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THE RELATIONSHIP BETWEEN DIET QUALITY AND FALLS RISK, PHYSICAL FUNCTION AND BODY COMPOSITION IN OLDER ADULTS

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Abstract: *Objectives:* We aimed to examine associations between diet quality, falls risk, physical function, physical activity and body composition. *Design:* Cross-sectional study. *Setting and Participants:* Data collected from 171 men and women, aged 60-88 years old, as part of the Falls Risk and Osteoporosis Longitudinal Study. *Measurements:* Dietary Intake (Dietary Questionnaire for Epidemiological Studies Version 2 (DQES v2)), Falls Risk (FES-I, ABC, Berg Balance and Physiological Profile Assessment), Physical Function (SPPB), Physical Activity (PASE) and Body Composition (fat mass, lean mass, BMD, BMI, android/gynoid ratio) were ascertained. Diet quality was determined using two measures (Healthy Eating Index - HEI and Healthy Diet Indicator - HDI). One-way Analysis of Variance was used to compare mean scores between females and males and Pearson product-moment correlation coefficients were calculated to examine bivariate relationships. *Results:* Although females and males were analysed separately, the HDI-total score showed more associations that the HEI in both genders. The HDI showed, in females weak negative associations with BMI (r =-.21, p=.04), gynoid fat (r =-.20, p=.01), total fat mass (r =-.20, p=.02), with a weak positive association between HDI and percentage lean mass (r =.20, p=.03). Males showed positive associations between HDI and age (r =.30 p=.02) physical function (SPPB)(r =.26, p=.04), and subjective falls-risk (ABC) (r =.26, p=.03). In addition, in males, a negative association was found between HDI and FES-I (r =-.25, p=.04). The only measure that was significantly associated with the HEI-total score was the android/gynoid ratio in males (r =-.29, p=.04). When controlling for age, females demonstrated weak positive associations between gynoid (r = .19 p = .02), android (r = .19, p = .02) and total fat mass (r = .20 p = .02) as well as weak negative correlation with lean mass (r = 1.19, p = .03). Age also impacts on the FES-I (r = .29 p <.01) and ABC (r = -.23 p <.01). *Conclusions:* The relationships between dietary quality and body composition, falls risk and physical function in older community dwelling, higher functioning adults appear to be gender specific. Better diet quality in females, is associated with lower BMI and fat mass, and higher lean mass, compared to males that are older and appear to have better physical function, are less likely to self-report falls risk, and have a better fat distribution i.e. a lower android/gynoid ratio have better diet quality. Furthermore, age is an important confounder and should be taken into consideration when assessing diet quality in older adults. In addition these gender and age differences may be clinically relevant and could aid in the delivery of targeted interventions.

Key words: Diet quality, community-dwelling, gender, aging.

Introduction

Falls are the leading cause of unintentional injury and injury-related death among older adults, with one-in-three adults over the age of 65 years falling annually (1). Injuries associated with falls impact on physical function and may have psychological implications such as social isolation and depression due to the fear of future falling (2, 3). Falling may restrict habitual physical activity, inciting a further decline in physical function, consequently reducing functional ability and quality of life (1).

Appropriate nutrition and physical activity have the potential to prevent or delay many conditions of later life, including sarcopenia and osteoporosis, which contribute to an increased mortality from falling (4, 5). Sarcopenia significantly increases the risk of an older adult falling (6), and furthermore, older adults with a reduced bone mineral density (BMD) are also at an increased risk of fracture (7). Minimising the risk or progression of sarcopenia and osteoporosis can be achieved through appropriate physical activity (8) and good nutrition, such as the consumption of fruit, vegetables, grains, dairy, and lean meat (6, 9, 10).

Assessing an individual's dietary intake can be challenging (11). Rather than simply examining the relationship between the intake of individual nutrients and health, diet quality indices allow the assessment of both the quality and diversity of the diet and it's association with health status (12, 13). Two such indices are the Healthy Diet Indicator (HDI) which is based on the World Health Organisation dietary guidelines for the prevention of chronic disease (14, 15), and the Healthy Eating Index (HEI), a valid and reliable tool designed to encompass dietary behaviours rather than study single nutrients in isolation (16). These two indices have previously provided insight into the prevention of chronic disease through assessing nutritional intake (14, 17).

