2 The Aging Body and Nutrition

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Abstract

Nutritional requirements change with aging; thus, the diet of older people should be nutrient dense with lower caloric intake. However, with tooth loss, dietary changes move in the opposite direction. Replacement of missing teeth results in people feeling that they can chew better but does not automatically result in dietary change unless a dietary intervention is undertaken along with improved function. Dietary intervention for people with complete dentures will result in a better "quality" diet, and this change is even greater when a lower denture is supported by mandibular implants. The "rate-limiting step" in dietary alteration appears to be what can be achieved with the least stable prosthesis. As prosthetic stability improves, dietary change can be more effective.

The amount of food that we require for maintenance and function of the body is influenced by changes associated with aging, and there are associations between nutrient intake and some of the progressive changes seen in older people. In this chapter those aspects of age change that can be affected by diet/nutrient availability will be reviewed. Following this will be a description of how oral health can influence foods choice and dietary intake, which can influence nutritional status. Finally, strategies will be described that can help patients make functional changes to alter their dietary patterns in order to benefit their health.

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2.1 Alterations in Tissues with Age that may be Affected by Nutrient Intake

2.1.1 Muscle

There is a progressive loss of muscle mass and, hence, strength with increasing age (sarcopenia). The rate of loss of muscle is affected by the level of physical activity of the individual, with those who are physically inactive losing between 3 and 5% of muscle mass per decade beyond the age of 30 [1–3]. The mechanisms for the development of sarcopenia are not clear, but it is likely associated with reductions in the anabolic stimuli to muscle from growth hormone and estrogen/androgen secretion alongside changes in innervation from loss of motor neurons [4–6]. There are some data that suggest that low protein intake, as well as low intakes of vitamin D, other antioxidants, and the B-complex vitamins, may also be linked to increased rates of muscle loss [7–9]. Chronic conditions that result in lower levels of

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exercise or increases in systemic inflammatory markers are risk factors for sarcopenia, as is smoking [6, 10, 11].

This rate of loss is reduced in those who are physically active with the reduction reflecting the extent of physical activity undertaken by the individual. However, there are very few who remain sufficiently active that they retain the bulk of their muscle mass into older age (high-performance athletes and weight lifters are best at retaining muscle into aging providing they continue to exercise regularly). The most effective forms of exercise to retain muscle mass are those which involve resistance training rather than aerobic activity per se [12, 13].

The rate of loss seems to accelerate beyond the age of 75; the reasons for this acceleration remain unclear but may simply reflect a combination of the loss of anabolic stimuli alongside an increasingly sedentary lifestyle that is often associated with advanced aging [14, 15].

Obesity can protect against some of the effects of sarcopenia in the young old, as about 25% of body weight is muscle and it takes more physical strength for an obese person to move. However, in the longer term, this protective effect is counterbalanced by a sedentary lifestyle, increasing insulin resistance associated with deposits of abdominal fat, and the production of TNFα by adipocytes, which is catabolic and may interfere with insulin receptors, resulting in greater insulin resistance [16].

Muscle is a complex tissue, and loss of muscle mass affects the various components of muscle differently. Thus, there is a disproportionally greater loss of type II fibers in proximal muscle groups; this is associated with an increase in type I collagen in the same muscle bundles. Actions that depend on fine control from by type II fiber activity are more strongly affected by increasing age. In terms of oral health, this reduced type II fiber activity would make daily oral hygiene tasks more difficult [2].

As noted above, deficiencies in protein intake and in some micronutrients are associated with increased rates of muscle loss, but there is no evidence that vitamin supplementation above recommended levels or high protein intake would result in a protective effect in the absence of resistance exercise.

There is an increased risk of protein/energy malnutrition in older people, which is driven by a combination of food choice [17]. Older people tend to exclude protein-rich foods; their appetite declines, they have difficulty digesting high protein content foods, and they fear raised cholesterol levels, thereby reducing their intake of red meat. The higher cost of protein also reduces the tendency of older people to choose these foods.

