14]. Individuals may feel less comfortable using a paper diary in public places. Most importantly, the paper diary does not provide real-time external feedback; even if the individual returns the diary to the interventionists or clinicians, the feedback is often provided at the next visit and thus is delayed. The feedback provided to the recording in the paper diary depends on the extent of self-monitoring performed; if the person self-monitored very little or not at all, there is little feedback that the interventionist can provide on the diary [8]. The emerging technology is beginning to provide some practical alternatives to the paper diary; however, for some individuals, this remains a preferred approach [16].

Electronic Devices

PDA. It is important to note that this section reports on the results of studies that used PDAs. Today, the PDA is incorporated into the smartphone. However, since these strategies can now be applied to smartphones or other mobile devices, it is worth reviewing the information that was provided from the use of this handheld device.

A PDA is a handheld computer which has the capability of containing a specially designed dietary software program to self-monitor dietary intake; it offers an alternative option to the paper diary. The PDA-based software programs used for dietary self-monitoring in published research studies include DietMatePro (PICS, Inc, Reston, VA), CalorieKing (Wellness Solutions, Inc, EI Inc), BalanceLog (Microlife), NutriBase (CyberSoft), Diabetes Pilot (Mount Prospect, IL), and Diabetes Meal Planner (Glycemic Diet Software, LLC). With the use of the PDA, individuals are no longer required to look up nutrients in a nutrition information book, which likely reduces the burden of recording. PDA users need to only enter the type and amount of foods eaten. The software calculates the nutrient content immediately and compares it to a daily target or nutrient intake goal that is displayed on the screen and thus provides immediate feedback on nutrients consumed compared to the daily goal. This feedback helps the individuals make necessary changes during the next meal to stay closer to the goals and improve the quality of their diet. PDA users can preset a number of target nutrients for self-monitoring, which provides feedback on several nutrients (e.g., calories, fats, sodium), without the effort of searching for this information in a book. The use of the PDA also permits individuals to save frequently eaten meals and thus eliminate the need for repeated searching and entry. As the PDA is portable and reportedly more socially acceptable, individuals can record in most settings; it can reduce the uneasiness of self-monitoring and also improve adherence to recording at the time of eating [17].

Data from the foods entered into the PDA are available for review by providers or researchers as often as the providers syncs the data on a computer, permitting them to observe dietary problems as they arise [18]. Some dietary software programs record the date and time of each food entry, which provides data on adherence to self-monitoring [19]. Moreover, it also can improve the researcher's ability to monitor the success of dietary interventions [20]. A PDA with camera and mobile telephone card, "Wellnavi," was developed to assess dietary intake. This device can be used by having the individual take a photo of a meal and immediately send it to dietitians or health professionals for analysis [21]. Another benefit of using the PDA is the capability to provide additional custom software onto the PDA. Burke et al. [19] reported the addition of a customized feedback program that, through the use of a customized algorithm, tracked the participants' adherence to calorie, fat gram, and exercise goals and provided a daily feedback message related to what the person had entered into the PDA. The feedback messages provided positive reinforcement and guidance for goal attainment, which could improve overall diet quality.

Several studies have reported the use of PDAs for dietary assessment among different population groups including individuals without any dietary restrictions [22], healthy non-obese adults [23], individuals with and without diabetes [21], low-income pregnant women [24], and individuals with eating disorders [25]. These findings suggest that a PDA may be a beneficial tool for assessing dietary intake for individuals with an array of medical conditions and a reliable source of data for assessing dietary habits. However, available literature on PDA use for dietary self-monitoring and diet quality is limited. A pilot study tested the feasibility of using a PDA-based dietary self-monitoring among individuals following a hemodialysis dietary regimen and found this approach to be effective in reducing sodium intake among patients receiving in-center hemodialysis treatment [26]. Another pilot study suggested that a PDA with a dietary software program was a potential tool for self-monitoring food intake, possibly enhancing diet quality through dietary goal attainment [20]. The study participants reported the benefits of immediate feedback on eating habits while using the PDA for self-monitoring and also found the device both useful and easy to use [27]. A study by Forjuoh et al. [28] also reported a significant improvement in glycated hemoglobin (HbA1c) in 6 months among patients with diabetes with the use of a PDA. Similarly, in a dietary intervention that tracked diet, exercise, medication, and glucose among adult patients with poorly controlled type 2 diabetes, the use of PDA-based dietary self-monitoring for 6 months was associated with improvement in diet quality as indicated by decreases in average HbA1c, blood pressure, dietary glycemic index (GI), daily caloric intake, and carbohydrate intake [29].

In a 4-week, randomized control study, Beasley et al. [16] found better self-monitoring adherence to the Ornish Prevention Diet with the PDA-based dietary software program compared to the paper diary group among overweight and obese adults without dietary restrictions, suggesting that the use of a PDA may improve adherence to dietary regimens compared to paper-based methods. In a 6-month weight loss intervention study, Acharya et al. [17] examined the differences in dietary changes between overweight and obese participants assigned to use a paper diary or PDA for self-monitoring and found that both groups had significant reductions in energy, percent calories from total fat and saturated fat intake, with no differences between the groups. However, compared to the paper diary group, the PDA group significantly increased the servings of fruit and vegetables consumed and decreased their intake of refined grain servings. Among the two groups, interactions were also seen in relation to self-monitoring and change in percent calories from total fat, monounsaturated fatty acids, and trans-fatty acids, suggesting that those in the PDA group improved their diet more at a lower level of adherence to self-monitoring and that the paper group needed to be more adherent to self-monitoring to improve their diet quality. These findings suggest the PDA might be a beneficial tool in helping individuals increase awareness of their eating behaviors, which in turn might improve long-term dietary changes. Moreover, the use of the PDA for dietary self-monitoring may reduce the burden of the self-monitoring task, which is particularly important for individuals trying to lose weight.

In a two-group randomized study of healthy adults, participants in the intervention group showed significantly improved diet quality with increases in vegetable servings and a trend toward greater intake of dietary fiber when compared to the control group, suggesting that the use of portable handheld technology for recording dietary intake can increase consumption of healthy food groups [30]. Results from the trial that compared the use of the PDA with and without a feedback message to a paper diary in a weight study revealed that those who used the PDA were significantly more adherent to the components of the intervention (attendance, self-monitoring, daily energy and fat gram goals, and weekly exercise goals) compared to those who used the paper diary [31]. Additional results revealed that a significantly larger proportion of the PDA plus feedback group achieved a 5 % weight loss compared to the PDA without feedback and the paper diary group [15], and at the end of the 2-year trial, it was the only group that had maintained a significant weight loss [32].

The cumulative findings of these studies indicate improved diet quality and enhanced adherence to dietary regimens lead to improved clinical outcomes, which might be partly explained by the advantages of using a PDA over a paper diary. Moreover, studies lasting longer than 6 months also indicate that the dietary changes observed may be sustainable [32]. It is possible that the feedback individuals receive while using the PDA helps to increase awareness of their dietary patterns or eating habits, keeping them motivated and on track, leading to improved self-monitoring adherence and better diet quality. In Table 25.2, we summarize the common software programs that are available today for use with the mobile devices. It should be noted that most of the software programs used in with these devices have not been tested empirically [33].

Although the PDA might provide some advantage over the use of a paper diary when it is used for self-monitoring dietary intake, limitations to using a PDA should also be noted. Use of mobile devices might be a barrier for some individuals. Compared to the paper diary, it may take longer to learn to use the device. Some individuals, in particular those with lower literacy skills and the elderly, may encounter difficulty in using the device; however, that has not been reported. Studies have described participants reporting difficulty in searching the database for food items, recording portion size for commonly consumed foods, and thought that the software used in the program was not user-friendly [19, 29, 34]. It is still unclear if a person saves time with a mobile device as this may vary depending on the software being used and the screen design. Beasley et al. [22] reported that it takes approximately 8 min to record each meal using the PDA program. However, with continued use and special features, such as saving commonly eaten meals, PDA use may save time in the long run. It is important to note that the self-monitoring software that is available today is much more user-friendly than the software used in the studies reported by Burke and by Beasley; also, an important addition is the bar code scanner that is available on phones with a camera. This device adds the food label data to the software database, which is particularly valuable for uncommon or ethnic foods.

As previously discussed, PDAs as stand-alone devices have become obsolete; today, the functionality of a PDA has been incorporated into the smartphone. Also, increasingly more programs have become available for use on the Internet, and most recently, downloadable applications (apps) have become available for use on various smartphone platforms [33]. However, while the

Table 25.2 Common software programs used for dietary self-monitoring in electronic devices

Software	Special features
DietMatePro (http://dietmatepro.com/)	USDA-based, 6,000-item food database
	Only monitors diet and provides feedback related to daily goals
	Date and time stamps for each entry
	Can save unique meals
BalanceLog (http://metabolicratetest.com/microlife-balancelog-software/)	USDA-based, 4,000-item food database
	User-friendly with excellent graphic displays
	Does not include date and time stamp
CalorieKing (http://www.calorieking.com/)	Has 50,000 items in food database, updates weekly
	Can graph a person's progress
	Can monitor calories, carbohydrates, fats, fiber, protein
	Can self-monitor weight
	Multiple users permitted on license
	Does not include date and time stamp
Glycemic Diet Software (http://www.glycemicdietsw.com/)	Calculates glycemic index (GI) as well as glycemic load (GL)
	Can monitor calories, carbohydrates, fat, and protein
	Has capacity to store data for only 30 days
NutriBase (http://www.nutribase.com/)	Has >30,000 items in food database
	Can monitor both dietary and exercise behaviors, as well as body weight
	Date and time stamps for each entry
	Allows saving of custom foods
	Food entry prompts a "pop-up" question
	Provides color-coded "alerts" for sodium, saturated fat, and cholesterol
	Excellent graphic displays
MyNetDiary (http://www.mynetdiary.com/)	Database: 102,000 foods; includes brands, restaurant chains, and ethnic foods
	Generates reports up to 36 nutrient values
	Food records downloadable to Excel spreadsheet for subsequent analysis
	Monitors diet, weight, physical activity, and water
	Provides personalized analysis and feedback
	Dietitian support and community forum
	Remembers the user's prior entries and permits subsequently consumed foods to be entered in three keystrokes
SparkPeople (http://www.sparkpeople.com/)	Monitors several nutrients, physical activity, weight, and health measurements
	Provides daily feedback on achievement of goals
	Has recipe calculator
Lose It! (http://www.loseit.com/)	Can monitor diet, exercise behaviors, body weight, and hours of sleep
	Provides feedback on up to nine nutrients based on a database with 60,000 foods
	Online group can be created where members can communicate and share information with each other
	Provides technical support and community forum
	Date and time stamps for each entry
Livestrong (http://www.livestrong.com/)	Has more than 625,000 foods in food database
	Contains a smoking cessation application
	Allows interaction among members and forum
	Date and time stamps for each entry
Diabetes Pilot (http://www.diabetespilot.com/)	Monitors glucose level, insulin, meals, exercise, blood pressure, test results
	Excellent graphic displays

Various software programs currently available for dietary self-monitoring and features of each. Many of these programs are available at no cost

PDA has become an obsolete device, what we have learned from its use can be applied to the newer technology. These applications are discussed further in the next section.

Web-Based Technology

The use of the Internet has provided an alternative approach to self-monitoring using a paper diary. Some programs available on the Internet that provide the structure for dietary self-monitoring include http://www.FitDay.com, http://www.sparkpeople.com, http://www.caloriecount.about.com, http://www.mynetdiary.com, http://www.loseit.com, http://www.diabetesPilot.com, and http://www.livestrong.com. These computer and web-based applications are user-friendly and are relevant to a variety of age groups. Another benefit of the web-based dietary self-monitoring program is the possibility of real-time interaction and ability of timely goal-related feedback from the interventionists/providers to the individual's with consideration of their changing circumstances [35], which is essential for continued success and reinforcement. A potential limitation to Internet programs is that they require access to a personal computer or a portable device, such as a smartphone or tablet with wireless capability. However, considering the rapid growth in the penetration of wireless devices, this is increasingly less of a problem [36]. The orientation session for self-monitoring with an electronic diary might need to be lengthened to ensure that there is sufficient time to teach the participant the necessary skills and permit practice in order to build confidence in the use of the technology. Sevick et al. reported that they found no difficulties in having individuals in the older age or lower socioeconomic groups learn how to self-monitor using handheld devices [37].

In brief, with the proliferation of wireless devices, smartphones, and Internet connectivity, technology is playing an increasingly greater role in the way that people take control of their health. But as individuals turn to technology to help them learn more about their health, it is critical to stay focused on the behavioral issues like long-term dietary changes. A recent survey reported that 285 million Americans are mobile subscribers, and of the 257 million active "data capable" devices, 50 million of those are smartphones capable of more advanced wireless services [36]. It was expected that 50 % of the US population would be using smartphones by the end of 2011 and their continued use is likely going to increase for at least another 3 years [38]. In light of the ever-growing use of the smartphone, it is possible that dietary self-monitoring will be practiced increasingly more on the smartphone in the future. Breton et al. [33] reported that as many as 67 apps related to food and nutrition are available for download on smartphones. When these applications were reviewed for adherence to 13 evidence-informed practices advocated by governmental agencies, none of the applications had incorporated all these practices. Although these apps are becoming readily accessible and more popular, individuals seeking assistance in making dietary modifications should not solely rely on the use of these apps until they are evaluated for their efficacy.