Much of the research that links nutrition and falls-risk focuses on the intake single nutrients particularly dietary

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protein, calcium, and vitamin D (1, 6, 18, 19). How dietary intake as a whole affects falls-risk, perception of falls-risk, or physical function, has yet to be examined. Data from the most recent national dietary survey in Australia (2011-2012) demonstrated that only 8% of adults were eating the recommended daily serves of vegetables, and 49% were eating the recommended daily serves of fruit (20). A decrease in the intake of foods from these food groups has been linked to a reduced BMD, which in turn increases the risk of fracture (7). As appropriate dietary intake generally declines with age (21) it is possible that poor diet quality could exacerbate the risk of falling.

Another modifiable risk factor that has been linked to an individual's risk of falling is obesity (22-24), which is increasing in the Western world at a rapid rate (20). Beyond the fact that poor dietary intake can contribute to excess body weight, the link between body composition, diet quality and falls risk has yet to be examined, even though it is well established that both diet and physical activity are modifiable independent risk factors for unfavorable changes in body composition. With age, risk factors associated with functional and health-related characteristics change which include declines in muscle mass (25, 26) and strength (27, 28) as well physical function (29, 30). Body composition is also affected by age, including increases in fat mass percentage (31) and declines in bone mineral density (32).

The aim of the current study was to develop an understanding of the associations between falls risk, physical function, body composition and diet quality in a cohort of older adults. Given the relationships between dietary intake, BMD and body composition we hypothesise that individuals with better diet quality will have reduced falls risk and physical function through more favourable body composition characteristics and higher BMD.

Experimental Methods

Participants

Participants were 171 cognitively unimpaired, community-dwelling individuals aged 60 years and over, able to walk independently (with/without walking aid), willing to undergo a bone density scan, spoke English, and able to follow simple instructions. All gave their informed written consent to participate in the study, which was approved by the University of Canberra Committee for Ethics in Human Research (protocol 12-39).

Measures

Falls-Risk Assessment

Participants completed four falls-risk assessments. Two subjective assessments, Falls Efficacy Scale - International (FES-I) and Activities-specific Balance Confidence (ABC) scale, were administered as outlined by Yardley et al (2005) (33) and Powel and Myers (1995) (34), respectively. Participants completed two objective falls-risk assessments, the Physiological Profile Assessment (PPA), adhering to the protocol as described by Lord and colleagues (35) and the Berg Balance Scale which was administered as outlined by Thorbahn and Newton (36)

Reported Falls

Participants were asked to report the number of falls (any event where the individual came to rest on a lower level) incurred over the previous 12 months.

Health-Related Characteristics

Assessments of general health and cognitive ability were undertaken as a means to ascertain any individual health-related issues. General health of the participants was measured using the 12-Item Short-Form Health Survey (SF-12). Both the physical (PhysSF-12) and mental (MenSF-12) sub-scale values were calculated (37).

Functional Characteristics

Two functional characteristics (physical activity and physical function) were analysed to ascertain the overall functional capacity of the participants. Physical activity was assessed using the Physical Activity Scale of the Elderly (PASE) a validated, reliable tool (38, 39). Scores were recorded as hours per week (hr/w).

Physical function was measured using the Short Physical Performance Battery (SPPB) (40).

Body Composition Characteristics

Body weight was measured using an electronic scale (Tannita BC-541, Australia) and height by a stadiometer (Seca 240, Germany). Android, gynoid and total body fat mass as well as lean mass were assessed by dual-energy X-ray absorptiometry (DXA) using a Lunar Prodigy Pro scanner (GE Lunar Corp., Madison, WI USA). Bone Mineral Density (BMD) (g/cm2) values of both the femur and anterior-posterior spine of lumbar 1-4 (spine) were also measured by DXA. Individuals with hip replacements or spinal fusions were not assessed for BMD. Analysis was carried out with the software enCORE™ v 14.1.

Dietary intake

The Dietary Questionnaire for Epidemiological Studies, Version 2 (DQES v2) is widely used to assess dietary intake over a long period of time, which has been described in detail elsewhere (41, 42). Briefly, it is a valid 74 item semi-quantitative self-administered questionnaire which includes questions regarding habitual fruit and vegetable intake, the amount and types of milk, bread, spreads used, the amount of sugar consumed daily, weekly egg intake and cheese eaten. The questionnaire contains photos depicting average serving sizes, and a list of 74 food items with frequency options ranging from never to 3 or more times per day (43).