2.1.2 Gastrointestinal Tract

There is a tendency for hypo- or achlorhydria to develop with increasing age. This is associated with the development of atrophic gastritis, but it is unclear whether this is an age effect per se or a product of increasing rates of infection with *Helicobacter pylori* infection. The location of *H. pylori* infection in the stomach determines the pathology that results, so infection of the pyloric antrum occurs in people who secrete more acid naturally and serves as a stimulus for further acid secretion. This, in turn, results in gastric or duodenal ulceration. People with normal levels of gastric acid secretion develop *H. pylori* infection in the fundus of the stomach that results in an atrophic gastritis and reduction in acid secretion. Rates of hypochlorhydria and achlorhydria increase from around 24% in people aged 60–69 to 37% in those over 80 [18, 19].

Duodenal absorption of the B-complex vitamins is pH dependent, so, in those with reduced gastric pH, absorption is reduced. This is most commonly seen with vitamin B12, resulting in pernicious anemia. The prevalence of B12 deficiency is approximately 10–15%, with levels of around 35% for a combination of marginal and overt deficiency states. About 30–40% of these subjects have atrophic gastritis.

From rodent models of aging, there is some evidence of changes in structure of the small bowel that affect absorption in aged animals. However, current data for man does not support similar changes occurring, so there should be no alterations in the ability of the small bowel to absorb digested foods [20].

There are increases in gastric emptying time and colonic transit time that are likely associated with reduced sympathetic tone in older subjects. These have an effect on satiety and, therefore, on food intake. With reduced rates of gastric emptying, satiety is reached at lower levels of food intake [21].

2.1.3 The Eye

The major cause of damage to the eye is sunlight, but there are two causes of age-related damage to the eye that may also have nutritional links, cataract and age-related macular degeneration (AMD).

The evidence for cataract is stronger than for AMD, but there are associations with vitamin C status and intake of the carotenoids lutein and zeaxanthin, with increased consumption leading to a protective effect for both conditions. This evidence supports the current dietary recommendations of five portions of fruit and vegetables daily, including citrus fruits to obtain vitamin C and green leafy vegetables like spinach and kale for the carotenoids. There is also less robust evidence that some of the fat-soluble vitamins are protective against AMD.

Individuals with intermediate and advanced AMD are often given high-dose vitamin supplements, including zinc, to try to reduce the rate of progression of this disease, but there is no evidence that vitamin supplements can have a protective effect against these age-related eye diseases [22, 23].

2.2 Nutritional Requirements with Aging

Muscle is one of the principle tissues that uses sugars as a form of energy, and it is particularly important in terms of maintenance of body temperature, as sugar metabolism in muscle releases heat. To generate heat, we shiver when cold. The reduction in muscle mass associated with sarcopenia is associated with poorer thermoregulation and is why older people "feel the cold" more, as they have less capacity to generate body warmth.

As their reduced muscle mass is less metabolically active than that of younger people, older people need to reduce their energy consumption and take in fewer dietary calories for a given level of physical activity. This change is reflected in alterations in the recommended dietary reference values (DRVs) for intake of energy, as either sugars or fats with increasing age (Table 2.1). Interestingly there is marked variation between DRVs from different national organizations with variation in recommended intakes for people

Table 2.1 Recommended daily intakes of energy by age from the UK, WHO, the USA, and EU (where data were originally given in calories, these have been converted into MJoules by multiplying by 0.00418) [75–77]

	UK/WHO		USA				EU			
			Sedentary[a]		Active[b]		Low[c]		High[d]	
Age	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
15–18	11.51	8.83	9.2	7.5	12.5	10.0	11.8	8.9		
19–50	10.6	8.1	10.0	7.9	12.1	9.6	11.3	8.4	12.0	9.0
51–59	10.6	8.0	8.75	6.7	10.4	8.75	11.3	8.4	12.0	9.0
60–64	9.93	7.99	8.75	6.7	10.4	8.75	8.5	7.2	9.2	7.8
65–74	9.71	7.96	8.75	6.7	10.4	8.75	8.5	7.2	9.2	7.8
75+	8.77	7.61	8.75	6.7	10.4	8.75	7.5	6.7	8.5	7.6