Factors to Consider in Dietary Self-Monitoring

It is well recognized that adherence to self-monitoring is less than ideal [39, 40]. Eating behaviors are frequent, may not be consciously thought about, and may not be the most salient event in everyday life. Thus, if individuals do not complete the dietary self-monitoring in a timely manner, the delayed recording of food intake is subject to recall bias. Records focused on human memory have revealed that recall can be unreliable [41]. Burke et al. [41] have shown high levels of nonadherence to timely self-monitoring among participants using paper diary. Even with the use of a PDA, dietary self-monitoring was often infrequent, delayed, and became increasingly more intermittent and delayed over time with the interval between the eating and recording behaviors increasing over time [42]. Through the use of electronic paper diaries and the PDA, Burke and colleagues have demonstrated that not only the amount of recording matters but also the timing of the recording in relation to the eating [40, 42]. Thus, it is important to be consistent and timely in self-monitoring dietary intake. Moreover, it is imperative that the self-monitoring process be made as simple as possible in order to improve consistency and compliance. The emerging technologies may simplify this process and improve outcomes.

The validity of dietary reporting remains a major problem that technology may not resolve. It is well known that many individuals tend to underestimate their food, nutrient, and related energy intake [43]. Yon et al. [44] reported that the use of the PDA did not improve validity of energy reporting with 41 % of participants under-reporting their energy intake. Although PDA- or computer-based self-monitoring approaches offer a number of options to improve recording adherence (saved meals, calculating subtotals, reminders), individuals must select appropriate foods, record all the foods consumed, record in a timely manner, and estimate portion sizes accurately. According to Beasley et al. [22], many of the errors from food diaries come from inaccurate portion estimation, and PDA-based programs have no benefits over paper-based approaches in reducing this source of error [45]. Regardless of the self-monitoring method used, we still need to address the knowledge gap about food portion sizes and develop strategies to improve the skill of portion size estimation among individuals wishing to manage their weight and improve their eating habits and diet quality.

The observed decline in adherence to dietary self-monitoring over time [46, 47] suggests a need for innovative strategies to enhance adherence. A study by Shay et al. [48] reported better adherence to dietary self-monitoring when participants used their preferred self-monitoring method. Hence, it may be important to encourage more individualized approaches to try different self-monitoring methods until participants feel comfortable with the method that works for them. This tailored approach would include self-determined dietary goals, variation of approaches to personal preferences, and refocusing the practical procedure of improving diet quality and creating an environment where clients and professionals work together in partnership. Therefore, offering individuals a choice of self-monitoring approach may be an important tool to promote adherence, which in turn may improve food choices or diet quality over time.

Conclusions

Although technology-based applications for dietary self-monitoring are still relatively new, the rapid proliferation of these programs presents new possibilities and also new challenges. Mobile technologies can be useful tools for assessing dietary intake and diet quality. Additionally, the automatic feedback that is presented in the software with the display of current intake in relation to goals serves as a means to increase one's awareness of progress toward daily goals. However, there is a serious need for an evidence base for these self-monitoring programs. As industry is far ahead of the science in this field, we need to conduct randomized trials and establish the efficacy of these programs. Moreover, studies are needed to assess efficacy of their use in diverse populations and in their long-term use for weight loss or improved dietary self-management.

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26 A Systematic Review of Peer-Reviewed Studies on Diet Quality Indexes Applied to Old Age: A Multitude of Predictors of Diet Quality

Heinz Freisling, Viktoria Knaze, and Nadia Slimani

Key Points

- This review examines 45 different factors associated with diet quality in old age.
- The different factors were categorised into six domains: socio-demographic, health, lifestyle, psychosocial, social-environmental and physical-environmental.
- A number of factors in all six domains were significantly associated with diet quality in older adults.
- Possible strategies to improve diet among elderly, particularly the men, the overweight and obese individuals and those with lower educational levels may improve nutrition knowledge or encourage the use of food labels with more targeted nutrition education messages in these population groups.
- Formulation of dietary guidelines should take into account the impaired health of older individuals.
- Age-friendly local food environment such as close proximity and accessibility of local food stores may also help to ensure good-quality diet in older adults.
- Factors that need further improvement in how they are measured or defined particularly include ethnicity, oral health and the local food environment. Furthermore, living arrangement rather than marital status may be a better indicator of social environment in older adults.
- The factors identified as related to diet quality in older adults have yet to be measured longitudinally in order to update the current evidence.

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V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health, DOI 10.1007/978-1-4614-7315-2_26, © Springer Science+Business Media New York 2013

Keywords
Diet • Diet quality index • Older adults • Healthy ageing • Old age • Elderly

Abbreviations

24-HR	24 Hour dietary recall
BMI	Body mass index
DAS	Dietary Adequacy Score
DDS	Dietary Diversity Score
DGI	Dietary Guideline Index
DQI	Dietary Quality Index
EDI	Elderly Dietary Index
FFI	Food Frequency Index
FFQ	Food Frequency Questionnaire
HDS	Healthy Diet Score
HEI	Healthy Eating Index
HRT	Hormone replacement therapy
WHO	World Health Organization

Introduction

High prevalence of chronic diseases worldwide is observed and is steadily increasing. According to the World Health Organization (WHO), chronic diseases that are related to diet and nutrition, such as obesity, diabetes, cardiovascular diseases, osteoporosis and cancer, present the greatest, but still preventable, public health burden to the modern society [1].

At the same time, public health professionals are increasingly more faced with the considerable shift in the age structure of a population, where older adults, commonly defined as those of the age of 60 and over, comprise the fastest growing proportion worldwide [2]. In this age group, chronic diseases are the leading causes of morbidity, disability and mortality. However, disabilities and the onset of chronic diseases can be prevented or delayed. According to the life-course perspective of the WHO, there is an absolute benefit for ageing individuals and populations in changing at least some risk factors and adopting health-promoting behaviours, such as healthy diets, which often leads to an increased independence in older age [1].

In order to provide nutrition policy makers with a solid and evidence-based knowledge to implement appropriate public health strategies aimed at improving diets, the most important factors that influence dietary behaviour in this population group need to be identified and the reasons for these associations better understood.

A summary measure of diet, such as a diet quality index, has advantages when exploring possible associations between diet and multiple characteristics of interest such as socioeconomic and demographic factors, nutritional knowledge, beliefs, attitudes and other variables. Indexes of overall diet quality are described in the literature as an alternative approach to using single foods or food groups and nutrients with the purpose to assess diets. Indexes of diet quality, which are based on a priori-defined compliance with food and/or nutrient-based dietary guidelines, shall be distinguished from dietary patterns, which are derived a posteriori using statistical techniques like cluster or principle component analyses [3, 4]. Several indexes of diet quality have been developed using three major approaches: *nutrient-based*, *food-* or *food-group*-based and indexes based on a combination of both, nutrients and foods [3, 4].

Many studies have since been published assessing diet in such a holistic way and relating it to possible determinants. However, to bring forward a scientific argument conducive to undertaking specific health initiatives, a comprehensive overview of the available evidence is needed.

In response to that need, a systematic review of peer-reviewed studies that used predefined diet quality indexes to examine associations between diet quality and factors associated with diet among elderly populations (aged 60 years and older) was carried out in Medline up to March 2012. The aim was also to reveal possible reasons for the observed associations, which in turn may facilitate in (re-)developing public health strategies. Studies that did not use a summary index of diet quality are not discussed here.

Summary of Findings

The initial search yielded 63 articles, which were further evaluated regarding the inclusion criteria. This resulted in a set of 30 articles acceptable for inclusion.

Almost all of the 30 studies (Table 26.1) were conducted in high-income countries (i.e. Australia, Austria, Canada, Croatia, Cyprus, Sweden, the United Kingdom and the USA), except one study from Brazil [5]. The studies were quite heterogeneous in the sample size, ranging from 108 to 6,525 subjects [5–34]. Ten of the 30 studies were representative at the national level [8, 18, 21, 23, 24, 27, 28, 30–32, 34]. Two studies were prospective, community-based cohort studies [11, 30]. Of those two, Arabshahi et al. [30] evaluated the change in diet quality and associated factors over three points in time (i.e. 1992, 1996 and 2007). Three studies included women only [17, 26, 27] and 1 study included men only [15]. About half of the studies also included subjects younger than 60 years of age [6–8, 12, 17, 19–22, 24, 26–28, 30, 31].

In 15 of the 30 studies, instruments assessing long-term dietary intake such as food-frequency questionnaires (FFQ) and diet history questionnaires were used as the primary dietary assessment methods [11, 13–15, 17, 19, 21–25, 27, 29, 30, 33]. In the remaining studies, short-term instruments, mostly (repeated) 24-hour dietary recalls (24-HRs), were administered [5–10, 12, 16, 18, 20, 26, 28, 31, 32, 34].

Individual food and/or nutrient intake was estimated from these methods and diet quality indexes were calculated thereafter. In total, ten different indexes of diet quality were used. The components and main characteristics of these indexes are summarised in Table 26.2.

What these indexes have in common is that they are all based on the current nutrition knowledge and attempt to reflect contemporary dietary guidelines (e.g. food guide pyramids) and thus diet quality [4].

In the present review, associations between diet quality, as the outcome (dependent variable), and a total of 45 different factors (independent variables) were evaluated. These factors were categorised into the following six domains (Table 26.3): (1) *socio-demographic factors*, (2) *health factors*, (3) *lifestyle factors*, (4) *psychosocial factors*, (5) *social environment* and (6) *physical environment*.

In the following sections, the findings from the individual studies are examined and described in greater detail using the categorisation of predictors of dietary behaviour mentioned above and summarised in Table 26.4.

Socio-Demographic Factors

Diet quality was consistently better in women as compared to men, independently of the diet quality index used [6, 7, 16–18, 22, 30]. Only four studies (out of 30) found no significant differences in diet quality between men and women [5, 14, 20, 23]. In a longitudinal analysis, diet quality over time improved similarly in both men and women [30].

Associations with the age variable were less consistent. While four studies found better diet quality in older age groups (65 years and older) [7, 15, 27, 30], two studies reported that the quality of diet decreased with age (86 years and older and 75 years and older, respectively) [22, 32]. Other studies found no association [5, 13, 17, 18, 20, 23]. Improvements in diet quality over time were the highest in men of 45–54 years of age at baseline, while in women the age group was 35–44 years. In the age groups 55 years and older, improvements in diet quality were less pronounced in men and even decreased in women [30].

Ethnicity was found to be associated with diet quality, but the results were rather inconsistent. It is noteworthy that only studies conducted in the USA and the study from Brazil included ethnicity in their evaluations. Even though in a nationwide sample the US non-Hispanic whites were

Table 26.1 Characteristics of the studies included in the review ordered by year of publication

No	References	Country, region	Population	Sample size (n)	Type of study
1	Davis et al. [6]	USA	50 years and older	6,525	Cross-sectional survey
2	Shinkai et al. [7]	USA, Texas	37–81 years	731	Cross-sectional survey
3	Sahyoun and Krall [8]	USA	50 years and older	4,820	Cross-sectional survey
4	Bailey et al. [9]	USA, Pennsylvania	65 years and older	181	Cross-sectional survey
5	Ledikwe et al. [10]	USA, Pennsylvania	65 years and older	179	Cross-sectional survey
6	Lee et al. [11]	USA, Pittsburgh and Memphis	70–79 years	2,708	Prospective community-based cohort
7	Shatenstein et al. [12]	Canada, Quebec	55–75 years	460	Cross-sectional survey
8	Maynard et al. [13]	UK, Cambridge	61–80 years	1,234	Cross-sectional survey
9	Cabrera et al. [14]	Sweden, Goteborg	70 years and older	554	Cross-sectional survey
10	Shannon et al. [15]	USA, 6 US regions	Men 65–100 years	5,928	Cross-sectional survey
11	Vitolins et al. [16]	USA, South Carolina	65 years and older	122	Cross-sectional survey
12	Boynton et al. [17]	USA, Seattle	Women 50–75 years	172	Cross-sectional survey
13	Ervin [18]	USA	60 years and older	3,060	Cross-sectional survey
14	Freisling and Elmadfa [19]	Austria, Vienna	55–98 years	444	Cross-sectional survey
15	Johnson et al. [20]	USA, Mississippi	55 years and older	561	Cross-sectional survey
16	Moore et al. [21]	USA	45–84 years	2,384	Cross-sectional survey
17	Freisling et al. [22]	Austria, Vienna	55–98 years	444	Cross-sectional survey
18	Kourlaba et al. [23]	Cyprus	65 years and older	668	Cross-sectional survey
19	Moore et al. [24]	USA	45–84 years	5,633	Cross-sectional survey
20	Savoca et al. [25]	USA, southern regions	60 years and older	635	Cross-sectional survey
21	Grimstvedt et al. [26]	USA, Arizona	Women 55 years and older	108	Cross-sectional survey
22	Jovanovic et al. [27]	Croatia	Women 51–82 years	124	Cross-sectional survey
23	O'Neil et al. [28]	USA	51 years and older	6,237	Cross-sectional survey
24	Savoca et al. [29]	USA, southern regions	60 years and older	635	Cross-sectional survey
25	Arabshahi et al. [30]	Australia	25–75 years	1,511	Prospective community-based cohort
26	Chen et al. [31]	USA	50–65 years	1,684	Cross-sectional survey
27	Holmes and Roberts [32]	UK	65 years and older	662	Cross-sectional survey
28	Quandt et al. [33]	USA, North Carolina	60 years and older	622	Cross-sectional survey
29	Rehm et al. [34]	USA	20–75 years and older	1,155	Cross-sectional survey
30	Da Costa Louzada et al. [5]	Southern Brazil	60–90 years	228	Cross-sectional survey

found to have higher diet quality as compared to non-Hispanic blacks or Mexican-Americans [18], this observation was not consistent in all the studies conducted in the USA. For instance, Savoca et al. [25] found a higher diet quality in African-Americans as compared to non-Hispanic whites living in southern regions of the USA. In a representative regional survey conducted in the Lower Mississippi Delta, non-Hispanic African-Americans were found to have lower-quality diets as compared to the white respondents [20]. Shinkai et al. [7] reported a better diet quality in