Dietary Quality Indices

The Health Diet Indicator (HDI) is based on the World Health Organisation dietary guidelines for the prevention of chronic disease (15) . The HDI utilises a dichotomous scale, where a score of one is allocated if the individual meets the guidelines and a zero if they are outside the limits. A detailed description can be found elsewhere (14).

The Healthy Eating Index (HEI) is another valid and reliable tool designed to encompass dietary behaviours rather than study single nutrients in isolation (16).

Data from food frequency questionnaires were utilised to calculate a HEI score based on ten components: grain, vegetable, fruit, meat, and milk consumption, total fat, saturated fat, cholesterol and sodium intake and food variety. The first five components of the HEI measured the degree to which a person's diet conformed to the recommended number of serving (based on age and sex) of grains, fruits, vegetables, meats and dairy products. HEI scores range from 0 to 100, with higher scores equating to higher quality diet (44).

Procedure

After giving their informed consent, participants provided a basic medical history, undertook the cognitive assessment and underwent the battery of assessment tools as described above. All assessment tools and other measures were administered in the same order by the same investigator using identical instructions. Results were recorded electronically. Measures are presented as Arbitrary Units (AU) unless otherwise stated.

HEI and HDI scores were calculated by two independent researchers (DS and KP) for all responding participants.

Statistical Approach

A One-way Analysis of Variance was used to compare mean scores between females and males and Pearson product-moment correlation coefficients were calculated to examine bivariate relationships. In addition, partial correlations were under taken, controlling for age. Preliminary exploratory analysis indicated substantial and systematic sex differences in participants' health-related, physiological and functional characteristics and so was explored further. Upon confirmation, analyses were hereafter conducted separately for males and females. Descriptive statistics are presented as means ± standard deviations.

Pearson product-moment correlation coefficients (r) are reported as follows: weak (.10 to .29), moderate (.30 to .49) and strong (.50 to 1.00) (29). Statistical significance was taken at p value of 0.05.

Results

Participant characteristics are presented in Table 1. Males were significantly taller and heavier than females ($p < .001$) and were more likely to report better mental health ($p = .03$) and higher levels of physical activity ($p=.01$). Males had higher BMI ($p = .05$), BMD at both femur and APspine ($p < .001$) and relative skeletal mass index scores ($p < .001$) whereas females had a significantly greater proportion of android ($p < .02$), gynoid ($p < .001$), total body fat mass ($p < .001$) and lower percentage lean mass ($p < .001$) than the male cohort. HDI-total score was significantly higher in females compared to males, indicating that females had better diet

Table 1
Descriptive characteristics (presented as Mean ± SD) of female, male and total participants

Variable	Females (n=123) M (SD)	Males (n=48) M (SD)	Total (n=171) M (SD)
Age (years)	68.00 (6.29)	68.51 (6.04)	68.12 (6.21)
PhySF-12 (AU)	49.71 (8.41)	47.60 (10.56)	49.07 (9.14)
MenSF-12 (AU)	53.83 (7.05)	57.92* (18.34)	55.07 (11.80)
Height (cm)	163.85 (6.90)	177.95*** (7.10)	168.11 (9.50)
Weight (kg)	66.97 (11.82)	82.73*** (11.13)	71.73 (13.67)
BMI (kg/m2)	24.97 (4.38)	26.12* (3.16)	25.32 (4.08)
BMD (APspine g/cm2)	1.10 (.19)	1.23*** (.21)	1.15 (.21)
BMD (Femur g/cm2)	.90 (.14)	1.07*** (.18)	.95 (.18)
Total body fat mass (%)	37.86*** (8.60)	27.62 (6.69)	34.77 (9.33)
Android fat mass (%)	40.43* (11.14)	37.05 (8.64)	39.41 (10.55)
Gynoid fat mass (%)	45.58*** (7.23)	29.51 (6.08)	40.72 (10.11)
Lean Mass (%)	59.76 (8.31)	69.48***(6.42)	62.69 (8.97)
HEI-total score (AU)	75.77 (8.82)	73.87 (8.84)	75.34 (8.84)
HDI-total score (AU)	2.83* (.77)	2.51 (1.04)	2.75 (.85)

* p <.05, ** p<.01, *** p <.001

Table 2
Dietary data (presented as Mean ± SD) of female, male and total participants