[a]Sedentary means a lifestyle that includes only the light physical activity associated with typical day-to-day life
[b]Active means a lifestyle that includes physical activity equivalent to walking more than 3 miles per day at 3–4 miles per hour, in addition to the light physical activity associated with typical day-to-day life
[c]Low means no physical activity, desirable body weight
[d]High means recommended physical activity normal body weight

aged over 75 of between 7.5 and 10.4 MJ/day. The direction of these differences varies across the life span and, in some countries, reflects a recognition of differing levels of physical activity.

Sugars in the diet are categorized into two major groups commonly described as "free" and "bound." Bound sugars are those that are contained within the cells of foods, while free sugars are extracellular and are often added to foods to sweeten or as a preservative. Bound sugars can be converted into free sugars through the food preparation process; for example, the sugars in an orange are regarded as bound (within the cells of the orange), whereas when the same fruit is processed to produce juice, the same sugars are regarded as "free." Normal diets contain both free and bound sugars; however, it is free sugars that are regarded as particularly harmful in terms of human disease, particularly diabetes, obesity, cardiovascular disease, and, of course, dental caries. This is reflected in the WHO recommendation and the UK government's policy that free sugars should form no more than 5% of dietary energy intake. This applies across the age span [24, 25].

While there is a reduction in the need for dietary energy as a consequence of sarcopenia, there is no evidence of any requirement for a reduction in either protein or micronutrient intake with age; indeed, there are some suggestions that protein intakes should be higher in older people than in the young. As a consequence, older people need to consume a different style of diet compared with the young that is proportionally higher in nutrients per unit of energy than the young. This dietary pattern is described as being "nutrient dense" (see, e.g., http://nihseniorhealth.gov/eatingwellasyougetolder/choosenutrient-densefoods/01.html).

The need for increased nutrient density in diet is poorly understood by consumers, and the oral health team should be aware of this when giving dietary advice to older people. Equally, the WHO/UK government recommendations in relation to free sugars are recent and need to be explained carefully to older people.

2.3 Oral Conditions That Influence Food Intake

Food intake in older people is affected by many confounding variables that can be divided into those associated with aging/lifestyle and those associated with disease (Fig. 2.1). Patterns of food consumption are largely habitual and are driven by the member of the household who buys and cooks the food. If we want to change the pattern of food consumption, we need to influence not only the person we are trying to get to change but also the person they live with if that individual is the shopper/cook. There are two oral factors that affect food consumption, alterations in taste (and smell) perception and the number of teeth that an individual has.

2.3.1 Taste and Smell

There are five basic categories of taste: salt, sweet, bitter, sour, and savory (or umami). There is a progressive reduction in taste acuity with increasing age for all of these, with the exception of savory [26–30]. The mechanisms that underpin this reduction are not well understood; however there are reductions in taste in association with specific drugs and with dry mouth either as a result of pathological gland damage or induced as a side effect of drugs used for other chronic conditions [31, 32]. There are similar reductions in the sense of smell with age, and, in combination, these result in consumers getting less enjoyment from eating food as the taste becomes progressively more bland [30, 33].

A variety of approaches have been attempted to overcome this challenge to make foods more interesting for older people. These include the use of intense (artificial) flavorings and chemicals that enhance taste perception. The most common of the latter is the addition of salt to foods, but this also has potential health consequences. Monosodium glutamate is also a very effective taste enhancer, but its use does result in people needing to drink more water as it gives a sense of dryness to foods, and it also increases the viscosity of foods, making them unpalatable [34–37].