Table 26.2 Characteristics of the diet quality indexes included in the review in alphabetical order

Diet quality index	Number and nature of components	Components	Measurement	Studies using respective index
AHEI	4 food groups, 4 nutrients, 1 other	Fruits, vegetables, nuts, ratio of red to white meat, ratio of polyunsaturated to saturated fat, cereal fibre, *trans*-fatty acids, alcohol, multivitamin use	Quantitative food and nutrient intake	[21, 24]
DDS/DAS	4 food groups	Milk products, meat and alternatives, grain products, fruits and vegetables	Count of reported food groups	[12]
DGI	12 food groups, 3 others	Food variety, vegetables, fruit, wholegrain cereals, meat and alternatives, dairy foods, low-fat/reduced-fat dairy, fluids, salt use, saturated fat intake, alcoholic beverages, added sugars, 'extra foods'	Quantitative food intake (+ frequency)	[30]
DQI	2 food groups, 6 nutrients	Saturated fat, total fat, dietary cholesterol, fruits and vegetables, breads, cereals and legumes, protein, sodium, calcium	Quantitative food and nutrient intake	[14, 17, 32]
DQI-R	3 food groups, 5 nutrients, 2 others	Saturated fat, total fat, dietary cholesterol, fruits, vegetables, whole grains, calcium, iron, dietary diversity, dietary moderation	Quantitative food and nutrient intake	[15]
EDI	10 food groups	Meat, fish and seafood, vegetables, cereals, fruit, legumes, olive oil, alcohol, dairy, bread	Frequency of food intake	[23]
FFI	10 food groups	Rice and pasta, wholegrain bread, vegetables, fruits, pulses, nuts, milk products, beef and pork, poultry, processed meats	Frequency of food intake	[19, 22]
HEI	5 food groups, 4 nutrients, 1 other	Saturated fat, total fat, dietary cholesterol, sodium, grain, fruit, dairy, meat, vegetables, dietary variety	Quantitative food and nutrient intake	[5, 7–11, 16–18, 20, 25–29, 31, 33, 34]
HDS	4 food groups, 8 nutrients	Saturated fat, polyunsaturated fat, protein, total carbohydrates, dietary fibre, dietary cholesterol, calcium non-milk extrinsic sugars, fruit and vegetables, fish, pulses and nuts, red meat and meat products	Quantitative food and nutrient intake	[13]
Nutrient adequacy	15 nutrients	Protein, thiamine, riboflavin, niacin, folate, vitamins A, C, E, B-6 and B-12, iron, zinc, calcium, phosphorus and magnesium	Quantitative nutrient intake	[6]

AHEI Alternate Healthy Eating Index, *DAS* Dietary Adequacy Score, *DDS* Dietary Diversity Score, *DGI* Dietary Guideline Index, *DQI* Dietary Quality Index, *DQI-R* Dietary Quality Index-Revised, *EDI* Elderly Dietary Index, *FFI* Food Frequency Index, *HEI* Healthy Eating Index, *HDS* Healthy Diet Score

Table 26.3 Different factors (independent variables) evaluated in relation to diet quality in older adults by six domains

Socio-demographic	Health	Lifestyle	Psychosocial	Social environment	Physical environment
Age	BMI	Smoking	Intention to lose weight	Education	Rural area
Gender	Oral health	Physical activity	Weight loss attempts	Occupation	Local food environment
Ethnicity	Gastrointestinal problems	Alcohol consumption	Intentional weight loss	Income	Neighbourhood fast-food exposure
	Rheumatoid arthritis	Dietary supplement use	Nutrition knowledge and believes	Marital status or living arrangement	Main type of food shop used
	Chronic bronchitis	Energy intake	Food label use	Housing tenure	
	Long-standing illness or disability	Eating habits	Cooking skills	Social class/socioeconomic status	
	Diet-related chronic diseases	Wholegrain consumption	Social support	Diet costs	
	Medical condition	Dietary patterns	Childhood vegetable consumption		
	Appetite	Current use of HRT	Dietary/health attitudes		
	Medication		Self-perceived health		
			Family history of cancer		
			Parity		

Table 26.4 Associations of diet quality indexes with different factors (independent variables) in older adults ordered by the date of publication

No	References	Index	Dietary method	Factors studied	Results
1	Davis et al. [6]	Nutrient Adequacy	2*24-HDR	Living arrangement, education, physical activity, smoking, alcohol consumption, supplement use	Although middle-aged and older adults with living arrangements other than living with a spouse only (including those living alone) tended to have poorer dietary quality, the effects varied substantially across age, gender and ethnic categories; diet quality positively associated with higher education, exercise frequency, dietary supplement use, non-smoking, nondrinking
2	Shinkai et al. [7]	HEI	2*24-HDR	Oral health, gender, ethnicity, age, income, education	Oral health-related factors not associated with diet quality; diet quality positively associated with being female, European-American vs. Mexican-American, older than 65 vs. younger; no significant association with income and education
3	Sahyoun and Krall [8]	HEI		Oral health	Lower index scores associated with self-perceived ill-fitting dentures
4	Bailey et al. [9]	HEI	5*24-HDR	Oral health	Lower index scores associated with oral health problems
5	Ledikwe et al. [10]	HEI	5*24-HDR	Dietary patterns	Higher index scores associated with high-nutrient-dense pattern
6	Lee et al. [11]	HEI	FFQ	Intention to lose weight	Higher index scores associated with intention to lose weight
7	Shatenstein et al. [12]	DDS, DAS	24-HDR	Age, education, income, marital status, living arrangement, BMI, eating habits, social support, supplement use, smoking, health attitudes	Higher index scores associated with breakfast consumption, eating commercially prepared meals, social support, not consuming dietary supplements (men), not eating commercially prepared meals, health concerns, eating more than 3 meals daily (women + men)
8	Maynard et al. [13]	HDS	FFQ	Childhood vegetable consumption, social class, housing tenure, income, smoking, self-perceived health, BMI, anti-hypertensive/cardiovascular medication, chronic bronchitis	Higher index scores associated with childhood vegetable consumption, social class, housing tenure (owned outright associated with better-quality diets), smoking, hypertensive/cardiovascular medication, chronic bronchitis; not associated with self-reported general health, income, social class
9	Cabrera et al. [14]	DQI	DHQ	Education, socioeconomic index, smoking, physical activity	Higher index scores associated with higher education and socioeconomic index, but in men only; lower index scores for smokers and physically inactive elderly
10	Shannon et al. [15]	DQI-R	FFQ	Age, ethnicity, BMI, marital status, education, smoking, physical activity, dietary supplement use, self-perceived health, energy intake	Higher index scores inversely associated with younger age, very low calorie intake, higher BMI, African-American or Hispanic race, less educated, not using dietary supplements and smoking; no associations with marital status, physical activity and self-perceived health

(continued)

Table 26.4 (continued)

No	References	Index	Dietary method	Factors studied	Results
11	Vitolins et al. [16]	HEI	6*24-HDRs	Rural area, gender, ethnicity, age, education, income, living arrangement, self-perceived health, BMI	Lower index scores associated with lower education (in men), male gender, rural adults in general; no associations with BMI, self-perceived health, living arrangement, income, age, ethnicity
12	Boynton et al. [17]	DQI, HEI	FFQ	Education, smoking history, income, age, BMI, occupation, marital status, ethnicity, intentional weight loss, alcohol consumption, family history of cancer	Higher index scores associated with higher education and former smoking; no significant associations found with other factors examined
13	Ervin [18]	HEI	24-HDR	Gender, age, ethnicity, education, smoking status, oral health, self-reported health, BMI	Higher index scores associated with being non-Hispanic white, higher education, non-smoker, not being edentulous, self-rated good health, lower BMI
14	Freisling and Elmadfa [19]	FFI	FFQ	Gender, age, education, living arrangement, dietary supplement use, appetite, physical activity, oral health, gastrointestinal problems, medication	Higher index scores associated with being a woman, younger, higher educated, user of dietary supplements, physically active, not having eating difficulties and gastrointestinal problems
15	Johnson et al. [20]	HEI	24-HDR	Rural area, ethnicity, education	Lower index scores associated with ethnicity and education, rural adults in general
16	Moore et al. [21]	AHEI	FFQ	Local food environment: (1) supermarket density, (2) participant-reported assessments, (3) aggregated survey responses of independent informants	Higher index scores associated with best-ranked food environment (having supermarkets near the home)
17	Freisling et al. [22]	FFI	FFQ	Gender, age, education, BMI	Higher index scores associated with being a woman, younger, higher educated; no association with living arrangement
18	Kourlaba et al. [23]	EDI	FFQ	Age, BMI, education, gender, living alone, income, smoking status, physical activity	Higher index scores associated with lower BMI, higher income, higher education, being physically active; no significant association with other factors examined
19	Moore et al. [24]	AHEI	FFQ	Fast-food consumption, neighbourhood fast-food exposure	Higher index scores are inversely related with fast-food consumption and neighbourhood fast-food exposure
20	Savoca et al. [25]	HEI	FFQ	Ethnicity	Higher index scores associated with being African-American as compared to American Indians and non-Hispanic whites
21	Grimstvedt et al. [26]	HEI	7-d FR	Rheumatoid arthritis	Lower index scores associated with living with rheumatoid arthritis
22	Jovanovic et al. [27]	HEI	FFQ	Age, BMI	Lower index scores associated with being younger, normal weight or obese
23	O'Neil et al. [28]	HEI	24-HDR	Wholegrain consumption	Higher index scores associated with higher wholegrain consumption

(continued)

Table 26.4 (continued)

No	References	Index	Dietary method	Factors studied	Results
24	Savoca et al. [29]	HEI	FFQ	Oral health	Higher index scores associated with food modification whereas lower scores associated with food avoidance due to oral health problems
25	Arabshahi et al. [30]	DGI	FFQ	Age, BMI, education, occupation, medical condition, physical activity, smoking status, alcohol consumption, energy intake, weight loss attempts, current use of HRT, parity	Index score improvement over time associated with younger age, higher occupational level (men only), physical activity, HRT in women, parity, other factors not associated
26	Chen et al. [31]	HEI	2*24-HDR	Diet-related chronic diseases, nutrition knowledge and beliefs (NKB), food label (FL)	Higher index scores associated with diet-related chronic diseases, good NKB and use of FL
27	Holmes and Roberts [32]	DQI	4*24-HDR	Living arrangement, cooking skills of the main food provider, long-standing illness or disability limiting shopping and/or food preparation, appetite, oral health, age, smoking status, main type of food shop used, where meals were eaten and with whom	Higher index scores inversely associated with usually eating meals on one's lab as opposed to at the table, difficulty chewing (men), current smoking or 75 years or over (women), less-developed cooking skills
28	Quandt et al. [33]	HEI	FFQ	Dry mouth	No associations between dry mouth and index scores
29	Rehm et al. [34]	HEI	24-HDR	Diet costs	Higher index scores associated with higher energy-adjusted diet costs
30	Da Costa Louzada et al. [5]	HEI	24-HDR	Gender, age, ethnicity, education, income, marital status, diabetes, hypertension, history of cancer, smoking, BMI	Lower index scores associated with being divorced/widowed/single as compared to married; no significant associations with other factors examined

the European-American respondents as compared to the Mexican-American ones in a community-based sample from Texas. No association between diet quality and ethnicity was reported by the other studies [5, 16, 17].

Health Factors

Having a higher body mass index (BMI), notably a BMI above 30 kg/m^2, was related to lower diet quality in most of the studies that examined such associations [12, 15, 17–19, 23, 27]. In four studies, a regional survey in Brazil [5], a cohort in the UK [13] and in two regional surveys in the south of the USA [16, 20], no relationship between BMI and diet quality was found. Additionally, body weight was not associated with a change in diet quality over time [30].