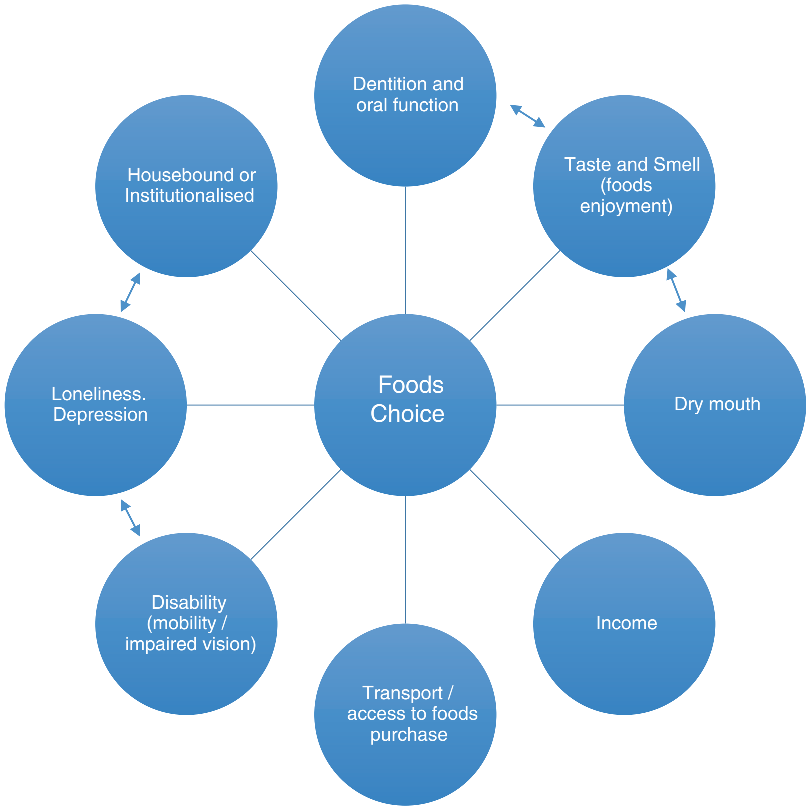

Fig. 2.1 The wide variety of factors that influence food choice in older consumers. Some factors are interrelated (arrows)

2.3.2 Saliva

Salivary flow and function remain remarkably consistent with increasing age in the medially fit and healthy individual, despite profound changes in salivary gland structure with time [38, 39]. However, dry mouth (xerostomia) is a symptom of increasing importance in older populations. Dry mouth is largely due to the side effects of many drugs used to manage the chronic diseases of older age, as well as the more rare pathological conditions that cause destruction of salivary gland tissue like Sjögren's syndrome, or as an aftermath of radiotherapy used in the management of head and neck cancer [40–43]. Reductions in both taste and smell will be compounded in people who suffer from xerostomia for two reasons:

- Both are "wet" sensations, i.e., the tastant is dissolved in water/mucin prior to its being sensed. Logically, saliva must have a taste if we consider its composition. However, it is ubiquitous, and so we ignore it when considering the taste of foods. When there is less saliva, there is less fluid bathing the taste buds into which tastes can dissolve, altering the perception for a given food.
- Saliva in xerostomic people is both sparser and has altered composition compared with that in people with normal salivary function, so the ubiquitous background "taste" is altered, driving changes in perceived taste. There is also less fluid present.

The bland taste of foods has a negative effect on food consumption, as it is not as enjoyable to eat [33, 44].

Consumers with profound xerostomia also have difficulty swallowing foods, because saliva is required to both "glue" a bolus of masticated food together and to lubricate its movement while passing through the esophagus. This problem is overcome by the consumer drinking water very frequently while eating; however water is less efficient as a lubricant/glue than saliva, due to the lack of mucins. Artificial salivas are of little value in relation to bolus formation and swallowing; they do contain bulking agents (often carboxymethylcellulose) or mucins, but, by definition, they are ineffective once swallowed unless topped up very frequently during a meal.

2.3.3 Number and Distribution of Teeth

The principle function for teeth in man is to break up foods into smaller particles to prepare the food for swallowing. The size of the particles in food that are perceived as "ready for swallowing" varies between individuals but also changes as chewing becomes less efficient, so that people with fewer or no teeth chew food less well and swallow bigger particles of food than those who have an intact dentition. This swallowing threshold is an innate characteristic.

Chewing food and mixing it with saliva have two effects: it reduces the size of the food particles in the bolus, but also enzymes in saliva (salivary amylases) start the process of digestion of starches into sugars in the oral environment. Interestingly, there is some very old and limited evidence that chewing, per se, is not required for digestion of foods with modern methods of foods preparation [45]. These data, however, were derived in young dentate volunteers, and extrapolating this to older people with fewer teeth may be inappropriate. Not only do older people have fewer teeth and, therefore, less efficient chewing; they also suffer from sarcopenia of the masticatory muscles that influence chewing force, so the composition of the food bolus is very different in a young person compared with an older one [46–49].

The efficiency of the act of chewing is affected profoundly by the number and distribution of teeth in the mouth [50–53]. In terms of research methodology, this effectiveness can be measured in one of two ways.

Study participants are given specified quantities of test foods and are told to chew them until they perceive they are ready for swallowing (the deglutition threshold). The chewed food is then removed from the mouth, and the particle size and distribution are measured either by sieving the food or using image analysis techniques. The test foods should be things that fracture into smaller pieces during chewing, like carrot or nuts, to make this process easier.

The alternative is to give people chewing gum which is in two different colors and ask them to chew for a specified number of chewing cycles. The gum is removed and analyzed in terms of the quality of mixing of the different colors, using either a visual scale or again (and more commonly) using image analysis techniques.

Both approaches have their advantages and disadvantages, but they consistently demonstrate that chewing is less efficient with fewer natural teeth, especially when the teeth do not meet in "opposing pairs." The least efficient chewing is seen in people with complete dentures that are supported by only the mucosa and bone. This is not surprising if you consider that putting a sample of food between dentures and chewing will result in the denture being displaced from its support and moving in the mouth. This is worse for a mandibular denture where the extent of support is less than for a maxillary one. In terms of chewing, the least efficient pattern of oral health is when someone has a few maxillary natural teeth and a mandibular complete denture. Chewing is only possible with dentures as a result of learned juggling of the denture by the muscles of the cheeks and tongue; for example, to incise food with upper and lower complete dentures, an individual has to stabilize the posterior of the upper denture by curling the dorsum of the tongue upward and the posterior of the lower denture by curling the sides of the tongue downward to allow pressure to be applied by the incisors without displacing the dentures. This is a complex, learned process that is compounded in humans by alerations in the fit of dentures with time. The average age of dentures worn in the UK is around 10–12 years; after this time even very slowly progressing alveolar resorption will result in a discrepancy between the fitted surface of the denture and the edentulous ridge. When there is a mismatch between the denture base and the underlying mucosa, the stabilizing adhesion and cohesion of the salivary film are less effective and so the dentures become intrinsically less stable.

This lack of fit often manifests itself when edentulous people are ill and in hospital. They commonly leave their dentures out for a period of time and then find that they can't chew as well when the denture is put back in the mouth. This is often misconstrued as the "gums having shrunk" when, in fact, it is more likely that they have forgotten how to juggle the dentures in function [54].

Table 2.2 percentage of women consuming selected fruit and vegetable items one or more times per week in 1994 among women who consumed the same food one or more times per week in 1990

Food	Number consuming the food in 1990	Percent consuming the food in 1994		
		Teeth lost		
		0	1–4	≥5
Banana	37,754	86	86	91
Cantaloupe	22,360	61	60	58
Apple or pear[a]	38,984	78	76[b]	67[b]
Raw carrot[a]	34,278	79	75[b]	67[b]
Cooked carrot	34,619	68	70	72

This should be Table 4 from [51]

[a]*P*-value <0.05 linear trend across these three groups

[b]*P*-value <0.05 comparing consumption of specific food items between women who lost teeth and women who did not lose teeth after adjusting for total energy intake, age, physical activity, BMI, and smoking

The effect of these changes in masticatory function with progressive tooth loss is reflected in the oral health data from the US Veterans Administration Longitudinal Study of Aging (commonly referred to as the VALDS or Veterans Administration Longitudinal Dental Survey). In this cohort, the research teams assessed diet over time with respect to tooth loss. Over an 8-year period, they showed that everyone developed a healthier diet (higher in fiber, lower in fats and cholesterol). However, in those subjects who had lost eight or more teeth during this follow-up period, the dietary changes were less marked and were characterized by dietary choices of reduced intake of foods that could be hard to chew, like raw carrot (Table 2.2) [51].