Oral health problems, such as poor dentition status [12], ill-fitting dentures [8], being edentulous [18] and having difficulties with chewing and swallowing [9, 19, 32], were associated with lower diet quality. Dry mouth symptoms, com-

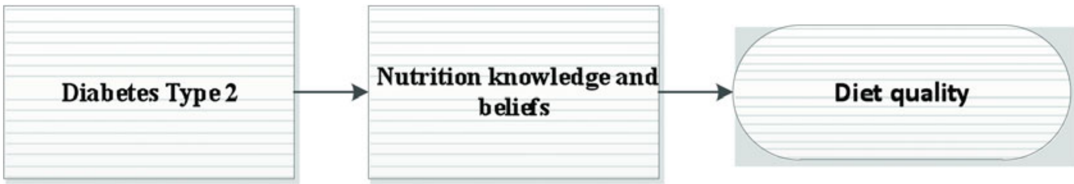

Fig. 26.1 A hypothesised pathway showing that associations between diet-related chronic diseases and diet quality are fully mediated by nutrition knowledge and beliefs (NKB); for instance, older adults with type 2 diabetes who improve their NKB as a consequence of the disease arrive at better-quality diets as compared to those who do not improve their NKB. *Note*: A mediator variable (here, NKB) is assumed to lie in the causal pathway between a given independent variable (here, diabetes type 2) and a given dependent variable (here, diet quality); a mediator variable may either partially or fully explain an observed association

monly experienced by the elderly, were not associated with diet quality in a study with older adults from Texas, USA [33]. Savoca et al. [29] showed that individuals who adapted to impaired oral health by avoiding certain foods were likely to have lower diet quality scores, whereas those who rather modified their food selection in response to oral health problems had higher diet quality scores.

A number of other health conditions were also associated with differences in diet quality. Older adults with gastrointestinal problems [19], rheumatoid arthritis [26] and chronic bronchitis [13] had a lower diet quality. Contrarily, US adults with diet-related chronic diseases (e.g. diabetes) reported a higher diet quality [31]. However, the observed associations were only significant in those patients with good nutritional knowledge. This specific pathway is visualised in Fig. 26.1. The association between the presence of a chronic disease and diet quality was also largely influenced by the patient's *use of food labels* and further depended on the type of diet-related disease. For example, patients with hypertension were less likely to have a high diet quality than patients with diabetes [31]. In older adults from Brazil, neither having diabetes nor hypertension was associated with diet quality [5]. Long-standing illness or a disability that limits shopping and/or food preparation was also not found to be associated with diet quality in materially deprived older people from the UK [32]. Furthermore, a diagnosis of a diet-related medical condition, such as gallstones, high cholesterol, high triglyceride, diabetes, hypertension and others, was not associated with a change in diet quality over time in adults [30].

Older adults from the UK who were receiving treatment for high blood pressure had lower-quality diets [13]. In middle-aged and older adults from Austria, receiving any kind of medication was not associated with diet quality [19].

Having a good appetite was associated with a better diet quality in women but not in men in deprived older adults from the UK [32]. In the Austrian study, no association between having a good appetite and diet quality was found either in women or in men [19].

Lifestyle Factors

A number of lifestyle factors were associated with diet quality. Most consistently, current smokers had poorer diets as compared to former or never-smokers [13–15, 17, 18, 32]. Two studies found no such association [5, 23]. Smoking status was not associated with a change in diet quality over time [30].

Being physically active was related with better diets in four out of five studies including improvements in diet quality over time [14, 19, 23, 30]. Shannon et al. [15] found no association between physical activity and diet quality.

Users of dietary supplements are known to have better diets as confirmed by two studies included in this review [15, 19]. However, there may also be populations where the use of dietary supplements may be associated with a lower diet quality [12].

Two studies that examined the association between diet quality and alcohol consumption (from less than 1 g/d to more than 40 g/d) did not find any association [17, 30].

Eating three or more meals a day, eating breakfast (in men) and eating prepared meals were positively associated with diet quality, while eating with others was not [12]. Furthermore, dietary patterns (high-nutrient-dense pattern) [35], higher wholegrain consumption [28] and higher energy intake [15] were positively associated with diet quality. The improvement in diet quality over time was greater in women who used hormone replacement therapy (HRT) as compared to those who did not [30].

Psychosocial Factors

Of the psychosocial factors examined, diet quality was positively associated with better 'nutrition knowledge and beliefs' and 'use of the food labels' [31], childhood vegetable consumption [13], the intention to lose weight [11], more developed cooking skills of the main food provider living in the household [32] and being able to receive social support [12]. Contrarily to the intention to lose weight mentioned above, intentional weight loss was not associated with a better diet quality [17]. Furthermore, 'weight loss attempts' were not associated with a change in diet quality over time [30].

Self-reported health status was not associated with better-quality diets [13, 15, 16, 18, 20]. Similarly, family history of cancer was not associated with better-quality diets either [5, 17]. However, at least in women who reported that health concerns were motivating their food choices, the diet quality was observed to be better [12].

Finally, women who had children compared to nulliparous women had a greater increase in diet quality over time [30].

Social Environment

Higher educational level was associated with a better diet quality in all studies which included this factor in their evaluations [6, 12, 14–20, 22, 23]. An exception being regional surveys from Texas and Brazil, where no differences in dietary quality were reported across educational levels [5, 7]. Further, education was not associated with a change in diet quality over time [30].

Occupational status (i.e. unemployed, retired, employed) was not associated with diet quality in postmenopausal women from Seattle, USA [17]. Similarly, no significant associations were found between diet quality and occupational social class, based on employment history in the UK [13]. In the same study from the UK, housing tenure was strongly associated with diet quality ('owned' outright associated with better-quality diets as compared to 'mortgaged' or 'rented') [13]. The type of occupation was associated with improvements in diet quality over time in men, but not in women [30].

A better financial status was associated with a better diet quality in older adults from Cyprus [23], but no such association was found in other studies [5, 7, 12, 13, 16, 17, 20].

A socioeconomic index that combines information on education and occupation in the study conducted in Goteborg was positively associated with diet quality in men but not in women [14].

Higher diet quality was positively associated with higher diet costs in US adults; however, older adults (65 years and older), in contrast to younger adults, consumed lower-cost, yet higher-quality, diets [34].

Being married as compared to being divorced, widowed or single was associated with a better diet in Brazilian older adults [5]. Particularly in men, the marital status seems to be a relevant factor, where a lower diet quality was observed in separated or divorced men [15], but not in women [17]. Although middle-aged and older adults with living arrangements other than living with a spouse only (including those living alone) tended to have poorer diet quality, the effects varied substantially across age, gender and ethnic categories [6]. Other studies found no association between diet quality and the marital status or living arrangement [12, 16, 19, 32].

Physical Environment

Older adults living in a rural area have been found to consume diets of poorer quality [16, 20]. This may be partly associated with the local food environment. Better diets were observed for older adults having supermarkets near the home (i.e. best-ranked food environment) [21]. Conversely, a lower diet quality was associated with the exposure to fast foods in the neighbourhood [24]. When the type of shopping locale was assessed in the UK, it was found that doing the main food shopping at a small supermarket rather than a hyper/supermarket was not associated with better-quality diets [32].

Discussion

In the last 12 years, at least 30 studies were published that used some type of a diet quality index to examine the associations between the quality of diet and the factors that may exert an influence on the diet in older adults aged 60 years and above. In this review, which is to our best knowledge the first using the described inclusion criteria, more than 40 different factors were identified and for the present review categorised into *socio-demographic*, *health*, *lifestyle*, *psychosocial*, *social environmental* and *physical environmental* domains.

Of the socio-demographic factors studied, gender was most consistently related to diet quality showing better-quality diets in women as compared to men [6, 16–19, 22, 30]. While this finding is as expected, also in older adults, it is more difficult to conceptualise the possible reasons for this observation. Some possible explanations include sociocultural reasons (e.g. women usually have more developed cooking skills), psychological reasons (e.g. women may be more concerned about their health) and/or behavioural reasons (e.g. women drink less alcohol than men) [36].

Less consistent were the results with regard to age and ethnicity, suggesting that other factors may be more important or may modify these associations in older populations. Nevertheless, age is an important variable to consider in dietary studies. Similarly, ethnicity is generally considered a strong predictor of health outcomes and behaviours [36]. Conflicting results with regard to age may relate to the fact that the gap between chronological and biological age can be large in older people and age as a single measure becomes less informative. This may be defined as the differences in deficits associated with ageing between individuals [37]. Considering an indicator of biological age in older adults, for example, a frailty index [37], in future health research may be worthwhile to consider. Conflicting results with regard to ethnicity may be partly explained by the encountered problems related to measurement and classification, which is not always straightforward, particularly in the cases where a subject is of mixed ethnicities. For instance, the same subjects may classify their ethnicity differently in different surveys [36].

In older populations, higher rates of health problems may have a considerable impact on diet through various pathways. Thus, it was not surprising that a number of health factors were significantly associated with diet quality.

Older adults that were overweight or obese had poorer diets [15, 17–19, 23, 27]. While it is unlikely that being overweight is a causal factor of a poor diet (rather the other way around), the BMI seems to be an important indicator of diet quality in the least.

Unlike the BMI, health problems such as poor oral health, gastrointestinal problems or rheumatoid arthritis may be more directly linked to a poor diet. An important finding with respect to oral health is that older adults who adapted to impaired oral health through avoiding certain foods were likely to have a lower diet quality, while those who modified their food selection in response to an impaired oral health had better diets [29]. If this finding can be generalised also to other health factors, it may have important implications in formulating public health strategies for this population. For instance, gastrointestinal problems may also lead to an avoidance of certain foods that in turn may result in a suboptimal diet. Furthermore, it is conceivable that rheumatoid arthritis impedes food preparation (e.g. cutting of food).

Of the lifestyle factors examined, smoking status was most consistently associated with diet quality. As expected, never or former smokers had a superior diet quality as compared to current smokers [13–15, 17, 18, 32]. Only 2 of 7 studies found no association between smoking status and diet quality [5, 23]. The associations with diet quality may be explained by a healthier lifestyle in general, including better-quality diets. As suggested by Boynton et al. [17], former smokers may have made a conscious decision toward a healthier lifestyle. A 'clustering' of healthful lifestyle behaviours is partly confirmed by the studies that reported positive associations between diet quality and physical activity levels [14, 19, 23, 30], though not all found a statistically significant association [15]. Furthermore, users of dietary supplements had better-quality diets [15, 19]. However, Shatenstein et al. [12] found an inverse association and suggested that supplements in Quebec older adults may have been used to consciously improve a poor diet. Alcohol consumption appears not to be related to diet quality [17, 30].

Six of the eight psychosocial factors examined were positively associated with diet quality indicating the importance of these factors. This goes along with the need to conceptualise these variables better because they are usually complex constructs and difficult to measure. Psychosocial variables can be seen to be in-between the pathway of diet and other more distal factors such as gender or education. For instance, women with better cooking skills or nutritional knowledge as compared to men may have better diets. It was also interesting to note that older adults who indicated an intention to lose weight had a better diet quality than did older adults without a weight loss intention [11]. Whereas postmenopausal women who actually lost weight intentionally did not differ in their dietary quality profile from the women who did not [17]. Lee et al. [11] suggested that weight loss intention might reflect an overall healthy lifestyle and is independent of the actual achieved weight loss.

Among the factors describing the social environment, educational attainment was most often used and virtually all of these studies described a positive association with diet quality [14, 17–20, 22, 23]. That improvement of diet quality over time was indifferent with regard to educational attainment [30] may suggest that greater efforts are needed to close the gap in diet quality between individuals with lower and higher education.

In relation to diet, the educational level may influence food choices by facilitating or constraining one's ability to understand nutrition education messages or dietary guidelines [38]. Reasons for the frequent use of education as an indicator of the social environment in older populations may include the ease of measurement, the applicability for subjects no longer in the labour force (e.g. retired) and the stability over lifespan. However, potential disadvantages should also be pointed out: first, changes in the economic well-being during adulthood may not be captured; second, the variability in educational levels is far lower than the range of income or wealth, which may decrease sensitivity; and third, the educational attainment varies by age cohort of the individual [39, 40].

Occupation is considered to be related to different exposures, and diet may be influenced through work-based cultures and social networks [40, 41]. However, in older adults, the proportion of people not anymore in the labour force is usually high; thus, occupational class may be a less relevant measure. This is probably the reason why only two studies included in the present review used occupation as an indicator for the social environment. Maynard et al. [13] found an association with employment history in women, but not in men. The second study evaluating occupation found no association between current employment status (unemployed, retired, employed) and diet quality [17].

Income was only used in 4 of the 30 studies, maybe because it is a sensitive and private topic in our society and the nonresponse can be high. Of those four studies [5, 13, 17, 23], only one found a positive association between income and a better diet quality [23]. Among the possible reasons for an absence of an association is that higher-quality diets are not necessarily related to higher diet costs, at least in older adults [34].

Marital status or household composition is also sometimes used as an indicator of the social environment. Either to expand other measures (e.g. household income applied to persons in the household not having a regular income) or to be used as a variable on their own right (e.g. married persons tend to have better diets) [36]. Five studies (of 30) used this measure to examine associations with diet quality, and findings suggest that marital status matters with regard to diet quality in older adults, especially in men [15]. However, the observed associations varied substantially across age, gender and ethnic groups [6, 15, 17, 23, 32]. Furthermore, in our current societies, marital status may increasingly provide little information with regard to the actual living arrangements [36] and misclassification is becoming increasingly problematic considering the worldwide trend for older people to live alone, in a retirement home or other.

Age-friendly physical environments can make a difference between independence and dependence for older people. Accessible and affordable public transport in urban and rural areas and location of housing (proximity to family members, services, food stores, etc.) can have an influence on diet quality. Different indicators for local food environments in relation to diet quality were evaluated in five studies [16, 20, 21, 24, 32]. Living in a rural area was associated with poorer diet quality [16, 20]. One possible reason being a limited accessibility to food stores. It has been shown that having supermarkets near the home was positively associated with diet quality [21]. A nationally representative survey in materially deprived older adults in the UK who were doing their main food shopping at a small supermarket was not associated with diet quality [32]. However, assessing the local food environment with a single question does not seem to capture this aspect properly. Supporting evidence for the importance of the local food environment is that the association with diet quality can be bidirectional. Older adults being exposed to a fast-food environment had a poorer dietary quality [24]. Overall, the physical environment is an important factor to consider in nutrition studies, but more consistent and comprehensive definitions for its measurement are warranted. Using the indicators described by Moore et al. [21] seems to be a good way forward to measure the local food environment.

Conclusions

Factors that influence diet quality in older adults are manifold, and they are interrelated in a complex way (Fig. 26.2). The use of well-defined and validated diet quality indexes (DQI) as a summary measure for the overall diet quality facilitates the study of multiple interrelated factors and its association with diet. Diet quality indexes also facilitate comparisons across different studies and countries. Such indexes are usually based on the same concept, i.e. to reflect contemporary dietary guidelines for a given population. However, one has to keep in mind that the validity of a given index applied may vary between studies, which may at least partly explain the observed inconsistencies between the studies. It also has to be noted that the conclusions drawn may not be generalisable to the populations of low- or middle-income countries as studies included in this review were performed in high-income countries and regions of the USA, Europe and Australia, with the exception of one regional survey of southern Brazil. Furthermore, all reviewed studies were of observational nature; thus, no causal conclusions from the results can be drawn.

The elderly population is more heterogeneous in terms of functional capacity, physical conditions, and social, economic and lifestyle situations than any other age group, and individual diversity tends to increase with age. This diversity adds an additional dimension in identifying

Fig. 26.2 The interrelationship between multiple factors of different domains and diet quality in older adults. *Note*: Diet quality is assumed to be the dependent variable (all *arrows* leading to diet quality), without implying causality, and the different factors are considered predictors that are themselves interrelated (thus, *arrows* are in both directions)

factors that are associated with diet in older adults. For example, a relationship between age and diet quality of an individual can be influenced to a different degree by the presence or absence of a particular medical condition, the individual nutritional knowledge, the local food environment and other factors (Fig. 26.3).

Nevertheless, a multitude of factors associated with diet quality in older adults were identified. Based on these findings, a number of conclusions and recommendations can be derived.

First, more efforts are needed to improve diet among elderly, particularly the men, overweight and obese individuals and those with lower educational levels. Possible strategies to amend this observed inequality may aim to improve nutrition knowledge or encourage the use of food labels with more targeted nutrition education messages in these population groups.

Second, health conditions that may directly affect food selection, such as impaired oral health or gastrointestinal problems, are important to consider in advising healthy diets. Ignoring health conditions of an individual in dietary guidance may lead to food avoidance and in turn to a poorer diet. The formulation of dietary guidelines should take into account the impaired health of older individuals. This also points to a more individualised dietary counselling.

Third, poor diets tend to be clustered with other unhealthy behaviours such as smoking or being physically inactive. Since former smokers tend to have better diets as compared to current smokers, strategies that lead to the cessation of smoking may indirectly also exert a positive effect on diet. Similar effects may be expected with strategies aiming to increase physical activity.

Fourth, age-friendly local food environment such as the proximity and accessibility of local food stores may also help to ensure good-quality diet in older adults.

Fifth, for future research and dietary surveillance and monitoring purposes, more consistent and improved assessment of a number of these factors is needed. Factors that need further improvement in how they are measured or defined particularly include ethnicity, oral health, and the local food environment. Furthermore, living

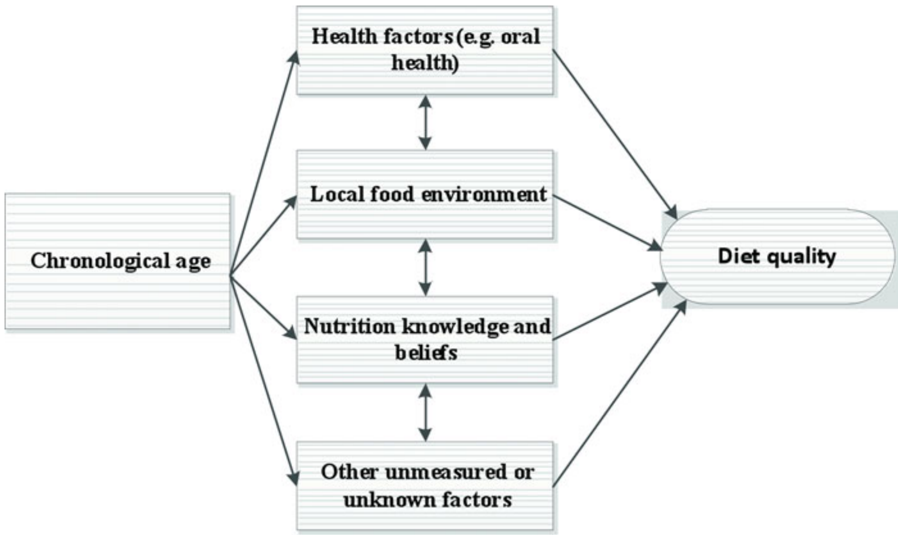

Fig. 26.3 Hypothesised pathways showing that associations between chronological age and diet quality are fully mediated by a number of different factors; depending on the presence or absence of a given factor, associations between chronological age and diet quality may vary considerably. *Note*: A mediator variable (here, e.g. local food environment) is assumed to lie in the causal pathway between a given independent variable (here, chronological age) and a given dependent variable (here, diet quality); mediator variables may either partially or fully explain an observed association

arrangement rather than marital status may be a better indicator of social environment in older adults.

All the factors presented herein, especially those found to be associated with diet quality, also need to be measured longitudinally to update the current evidence.

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27 System of Indicators for the Nutritional Quality of Marketing and Food Environment: Product Quality, Availability, Affordability, and Promotion

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Key Points

- We propose a system of indicators for the nutritional quality of the marketing and food environments in terms of product quality availability, affordability, and promotion.
- Indicators in the systems are constructed by observing marketing activities at the stockkeeping unit (SKU) level and by geo-coding the stores and media through which the marketing activities occurred.
- Our system constructs a diagnostic tool to assess the nutritional quality of the food environment created by marketing activities at community, city, provincial/state, national, and global levels. The environment and these marketing activities could then be examined in relation to behavioral, BMI, and health outcomes at the same levels of aggregation.
- We operationalize the indicators with marketing research data in Quebec as an example.

Keywords

Food marketing • Availability • Affordability • Promotion • Nutritional quality of marketing • SKU • Geo-coding • Obesity

Abbreviations

FSA Forward sortation area or a geographic region where all postal codes start with the same three letters

SKU Stockkeeping unit or a unique identifier for each distinct product sold in a store

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V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health,
DOI 10.1007/978-1-4614-7315-2_27,

Introduction

An increase in dietary intake along with food marketing and changes in the local, national, and global food systems are considered by many as the primary global drivers of the obesity and non-communicable disease (NCD) pandemics [1]. Empirical evidence from health research [2] has linked long-term change in BMI to consumption of specific food categories. Abundant consumer research exists on the various ways by which the different components of marketing strategies individually and jointly impact food choice (see [3] for a review). However, solid theoretical and empirical foundations remain absent for *which* marketing business practices cause *which* changes in food purchase, consumption, and diet and with *which* obesity and diet-related health consequences. At the same time, facing the pandemic of obesity and diet-related chronic disease, policy makers, researchers, and practitioners have longed for a surveillance system that can describe and monitor food marketing activities at various levels to support research and decision making. More research about food marketing and health outcomes can then be conducted to better inform policy and intervention aimed at preventing child and adult obesity and their chronic disease sequel. Yet, there is not much solid insight on how such a system should be implemented.

Therefore, we propose a system of indicators for the nutritional quality of marketing and food environments in terms of product quality, availability, affordability, and promotion. Marketing information is regularly collected for the commercial purpose of observing short-term and long-term impacts of marketing strategies as well as for monitoring changes in consumer demand and market conditions. The proposed indicators are constructed from such information about marketing activities at the stockkeeping unit (SKU) level and by geo-coding stores and media through which they are marketed. This allows for a very thorough and comprehensive diagnostic of the nutritional quality of the food environment on a community-by-community basis. Furthermore, the geo-coding enables aggregation of indicators from community to city, provincial/state, national, and global levels and can link the nutritional quality of marketing to behavioral, BMI, and health outcomes at the same levels of aggregation. Using Quebec as an example, we illustrate how to operationalize the indicators with marketing research data. The resulting system enables researchers and practitioners to monitor marketing activities and link them to diet quality and health outcome. Policy makers can also use the generated evidence to create effective industry regulations and interventions.

Background and Indicator Construction

Market Surveillance System

Market surveillance in a commercial context is used to understand consumer needs, monitor competition, and design optimal marketing strategies. A market surveillance system, in specific, is used to monitor long-term changes in the appeal of a firm's offerings through the regular selection, collection, and processing of data on the market and its actors. Market surveillance systems differ depending on its coverage (companies, competitors, end users, etc.), on the current and future strategies implemented, on the market under study, and on the regularity and aggregation level of the data collected [4]. Advancement in marketing science has allowed marketers to use sophisticated modeling and data analysis techniques to understand how marketing works. However, despite the usefulness of such a system and although marketing activities are obviously one of the core drivers of many other social issues, applications are rare outside of the business context. In the health domain, researchers and practitioners have begun to realize the important role of food marketing on obesity and NCD pandemics [1], and many studies have incorporated simple measures of food marketing, such as the number of grocery stores nearby or amount of exposure to television advertising, to explain food consumption and health outcome [5–7]. But these measures only represent a small

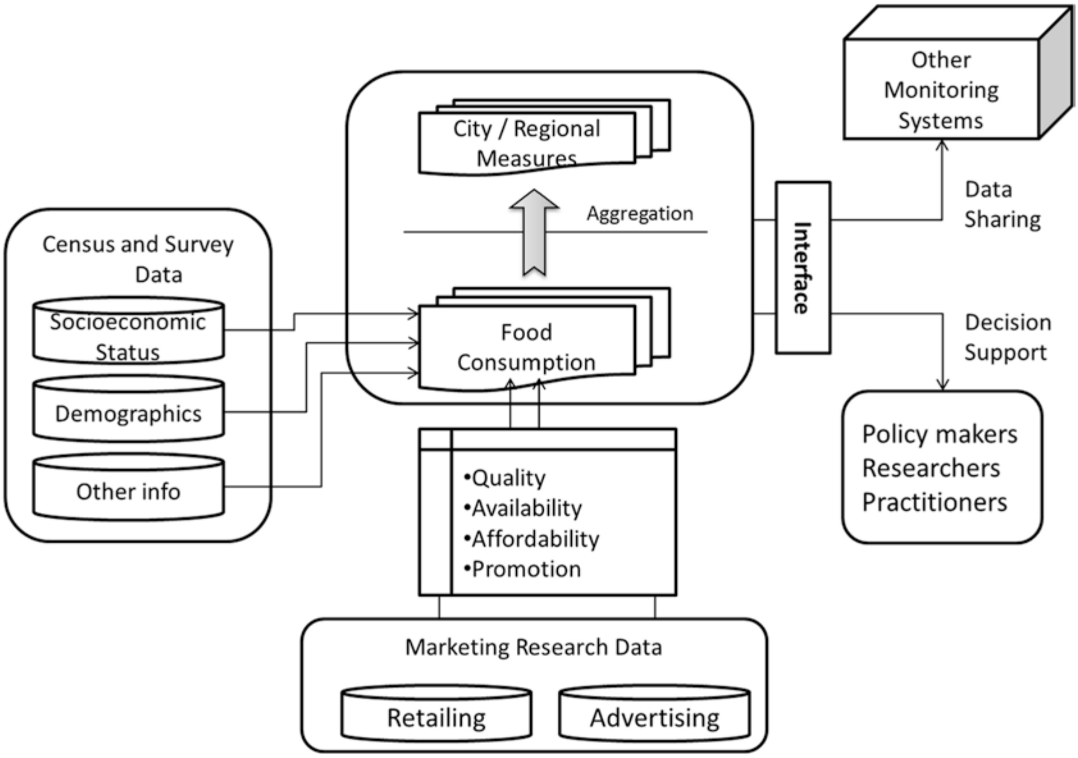

Fig. 27.1 Architecture. The figure shows the architecture of the real-time food marketing informatics platform. It utilizes the rich information embedded in modern marketing research databases to track food marketing activities at multiple levels (unpublished)

part of typical food marketing activities and do not take advantage of the well-developed marketing science literature, models, and techniques. We hope to address this gap by proposing a real-time food marketing informatics platform that utilizes the rich information embedded in modern marketing research databases to track food marketing activities at multiple levels: community, regional, and more. Figure 27.1 illustrates the architecture of the entire system. Policy makers, researchers, and practitioners are among the potential users who can submit queries to obtain trends, forecasts, and predictions on food marketing activities as well as link these pieces of information to health surveillance systems and databases through a data sharing interface.