These seminal data underpin our understanding of why there are differences in diet between those with and without teeth. This is illustrated in a wide range of cross-sectional studies, for example, the VALDS, the US National Health and Nutrition Examination Survey series, and the UK National Diet and Nutrition Survey, to name but a few (Table 2.3) [52, 53, 55–57].

These data consistently demonstrate that people with fewer or no teeth consume a less healthy diet than those with more teeth. This is manifest by diets characterized as being lower in dietary fiber (lower fruit and vegetable intake) and higher in sugar and fat intake [58]. However, these associations are by no means straightforward, as the pattern of tooth loss in population studies varies markedly with socioeconomic status of the individual; thus, poorer people are more likely to have worse oral health and also make less healthy dietary choices. However,

Table 2.3 Intake of key nutrients with differing dental status from the US Veterans Administration Longitudinal Study of Aging and the UK National Diet and Nutrition Survey [53, 55]

	Intact		Compromised		Edentulous	
	US	UK	US	UK	US	UK
Protein (g/day)	80	72	74	67	68	60
Fiber[a] (g/day)	21[b]	16[b]	19[b]	13[b]	16[b]	11[b]
Calcium (mg/day)	773[b]	883	677[b]	812	689[b]	722[b]
Niacin (mg/day)	32	34	28	31	34	27
Vitamin C (mg/day)	156	82	146	73	127	60

[a]The numerical differences in fiber intake between the UK and US data are largely associated with different analytical techniques used for the two surveys. The US method gives a greater numerical value than the UK method

[b]These values are below the recommended daily intake values (RNIs)

when these data are analyzed and controlled for social variables, the relationship between reducing numbers of teeth and diet remains.

The most likely mechanism for the component of this change, independent of social variables, is foods choice. People with few or no teeth choose not to eat foods that are difficult to chew (e.g., raw carrot, nuts, crispy bread). There are also some unusual foods choices that are made by people with dentures who, for example, often don't eat berries (if a seed gets under the denture and the person then bites down it hurts) or green leafy vegetables (the leafy vegetable can get stuck onto the acrylic surface of the denture, which is socially embarrassing). They prefer foods that are easier to chew, so avoid hard crispy and dry food textures and prefer soft, wet, pulpy, and slimy ones [59].

There is one study that explored the relationship between food consumption and dental status that does not show this relationship. Shinkai et al. used the "healthy eating index" (HEI) as their measure of dietary quality and showed no relationship between it and numbers of teeth/edentulism [60]. HEI is a measure of overall dietary quality and does not assess individual food groups, which may explain the lack of a relationship. Also the study sample was relatively small compared with those for NHANES and the NDNS.

2.4 Does Prosthetic Intervention Affect Foods Choice?

It would be logical to think that replacing missing teeth with a prosthesis will result in people choosing to eat a better diet because their masticatory performance will improve. However, there is very little evidence to support this.

Among male health professionals there is some evidence that the use of a removable part denture to replace missing teeth results in dietary patterns similar to those in subjects with an intact dentition [61].