Two unique characteristics distinguish the proposed system from previous applications. First, we capitalize on the rich information in commercial marketing research data. Marketing research data is routinely collected by major national marketing research companies, and they provide timely information covering major business activities in an incredible amount of detail. For instance, in the application discussed in a later section, we observe price, price discount, and in-store promotion at the SKU level—i.e., every unique item on the shelf—within each store. We can reconstruct, within the data duration, the exact product assortment, variety, prices, promotions, and even advertising exposure facing a typical consumer in a given community. Using the vast amount of information, coupled with our aggregation method based on modern marketing science, we are able to capture variations of food marketing activities far better than existing measures in health research. Second, we use geo-coding to link our food marketing data to communities. We use the FSA (forward sortation area) as the unit of community (a finer resolution such as census

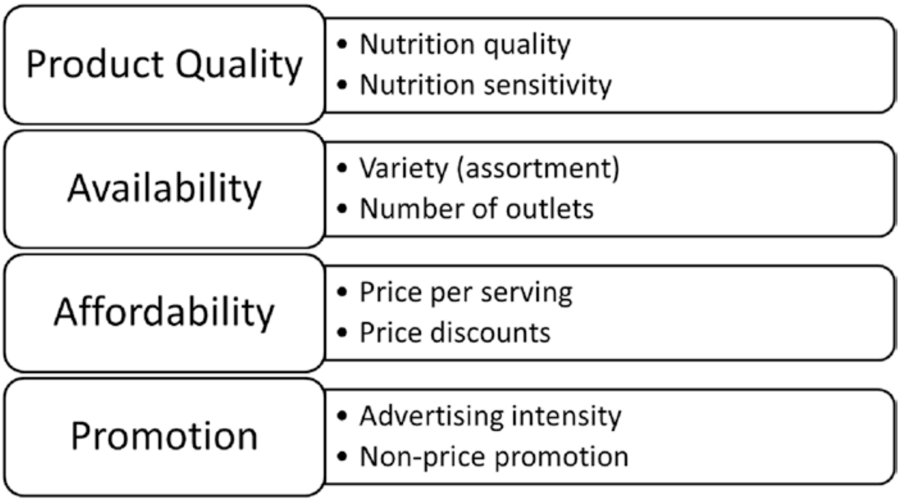

Fig. 27.2 Food marketing indicators. The figure lists all the proposed food marketing indicators (unpublished)

track level would have been used if data were available at that level). Similar systems have been used in population health, but none of them deliver timely and representative indicators at a high level of geographical resolution. Depending on the requirement of end users, additional aggregation can be performed to create higher-level indicators at city, regional, and/or other levels.

Marketing Literature and Conceptualization of Food Marketing Indicators

At the core of the aforementioned food marketing surveillance system is a set of indicators that track food marketing activities at various levels. Based on extensive literature review, we construct a four-dimension measure corresponding to the 4Ps of marketing, including food quality (product), availability (place), affordability (price), and marketing efforts (promotion), as shown in Fig. 27.2. These measures are tailored for food marketing so that we can not only capture the dynamics in food marketing practice but also reflect on the previous theoretical and empirical findings. These indicators are computed at category level and as described later can be extended to aggregations at the basket level. Researchers who are interested in studying specific food consumption can utilize the category-level indicators, for example, to explain how marketing influences consumption of a specific food (e.g., the correlation between access to fresh fruits and the consumption of fresh fruit).

Product Quality Indicator

In order to be successful, companies try their best to formulate products that will be accepted and liked by consumers. When it comes to food, products considered to be highly palatable seem to have increased amounts of sugar, fat, and salt [8]. In fact, in the case of food, taste sensations serve as a primary reinforcement and motivational source that provides immediate reward and punishment directly after food purchase and consumption [9]. A similar level of immediacy of reward and punishment applies to convenience and price—two other critical attributes driving purchase [10, 11]. Unfortunately, nutrition and health consequences are far less immediately and vividly experienced in comparison to taste, convenience, and price. Additionally, descriptive information on nutrition and health consequence provided at the point of purchase is still lacking in efficacy. Thus, in the present market, fatty and sweet foods have a bigger widespread attractiveness compared to other types of food on all three attributes immediately perceivable [12]. This multifactorial inherent preference for food that is high in fat, sweet, salt, or a combination of those three components has led companies to be hesitant in reformulating their products, especially those that are already well established in the market [13], even under public and governmental pressure [3]. This is particularly worrisome since changes in particular ingredients and macronutrients in food composition are very important as some food categories were found to be highly linked to long-term, gradual weight increase [14], while others lead to the opposite effect [2]. Based on recent medical literature [2] that provides the first rigorous empirical evidence on the link between consumption of certain food categories and weight gain and other health outcomes, we classify various food categories into healthy/unhealthy based on their propensity to weight gain and NCD development. This is a first simple level for defining nutritional quality at the product category level.

Second, nutritional quality at the product category level can be examined as a function of the nutritional composition of subcategories and brands that form the category. This opens the possibility to examine distributions and shifts in overall nutritional value of each product category. Recent developments in nutrient profiling models help sort the different types of food on the basis of their nutrient configuration [15]. Within nutrient profiling, nutrient density is defined as the quantity of beneficial ingredients over dietary energy of a certain food [16]. It is very important to look at the nutritional density of different food categories as well as the nutritional density for each individual food within a product category as it could help consumers learn how to make better health choices, guide nutritional information available on packages, as well as companies' health claims [17]. Therefore, we define the product category quality as the average nutrient profiling scores across all products within the category. This approach helps us track longitudinal variations in food supply quality and food consumption quality.

Other product design features, such as portion control and convenience package, although entirely unrelated with nutritional quality, are known to influence healthy eating through intermediary routes, such as by facilitating self-control for high-caloric food or reducing barriers to consumption for their healthier counterparts [10, 11]. The size of product packages has grown exponentially in the recent decades especially for calorie-dense, nutrient-poor food items [18]. Many studies show (e.g., [19]) that larger portion size increases consumption. Providing simple ways to indicate portion size can reduce intake, as shown by Wansink et al. [20]. However, smaller package size or adding portion controls does increase the cost of food manufacturing and transportation; therefore, this is a trade-off situation for manufacturers. Nevertheless, more and more manufacturers are engaged in marketing food products that facilitate healthier eating to capitalize on the trend of health eating. To reflect this fact, we propose one additional indicator for food quality: nutrition sensitivity. A nutrition sensitivity indicator counts the product design features that are unrelated to nutrition directly but would encourage more nutritious eating behavior, including but not limited to smart portion control and convenience packaging.

Food Availability Indicator

When it comes to food, two important aspects of place or distribution seems to play a role: availability of food variety and availability of food outlets [3]. We measure the distribution of food products at each neighborhood using the size of assortment (number of distinct products) and the convenience of access. It is well recognized that the industrialization and technological changes are creating cheaper and more easily available food calories [1]. The strong economic incentive to purchase, and the convenient access to, heavily processed food promotes the consumption of such products. This leads to overconsumption and diet-related NCDs [7, 21]. Therefore, food availability is a determining factor of food consumption. The variety of food items available for consumers was found to play an important role on food consumption, too. Previous research found that providing individuals with different product flavors [22], different colors [23], or any changes in the organization, structure, repetition, and balance within an assortment, even if just illusionary, affects the perceived variety within the assortment and could thus lead to the above-mentioned effect [24]. When faced with greater variety, individuals tend to consume more because they might underestimate the quantity of food available [25]. Their attention might be diverted from the actual food they are consuming [26] and thus not realize when they are actually full [27]. Most research on the variety of food options dealt with food consumption per se. Raynor and Epstein [21] pointed out the importance of variety in the food supply in increasing food intake, body weight, and fat. One important aspect that still needs more light to be shed on is whether the level of variety available in a food outlet, and not only the variety of food at time of consumption, could lead to changes in purchase behavior and subsequently to changes in food consumption and BMI. Therefore, it is useful to study the selections consumers are facing at the point of purchase, and we propose to use the number of distinct SKUs to present the variety. A larger number means a wide selection for consumers to choose from (e.g., a larger number of selections in yogurts means more types and flavors, which is more likely to satisfy consumers' taste and consequently leads to more consumption). By measuring and monitoring variety at the point of purchase, we expect to find that product categories that have higher levels of variety are purchased more than others, are consumed more by individuals, and lead to an overall increase in consumption and long-term BMI.

Previous research also pointed out that food consumption is often impulsive and mindless, triggered by the mere presence of food and food cues in the environment [11, 28]. It is in the best interest of marketers to make their food widely available and easily accessible to consumers [3]. Previous research found that children increased their consumption of fruits and vegetables only when it was easily accessible [29]. Furthermore, previous studies found that a poor diet quality was linked to a lack of local outlets carrying fruits and vegetables [30]. This effect was also observed for unhealthy food; increased availability led to increased consumption of the foods available [7]. Currently, ready-to-eat convenience food is becoming more and more widely available, and spending in away-from-home outlets is on the rise [31]. Furthermore, the easier accessibility of grocery stores (compared to convenient stores) seems to have a positive effect, lowering long-term BMI, mainly because they carry healthier food [32]. We propose to measure the number of outlets that carry a particular category as an indication of its degree of convenience and accessibility. This is the second indicator for food availability, in addition to the variety indicator; both should have a positive impact on food purchases.

Food Affordability Indicator

In recent decades, there has been a significant reduction in food prices due to advances in food production and distribution [33]. The reduction in prices is even greater for foods with a higher amount of sugar and fat [34] than healthier alternatives, such as fruits and vegetables [35]. Furthermore, prices at fast-food outlets and vending machines have decreased significantly unlike prices for full-service restaurants that experience price increases [36]. Decreases in prices of food was found to be linked to increases in consumption and food intake [37]. We propose to measure category affordability as average price per serving. The variation in affordability across categories could be one of the major factors to explain the variation in consumption across categories.

Temporary price discounts are frequently used by marketers as effective persuasive tools. Price discounts give consumers strong incentive and urgency to accelerate purchases and consumption. Temporary price reduction has been found to be linked to an increased level of food intake [38]. It seems that individuals consume at a faster rate items that were bought at a price discount [19] either because they feel that a future price discount for the item will happen again or because they want to get their money's worth [3]. It was also found that temporary price reduction leads to stockpiling, and consumers tend to increase consumption frequency and quantity per consumption occasion even without knowing it (see

[38] for a review of price promotion). To capture the influence of temporary price discount, we create a second affordability indicator that measures the depth, or the frequency, of temporary price discounts. We expect temporary price promotions to have a large and significantly effect of encouraging food consumption.

Promotion Indicator

We measure marketing promotion in the form of advertising and non-price promotion. Marketing communications create brand awareness, and Hoyer and Brown [39] show that increased awareness of food products leads to a smaller variety in food selection and reduces the likelihood of choosing food of the best quality. Advertising plays an important role in the food industry as food companies are one of the top advertisers in the market [40]. Marketing communication also plays an important role in creating and influencing the importance of the product's sensory and non-sensory benefits. Individuals usually try to balance between their taste goals and their health goals [41]. Fat and sweet food items compared to plain ones give individuals higher reinforcing value [42]. Advertising cues for these types of food increases individuals' gratification or hedonistic goals [43]. Current food advertising seems to be biased toward these calorie-rich, nutrient-poor food [44]. The numerous numbers of advertisements for high-energy-dense foods that have a high proportion of sugar, salt, and fat are considered by some as the main reason behind obesity [45].

In an effort to understand the influence of advertising on food purchases and consumption, several researchers have studied advertising bans for children implemented in Quebec [6, 46]. Goldberg [46] pointed out that the ban reduced the amount of children's cereals in the homes of French-speaking children in Québec but not for English-speaking children, who are still exposed to food advertising through American television stations. Dhar and Baylis [6] found that French-speaking households with children spent less on fast foods within and across provinces; this was true even compared to French-speaking households that do not have children. Gorn and Goldberg [47] further show that exposure to television advertising for unhealthy food might increase not only current consumption but future consumption also [48]. Brand advertisement often has a spillover effect and leads to higher consumption of food items in general [49, 50]. Therefore, capturing the degree of advertising is important, and we propose to use an advertising intensity indicator, which is the ratio of total advertising expenditure to total category sales [51]. We expect a positive correlation between advertising expenditure and food consumption in both the short term and the long term. We also expect a spillover effect within the same product category advertised.

Another popular form of promotion is point-of-purchase promotions, such as features and displays. Many studies have documented that in-store displays and features can significantly influence brand choices after controlling for price discounts [52]. Maximizing food visibility at point of purchase is important in increasing the chances for these products to be seen, considered, and bought [53]. The sight, smell, and touch of food are a continuous temptation, and they could stimulate purchase and levels of reported hunger and salivation [3]. The marketing literature also suggests that food displays could be considered as an indicator of price cuts. The mere presence of a promotional signal would lead consumers to believe that brand is on discount [54] or would help individuals form a consideration set [55]. We propose to measure the frequency of in-store promotions as a second measure of promotion, and we expect a significant positive effect on food consumptions.

Application in Quebec Market

We have developed a prototype of the aforementioned architecture for the province of Quebec, Canada. We obtained retailing and advertising activity data from a commercial source for the duration of 2008–2010. The retail data provided weekly tracking of selected product categories

Table 27.1 Operationalization of category-level food marketing indicators

Indicators	Operationalization
Food quality	We classify food categories into healthy/unhealthy based on prior literature on food consumption and health outcome [2]. We also consider using nutrient profiling models [56] to measure product quality. We obtain SKU-level nutritional fact label from various sources and compute nutrient scores [57]. This gives us measure of product quality at SKU level. We aggregate SKU scores to category quality by taking a weighted average, where weights are their market shares
	We measure the nutrition sensitivity as whether proper portion size is enforced by package design
Availability	We define product varieties as the number of distinct SKUs at point of purchase
	We define number of outlets as number of outlets carrying this category in a neighborhood
Affordability	We compute the regular price (highest price over 3-month moving windows) of each SKU. We then take weighted average (weights are market shares) of regular prices of all SKUs within a category to arrive at category price per serving [58]
	We define price promotion frequency as the number of weeks in which the price of SKU was at least two standard deviations below its average price [59]. We define price promotion depth as the percentage difference between a promotional price and the SKU's average price level [59]. Both measures are at SKU level, so we further aggregate these to category level
Marketing efforts	We define advertising intensity as the ratio of total category advertising expenditure to total category sales [51]
	We measure non-price promotion as the proportion (percentage) of SKUs that are on display at a given time in a category [60] within a community

The table shows how we define the proposed food marketing indicators using SKU-level marketing research data (unpublished)

based on information gathered at the retail point of sale. Data was collected and geo-tagged by stores in each FSA (forward sortation area). Prices, in-store displays, and sales were captured for each SKU weekly. The advertising data covered the brand-level advertising expenditure of the selected categories in the city of Montreal, Quebec City, and rural Quebec by language (English/French). We observed advertising spending per month on various media outlets, including newspapers, magazines, out-of-home, radio, and TV. Following the conceptualization of food marketing indicators, we constructed the empirical strategies to compute the corresponding indicators. The actual algorithms are defined in Table 27.1. Since our indicators are computed at the FSA level, we were able to link them directly to census data and other potential data sources by GIS mapping. We report a summary of selected statistics for fresh fruits and fresh vegetables below and validate the prediction power of the proposed indicators on purchase outcomes. We choose these two categories due to their importance in a healthy diet.

Descriptive Statistics for Fresh Fruits

Taking fresh fruits as an example, we created a map that shows the average price per serving in the Montreal Metropolitan area from 2008 to 2010. We first computed the average prices by each FSA, then we grouped these prices into five tiers, and finally we plotted the distribution of price tiers within the Montreal area to get a glance of the price differences among communities, as shown in Fig. 27.3. The average price for the middle tier is around $0.5 per serving, and the average price is $0.10 more/less for each higher/lower tier. The figure clearly shows a large cross-sectional variation in prices among communities.

Furthermore, we evaluated the dynamics in prices over time for a randomly selected neighborhood in Montreal. Figure 27.4 documents the average price of fresh fruits in Montréal-Nord by month, from January 2008 to December 2010. For this particular community, the fresh fruit category shows an obvious seasonal pattern. The regression line also indicates a positive trend in price per serving—fresh fruits are getting more

Fig. 27.3 Mapping the average price per serving for fresh fruits in Montreal and vicinity. The figure shows the distribution of price (per serving) of fresh fruits in the Montreal Metropolitan area. There is a large cross-sectional variation in prices among communities (unpublished)

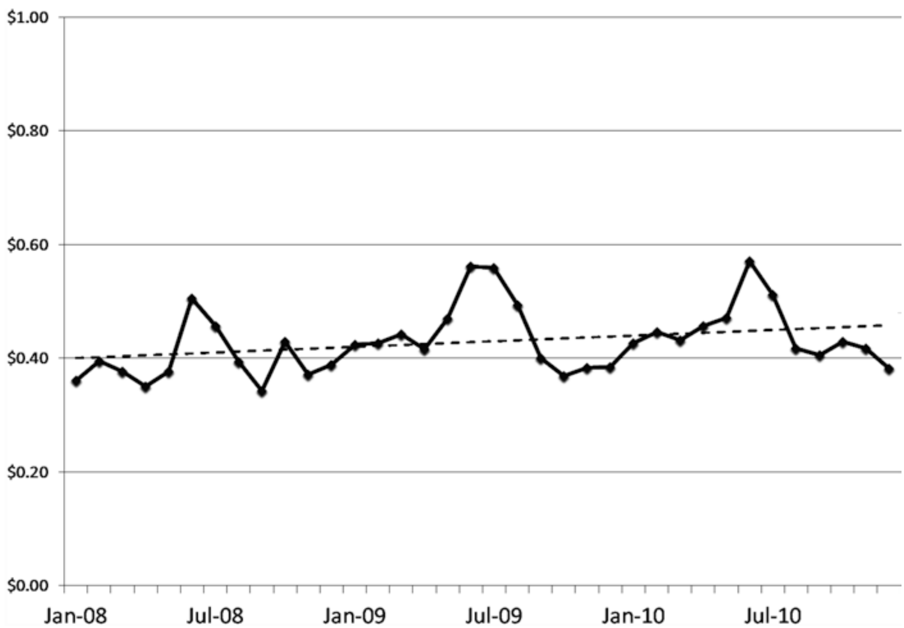

Fig. 27.4 Time trend of price per serving for fresh fruits—Montréal-Nord neighborhood. The figure shows the average price of fresh fruits in Montréal-Nord by month, from January 2008 to December 2010. It exhibits an obvious seasonal pattern (unpublished)

expensive during the 3 years. This is not surprising since the price of fresh fruit is sensitive to and influenced by many factors such as type, size, packaging, brand, and maturity of products. Logistical constraints and the retailers' profit optimization could also have a large impact on prices. Such results can reveal trends in marketing activities and identify areas that policy makers should be concerned about.

We also explored the link between food marketing environments and neighborhood socioeconomic status. Although food prices have dropped and food quality is improving, healthy eating is still expensive. At the same time, marketing activities often target specific demographic groups and community characteristics in order to maximize profit. This could be one of the driving factors behind the large discrepancy in food marketing activities across neighborhoods. We matched food marketing activities to census data and explored the correlation between demographics and the marketing indicators. Taking fresh fruits for example, we found a significantly negative correlation between neighborhood income and discount frequency (−0.04, $p<0.01$) and a significantly positive correlation between income and price (0.04, $p=0.01$). This implies that retailers sell more expensive fruits and discount less often in high-income neighborhoods, which is intuitive considering high-income shoppers are usually less price sensitive. Similar analyses can be used to identify the empirical discrepancies in food marketing across other demographics, help policy makers find ways to reduce and eliminate potential equity issues, and empower communities to build healthy eating environments.

Validating the Prediction Power of the Proposed Marketing Indicators

We conducted validation tests to examine the prediction power of the proposed food marketing indicators. We estimated the following log-log quantity model to investigate how well the proposed food marketing indicators can predict total purchase quantity of fresh fruits and vegetables. The model is specified as:

$$\begin{aligned}\log(\mathrm{Qty}_{l,t}) = {} & b0 + b1 * \log(\mathrm{nb\,of\,outlet}_{l,t}) + b2 * \log(\mathrm{nb\,of\,SKU}_{l,t}) \\ & + b3 * \log(\mathrm{regular\,price}_{l,t}) + b4 * \mathrm{discount\,frequency}_{l,t} \\ & + b5 * \mathrm{in\text{-}store\,promotion}_{l,t} + b6 * \mathrm{adv\,intensity}_{l,t} + b7 * \mathrm{control\,variables} + \varepsilon_{l,t}\end{aligned}$$

where l stands for location and t stands for time. Essentially, the above equation uses the proposed marketing indicators (place, price, and promotion) to predict purchase quantity. Product indicators are not used here since our applications are fresh fruits and fresh vegetables—both are very nutritious products. The discount depth indicator is dropped from the model due to a very high correlation (0.80, $p<0.01$) with the discount frequency indicator. We also added control variables such as area population and income to explain the regional differences. We estimated the above model using OLS for fresh fruits and fresh vegetables separately, and we report the results in Table 27.2. Both OLS models report a good fit: the R-square is 0.60 for fruits and 0.63 for vegetables. The availability indicators (number of outlets and number of SKUs) have significant and positive impact on sales. The price indicator is strongly negative for both categories, which is intuitive. A higher price leads to lower sales, and fruits shoppers are more price sensitive (−1.69) than vegetable shoppers (−1.23). However, price discount frequency is significant for fruits, but insignificant for vegetables. This is consistent with the estimates of price coefficient and reinforces the finding that fruits purchases are more sensitive to price manipulation, while vegetable purchases are more planned and less spontaneous. In-store promotions show strong and positive effects in both categories, confirming the effectiveness of promotion at points of

Table 27.2 Validation results for fresh fruits and vegetables

	Fresh fruits		Fresh vegetables	
	Estimate	Standard error	Estimate	Standard error
Intercept	–4.90**	0.71	–0.05	0.58
Log (number of outlets)	0.75**	0.03	0.74**	0.03
Log (number of SKUs)	1.24**	0.01	1.43**	0.01
Log (regular price per serving)	–1.69**	0.04	–1.23**	0.04
Discount frequency	1.34**	0.12	–0.04	0.07
In-store promotion frequency	4.32**	0.23	2.34**	0.13
Advertising intensity	11.77**	2.64	–0.30	1.63

The table shows the predicative power of the proposed food marketing indicators on fresh fruit and vegetables purchases (unpublished)
Note: $^{**}p<0.01$

purchase. Advertising, on the other hand, is only influential for fruit purchases but not for vegetables. Overall we find that the proposed marketing indicators are able to explain a larger amount of variation in fruits and vegetable purchases, and interestingly, we also discover that fruit purchases are more prone to marketing activities than vegetable purchases.

Extensions

We have shown that the proposed indicators are instrumental in predicting consumption of specific food products, taking market sales for each category as a proxy. Tracking each individual category is useful to examine the current state of marketing practices and their relative behavioral impact as a function of the nutritional quality of the product category (e.g., fruits vs. soft drink) or among options within a category (low-calorie soft drink vs. full-calorie products). However, consumer baskets as well as diets are composed of multiple categories. There is a need to develop a comprehensive measure of food marketing, covering all common categories in a consumer basket, in order to better link overall food environment exposure to actual diets at individual and population levels.

We are currently developing a way to consolidate the category indicators to an aggregate measure for consumer baskets. The aggregation should reflect the contribution of each individual category to the overall basket composition and health consequence. Since the same foods might play very different roles for different diet-related diseases, we specify different weights for the same food depending on the focal issue. For example, if the ultimate goal is to evaluate the impact of food marketing on obesity, we put more weight on sugar-heavy categories. On the other hand, if the focus is on hypertension, we put more weight on categories containing large amount of sodium. For the purpose of illustration, we provide our weights designed for monitoring the impact on obesity.

We define the aggregation weight for a category as the product of the category's quality weight and the category's basket share. The quality weight is drawn from prior literature about diet intake and obesity. For example, assume the basket consists of diet soda, regular soda, candy, and others. Based on Mozaffarian [2]—the long-term impact of consumption on body weight gain—we assign the following weights: –0.12/1.32/0.65 to diet soda/regular soda/candy, which is proportional to their ability to change body weight. The opposing signs of diet soda and regular soda, during aggregation, will ensure that a higher price will always discourage obesity outcome. The basket share indicates the importance of this particular category in comparison to the rest of the basket—it is defined as the ratio of purchase quantity (in servings) of a category to the total purchase quantity in basket. By defining the aggregation weight as the product of quality weight and basket share, we incorporate both nutrition quality and importance in diet into the aggregation process. In addition, categories might operate on different scales, e.g., a serving of fruit may cost twice of a serving of soft drink; it is necessary to normalize all indicators by their starting values (e.g., normalize the price indicator of fruit by dividing it by the price of fruit in the first month) before aggregation. We can then apply the aforementioned weights and take average to get a basket level indicator for obesity. This indicator shows how the entirety of all marketing activities, happening simultaneously to various product categories, influences healthy eating and consequently obesity as a whole.

Finally, a system of indicators of the nutritional quality of marketing and food environment needs to be linked to individual- and/or population-level measures of actual behavior, BMI, and health outcomes. The marketing systems of indicators, when linked to a public health informatics infrastructure, will allow for easier access to timely, representative, and geographically high-resolution health outcome indicators and will enhance health-related information retrieval, analysis, and decision making. Currently, our team has already begun working on creating a real-time knowledge-based system that focuses on the impact of food marketing on population health outcome.

Conclusions

One significant contribution of such a system is to monitor the progress of lifestyle/community/market (industry and media)/agriculture transformation that might lead to healthy eating and chronic disease prevention and guide the direction for future actions/transformation. Such a system can eventually help individuals, health professionals, business strategists, and policy makers to be better informed of the multiple and interacting ways by which biological (i.e., gene, brain, and physiology) and societal systems (e.g., education, health, agriculture, agribusiness, media, and finance) collectively operate on a diversity of spatial and temporal scales to influence food choice and diets and their economic, population health, and chronic disease consequences. For instance, with a good understanding of how food marketing and nutrition influence individual food choices, a continuous monitoring of manufacturers' and retailers' marketing activities over time would provide vital information to decision makers regarding whether there is an opportunity to improve the food environment and hence achieve food supply chain transformations toward healthy eating. The systems of indicators will further help managers, policy makers, and researchers combine more effectively their efforts in order to better understand the impact of food marketing on food purchases and behavior (and thereof on the obesity pandemic). The real-time food informatics platform we are creating enables monitoring of marketing activities while linking them to diet quality and health outcomes. This will enable managers, policy makers, and researchers to come up with better initiatives that could help consumers choose, and have access to, healthier food options.