In a range of studies that looked at a wide range of prosthetic interventions, from fixed partial dentures through removable partial dentures, complete dentures, and implant-retained or implant-supported restorations, no changes in diet were seen subsequent to the prosthetic intervention, despite a universal trend for perceived improvements in masticatory performance. While participants reported that they could chew better/more difficult foods, they did not appear to change their diet [61–68]. An interesting study by Awad et al. showed that people with implant-supported overdentures had no differences in their overall dietary intake of nutrients compared with a control group using conventional dentures, but the implant group were more likely to derive those nutrients from fresh whole fruits and vegetables [62]. This suggests some change in dietary behavior toward a healthier diet high in fruits and vegetables intakes. There is an increasing awareness that the things we measure in terms of dietary intake, like specific micronutrients, are only a small part of the health benefits of a diet high in fruits and vegetables, as they contain so many elements that are thought or known to be beneficial to health but that are not currently recorded in dietary assessment. One example would be lycopene from tomatoes, thought to be partially responsible for the health benefits of the "Mediterranean diet," but not assessed in a formal way during these sorts of studies.

The explanation for the conundrum that people think they can chew better but do not change their foods choice involves behavior change. People do not necessarily change a behavior/habit because something is done that will allow them to make the change. Doing something that will help/allow someone to make a behavior change is known as facilitating that change. However, behaviors/habits like foods choice extend beyond the benefits of dental care and require a specific approach to induce behavior change, rather than simply to facilitate that change. Behaviors are often entrenched and require interaction with all those involved in the behavior; in relation to diet and foods choice, this includes not only the person for whom one has provided a new prosthesis but also that person's family group, as dietary change will affect all not just one.

Within behavioral change, there is a concept called "stage of change" (Fig. 2.2) [69]. This illustrates the various stages that people go through in planning for and making a change. One of the roles of the dental team when making new prostheses for patients is to help move people forward along this pathway. There are a variety of "hooks" that are available to do this, not least that one is providing something for a patient that will make chewing easier/better, that will facilitate a change. If, at the same time, the dentist talks with the person about diet and the health benefits of change, they can be helped to move them up the change ladder toward a place where change happens. This is much less likely to occur if the dentist and staff do not act as facilitators in this process.

Moynihan and colleagues have used this approach in two ways, initially with a targeted dietary intervention delivered by a dietician during the various stages of denture manufacture and, subsequently, using community nutrition assistants. Denture manufacture is a process that takes a number of stages, so lends itself to a phased approach to delivery of dietary advice linked to a formal dietary assessment. From these studies, it has been clearly demonstrated that people can and will change their diet if this change is facilitated in an appropriate manner during care. Furthermore, Moynihan et al. showed that these changes were more profound in people with implant-retained/implant-supported overdentures than in a control group with conventional dentures (Table 2.4). This study demonstrated, for the first time, that stability of the lower prosthesis was the "rate-limiting step" in terms of the magnitude of change that could be accomplished [70–73].

Bartlett et al. extended this work in a small pilot study looking at the use of denture fixatives and nutrition advice in complete denture wearers. The study used a cohort of edentulous people, all of whom received new dentures, dietary advice, and advice about the use of denture fixatives. Within the cohort, there was a marked improvement in fruit and vegetable intake and reduction of fat intake (Table 2.5). However, they were unable to differentiate between the effects of their dietary intervention alone (which comprised simply giving people some information leaflets about diet) and the

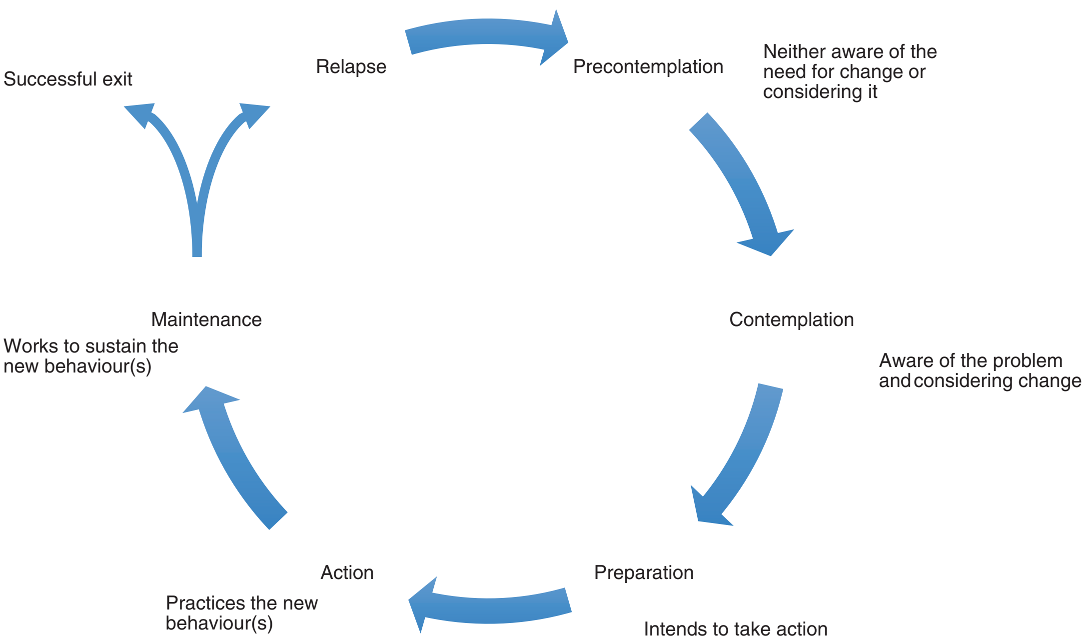

Fig. 2.2 Stages of awareness during a process of change (Adapted from Prochaska and DiClemente (1992)) [69]

Table 2.4 Changes in selected nutrient intake between conventional denture wearers and users of implant-supported overdentures after a tailored dietary intervention [73]

		IOD $n = 28$		CD $n = 28$		
	Time	Mean	95% CI	Mean	95% CI	*P*
Energy MJ/day	Base	7.1	6.9, 7.2	6.5	6.4, 6.6	0.001
	3/12	7.3	7.1, 7.6	7.0	7.0, 7.2	0.264
Difference		−0.27	−0.5, −0.03	−0.4	−0.7, 0.1	
Fruits and vegetables g/day	Base	445	350, 450	301	239, 363	0.013
	3/12	467	438, 626	425	281, 429	0.296
Difference		−21	−138, −35	−124	−106, −2	
Fiber g/day	Base	11.1	10.5, 11.7	10.2	9.7, 10.7	0.017
	3/12	11.7	11.2, 12.3	10.5	10.0, 10.8	0.002
Difference		−0.7	−1.3, −0.3	−0.3	−0.7, −0.2	
Saturated fatty acids (% energy)	Base	11.8	11.5, 12.2	12.0	11.6, 12.4	0.415
	3/12	11.0	10.7, 11.4	11.8	11.6, 12.1	0.004
Difference		0.8	0.34, 1.22	0.28	−0.19, 0.75	

Table 2.5 Change in food consumption associated with the use of a denture adhesive [74]

	Fruit/vegetable (servings)	Total fat (g)	Saturated fat (g)	Protein (g)	Starchy foods (servings)
n	35	35	35	35	35
Base	2.2	83.6	33.5	13.7	3.6
30 days	3.6	60.5	22.2	13.6	3.6
Change (95% CI)	1.4 (0.9, −1.9)	−23.2 (−31.4, −14.9)	−11.3 (−14.7, −7.9)	0.1 (−0.2, 4.9)	0 (−0.6, 0.6)
P	<0.0001	<0.0001	<0.0001	NS	NS

effect of use of a denture fixative. There were marked improvements in the reported chewing ability of these subjects when the fixative was used [74].

Conclusions

There are profound changes in body composition with increasing age that result in a need for an altered dietary pattern to one lower in energy but with static intake of micronutrients and protein, a "nutrient dense" dietary pattern.

Food choice is affected by the number and organization of the remaining natural teeth so that people with fewer contacting teeth or no natural teeth choose to eat foods that are easier to chew and avoid those with hard textures or that are difficult to chew.

The changes in foods choice result in reductions in intake of key nutrients especially fruits and vegetables and hence dietary fiber.

It is possible to encourage patients to improve their diet in association with denture wear/use but only if there is a dietary intervention in association with a dental one. Restoration of dental function alone does not result in improvement in dietary choice.

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