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Diet Quality: What More is There to Know?

28

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Key Points

- Diet quality scores are related to health outcomes. Thus, diet quality is as important as quantity, a fact which is overlooked when food security is measured.
- However, an evidence-based approach to the assessment, measurement and application of diet quality is required to improve morbidity and mortality due.
- This chapter lists the most up-to-date resources on the regulatory bodies, journals, books, professional bodies and websites that are relevant to an evidence-based approach to diet quality.

Keywords

Diet quality • Nutrition • Evidence • Resources • Books • Journals • Regulatory bodies • Professional societies

Introduction

The availability of or access to sufficient calories (i.e. "food security") is increasing worldwide [1]. However, food-secure individuals and populations with access to sufficient calories (i.e. adequate quantities of food) may still lack essential nutrients or those dietary components that are yet unmasked as being important for human health. These components are encompassed within the concept of "diet quality". Diet quality scores are

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V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health, DOI 10.1007/978-1-4614-7315-2_28, © Springer Science+Business Media New York 2013

related to health outcomes. So despite "food security" nutritional inadequacies in poor-quality diets ("hidden hunger") increase the risk of both short- and long-term morbidity and mortality. Thus, diet quality is as important as quantity, a fact which is overlooked when food security is measured. However, the term "diet quality" itself is subjected to a variety of interpretations, definitions and usage.

Methods of measuring diet quality have recently been developed and several scoring systems have been derived. Diet quality can be measured by scoring food patterns relative to national dietary guidelines and the diversity of healthy choices within core food groups. On the other hand, some have interpreted diet quality in terms of micro- or macronutrient profiles of single food items. In our view, both are valid especially when considered with the wider context of food and nutrition. Nevertheless, assessment of the quality and variety of the whole diet allows analysis of associations between foods and health status to be undertaken in order to determine risk factors. Refinement of diet quality scoring systems has facilitated identification of both protective and harmful diets. They also potentially unmask dietary components that are not essential for life per se but have been shown to significantly improve health-related outcomes. These include, for example, polyphenols in wine (when consumed moderately).

Diet quality scores are inversely related to health outcomes. So despite 'food security' nutritional deficiencies in poor-quality diets ('hidden hunger') increase the risk of both short- and long-term morbidity and mortality. One review reported that improved diet quality reduced all-cause mortality up to 42 %, cardiovascular disease (CVD) mortality by up to 53 %, CVD risk by up to 28 %, cancer mortality by up to 30 % and all-cancer risk by up to 35 % [2]. This does not mean to say that diet quality is related to just the physical manifestations of disease. For example, a better diet quality has been shown to be related to a reduced cognitive decline in the elderly over an 11-year period [3].

Thus, diet quality is as important as quantity, a fact which is overlooked when food security is measured. Targeted nutritional interventions may improve the most critical aspects of an individual's or population's specific deficiencies [1]. However, an evidence-based approach to the assessment, diagnosis and treatment of nutritional deficiencies is required to prevent morbidity and mortality from either inadequate or excessive micronutrient supplementation. This does not mean that all diseases are related to diet quality. For example, one recent study on ovarian cancer specifically showed no relationship with diet quality assessed with the Health Eating Index [4]. Studies like the aforementioned, albeit negative, allow health professionals to redirect their investigations to other causative mechanisms (e.g. epigenetics or environmental risk factors) and reaffirm the need for an evidence-based approach. Other examples of the definitions, measurement and applications of diet quality can be found in this book and also via the recommended resources in the tables below.

Tables 28.1, 28.2, 28.3, 28.4, and 28.5 list the most up-to-date information on the regulatory bodies (Table 28.1), journals (Table 28.2), books (Table 28.3), professional bodies (Table 28.4)

Table 28.1 Regulatory bodies

Centres for Disease Control and Prevention (CDC)	www.CDC.gov
EUR-Lex (English)—access to European Union Law	http://eur-lex.europa.eu/en/index.htm
European Food Information Council	www.eufic.org
Food and Agriculture Organization of the United Nations (FAO)	www.fao.org
Forschungsinstituts für Kinderernährung (Research Institute of Child Nutrition)	www.fke-do.de
Health Canada	www.hc-sc.gc.ca/fn-an/nutrition/index-eng.php
US Department of Health and Human Services	health.gov
US Food and Drug Administration (FDA)	www.fda.gov
US Department of Agriculture (USDA)	www.usda.gov
US Department of Agriculture (USDA) Center for Nutrition Policy and Promotion	www.cnpp.usda.gov
World Health Organisation	www.who.int

This table lists the regulatory bodies involved with diet quality

Table 28.2 Journals

American Journal of Clinical Nutrition	www.ajcn.org
Archivos Latinoamericanos de Nutrición	www.alanrevista.org
British Journal of Nutrition	journals.cambridge.org/action/displayJournal?jid=BJN
Citrus Industry Magazine	www.citrusindustry.net
European Journal of Clinical Nutrition	www.nature.com/ejcn/index.html
Food and Nutrition Research	www.foodandnutritionresearch.net
International Journal of Behavioral Nutrition and Physical Activity	www.ijbnpa.org
International Journal of Paediatric Obesity	informahealthcare.com/loi/jpo
Journal of the Academy of Nutrition and Dietetics	www.adajournal.org
Journal of Adolescent Health	jahonline.org
Journal of the American Dietetic Association	www.ADAJournal.org
Journal of Clinical Nutrition	www.nutrition.org
Journal of Internal Medicine	www.jim.se/
Journal of Marketing	www.marketingpower.com/AboutAMA/Pages/AMA%20Publications/AMA%20Journals/Journal%20of%20Marketing/JournalofMarketing.aspx
Journal of Nutrition Education and Behavior	www.jneb.org
Journal of Public Policy and Marketing	www.marketingpower.com/AboutAMA/Pages/AMA%20Publications/AMA%20Journals/Journal%20of%20Public%20Policy%20Marketing/JournalofPublicPolicyMarketing.aspx
Nutrition	www.elsevier.com/wps/find/journaldescription.cws_home/525614/description#description
Nutritional Neuroscience	www.maney.co.uk/index.php/journals/nns
Nutrition Research	www.nrjournal.com
Obesity Reviews	www.iaso.org/publications/obesityreviews
Official Journal of the European Union	eur-lex.europa.eu/JOIndex.do?ihmlang=en
Public Health Nutrition	journals.cambridge.org/action/displayJournal?jid=PHN
Stroke	stroke.ahajournals.org

This table lists the journals publishing original research and review articles related to diet quality

Table 28.3 Books

Bray GA, Bouchard C, Handbook of obesity: Etiology and pathophysiology Marcel Dekker, 2004, New York, USA
Bray GA, Bourchard C, James WPT, Handbook of obesity: Clinical applications, Marcel Dekker, 2004, New York, USA
Drescher LS, Healthy food diversity as a concept of dietary quality: measurement, determinants of consumer demand and willingness to pay, Cuvillier Verlag, 2007, Göttingen, Germany
Dube L, Bechara A, Obesity Prevention: The role of brain and society on individual behavior. Academic Press, 2010, London, UK
Food and Agriculture Organisation (FAO) guidelines for measuring household and individual dietary diversity. FAO, 2011, Rome, Italy. www.fao.org/docrep/014/i1983e/i1983e00.pdf
Cheng G. Indicators of diet quality during growth and their associations with body composition and the timing of puberty. WiKu-Verlag Verlag für Wissenschaft und Kultur, 2010, Cologne, Germany
Hu FB, Obesity Epidemiology, Oxford University Press, 2008 New York USA
Institute of Medicine, Dietary Reference Intakes, The National Press 2010 Washington, DC. USA
Kimball DA, Citrus Processing. A Complete Guide, 2nd Ed. Aspen 1999 Gaithersburg Maryland –U.S.
Parker CG, Diet Quality of American Young Children, Nova Science Pub Inc, 2010 USA
Volkarsky KB, Diet Quality of American School-Age Children, Nova Science Pub Inc 2010 USA
Swindale A and Bilinsky P. Household dietary diversity score (HDDS) for measurement of household food access: indicator guide. Version 2. Food and Nutrition Technical Assistance (FANTA)/Academy for Educational Development (AED) 2006 Washington, DC. www.fao.org/docrep/014/i1983e/i1983e00.pdf
Coulston A, Boushey C, Nutrition in the Prevention and Treatment of Disease, 2nd ed. Academic Press 2008, Burlington, MA, USA
Kuhnlein HV, Erasmus B, Indigenous peoples' food systems for health: interventions for health promotion and policy. FAO of the United Nations 2011 Rome, Italy
Willett W, Nutritional Epidemiology, Oxford University Press, 1998 New York USA

This table lists some important books on diet quality

Table 28.4 Professional societies

The Academy of Nutrition and Dietetics	www.eatright.org
American Heart Association	www.heart.org/HEARTORG/
American Society for Nutrition	www.nutrition.org/
American Society for Nutritional Sciences	www.faseb.org/asns
American Stroke Association	www.strokeassociation.org
Citrus Research and Education Center (CREC), Institute of Food and Agricultural Sciences (IFAS), University of Florida	www.crec.ifas.ufl.edu
European Fruit Juice Association—AIJN	www.aijn.org/
Food Marketing Institute	www.fmi.org/
German Nutrition Society	www.dge.de
German Society for Epidemiology	dgepi.visart.de/short-english-summary.html
International Society for Behavioral Nutrition and Physical Activity	www.isbnpa.org
Korean Stroke Society	www.stroke.or.kr/
National Academy of Sciences/National Research Council (NAS/NRC)	www.nationalacademies.org/nrc/
Sociedad Española de Nutrición Comunitaria (Spanish Society of Community Nutrition)	www.nutricioncomunitaria.org/
Society for Nutrition Education and Behavior	www.sne.org
Women's Health Australia—The Australian Longitudinal Study on Women's Health	www.alswh.org.au/

This table lists the professional societies involved with diet quality

Table 28.5 Relevant internet resources (i.e. those devoted to micronutrient deficiency)

American Heart Association	www.heart.org/HEARTORG/
	www.heart.org/HEARTORG/GettingHealthy/NutritionCenter/Nutrition-Center_UCM_001188_SubHomePage.jsp
	my.americanheart.org/professional/Councils/NPAM/Council-on-Nutrition-Physical-Activity-and-Metabolism_UCM_322856_SubHomePage.jsp
Canadian International Development Agency	www.acdi-cida.gc.ca/acdi-cida/ACDI-CIDA.nsf/eng/FRA-4422402-563
Centre for Indigenous Peoples' Nutrition and Environment	www.mcgill.ca/cine/
Department of Health and Human Services Dietary Guidelines for Americans 2010	health.gov/dietaryguidelines
Food and Agriculture Organization	www.fao.org
Healthy Eating Quiz	healthyeatingquiz.com.au
Indigenous Nutrition	www.indigenousnutrition.org/index.html
International Food Policy Research Institute	www.ifpri.org
Linus Pauling Institute	lpi.oregonstate.edu
Micronutrient Initiative	www.micronutrient.org
National Institutes of Health	www.nih.gov
	health.nih.gov/topic/WeightLossDieting
	riskfactor.cancer.gov/diet
	NordForsk/SYSDIET www.nordforsk.org/en/funding/finansieringsformer/nordic-centre-of-excellence
The Nutrition Source (Harvard School of Public Health)	www.hsph.harvard.edu/nutritionsource
United States Department of Agriculture Choose MyPlate	www.choosemyplate.gov
Uppsala University	www.pubcare.uu.se/medarbetare/Klinisk_nutrition_och_metabolism/Riserus_Ulf/
World Health Organization	www.who.int/nutrition/topics/vad/en/

This table lists some internet resources on diet quality

and websites (Table 28.5) that are relevant to an evidence-based approach to diet quality.

Acknowledgements We would like to thank the following authors (in alphabetical order) for contributing to the development of this resource:

Dr. Kathleen Abu-Saad, Ms. Ann M. Albertson, Dr. George Antonogeorgos, Dr. Laura Burke, Prof. Luciano Cinquanta, Prof. Clare Collins, Prof. Hélène Delisle, Prof. Jong-Bang Eun, Dr. Jeanne Freeland-Graves, Dr. Cheng Guo, Prof. Melanie Hingle, Dr. Ruth Kimokoti, Dr. Hyunjung Lim, Dr. Yu. Ma, Prof. Wilna Oldewage-Theron, Dr. Christina Palacios, Dr. Clara Rodríguez-Bernal, Assoc. Prof. Ulf Risérus, Dr. Marie Ruel, Dr. Anne von Ruesten and Prof. Youfa Wang.

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V.R. Preedy et al. (eds.), *Diet Quality: An Evidence-Based Approach, Volume 2*, Nutrition and Health,
DOI 10.1007/978-1-4614-7315-2, © Springer Science+Business Media New York 2013

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