Variable	Females (n=123) M (SD)	Males (n=48) M (SD)	Total (n=245) M (SD)
Energy (kJ/day)	6785 (1874)	8366*** (1658)	7229 (1941)
Protein (g/day)	81.01 (31.50)	85.24 (18.12)	82.20 (28.40)
Protein % En	20.2*** (3.4)	17.4 (2.4)	19.4 (3.4)
Carbohydrate (g/day)	173.21 (50.62)	206.23 (50.67)	182.48 (52.63)
Carbohydrate % En	41.0 (5.4)	39.4 (5.3)	40.6 (5.4)
Fat (g/day)	62.43 (21.20)	76.66 (19.34)	66.43 (21.61)
Fat % En	33.9 (4.6)	33.8 (4.0)	33.8 (4.4)
Alcohol (g/day)	11.2314 (10.55)	26.90 (23.48)	15.65 (16.79)
Alcohol % En	4.9 (4.6)	9.4*** (7.2)	6.2 (5.8)

%En = Percentage of total Energy intake; *** p<.001

Table 3
Correlation of Healthy Diet Indicator (HDI) and Healthy Eating Index (HEI) total scores in females and males with potential diet outcome characteristics (r)

		Age	Number of falls	SF12-Phys	SF12-Men	PASE	FES-I	ABC	BBS	PPA	SPPB	BMD Spine	BMD Femur	BMI	% Lean	% Android fat	% Gynoid fat	% Total fat	A/G ratio
Female	HDI	.07	-.07	.07	-.13	.02	-.13	.01	.09	-.07	-.02	-.06	-.03	-.21*	.20*	-.13	-.20*	-.20*	-.05
	HEI	-.04	-.03	.16	.10	-.02	-.11	.14	.15	-.05	.11	-.02	.01	-.15	.13	-.14	-.14	-.16	-.10
Male	HDI	.30*	-.08	-.07	.09	.17	-.25*	.26*	.24	.00	.26*	.00	-.10	-.09	.20	-.07	-.22	-.19	.05
	HEI	.15	-.03	.11	.13	-.24	-.10	.11	-.12	.01	.03	-.06	-.25	-.22	.00	-.05	.12	.02	-.29*

* p<.05

quality. However there was no significant difference in HEI-total scores between males and females.

Males had significantly higher daily energy intake and alcohol consumption compared to females (p<.001), however females had a higher intake of protein (p<.001). There were no significant differences between the genders in carbohydrate or fat intake (Table 2). Correlations between age and energy intake showed a positive correlation (r = .33 p = .02) in males, indicating that as men age their energy intake increases, specifically from carbohydrates (r = .42 p < .01). This increase in energy intake was not demonstrated in females.

Healthy Diet Indicator

In females, the HDI-total score showed a weak negative association with BMI (p = .04) and percentage of both gynoid fat (p = .01) and total fat mass (p = .02) (Table 3). There was also a weak positive association between HDI and percentage lean mass (p = .03) for females. Males showed moderate positive associations between HDI with age (p = .02), and weak positive association with physical function (SPPB) (p = .04) and subjective falls-risk (ABC) (p = .03) and a weak negative association between HDI and FES-I (p = .04).

When controlling for age in females, a different pattern of associations arise.. Females demonstrated weak positive associations between gynoid (r = .19 p = .02), android (r = .19 p = .02) and total fat mas (r = .20 p = .02) as well as weak negative correlation with lean mass (r = 1.19p = .03). Age also impacts on the FES-I (r = .29 p <.01) and ABC (r = -.23 p <.01) results indicating that those with better diet quality are more concerned with falling. No other associations were identified.

Healthy Eating Index

The HEI showed different relationship between diet quality and the physical and functional characteristics as well as fall-risk measures. The only measure that was significantly associated with the HEI-total score was the android/gynoid ratio in males (p = .04). This weak negative association indicates that those with better overall diet quality had a lower android/gynoid ratio (Table 3). When controlling for age no associations were found.

Discussion

The results from this study provide insight into the relationship between dietary quality and body composition, falls risk and physical function in older community dwelling, higher functioning adults. However, these relationships do appear to be gender specific. Better diet quality in females, is associated with lower BMI and fat mass, and higher lean mass. Males with better diet quality, on the other hand are older and appear to have better physical function, are less likely to self-report falls risk and have a better fat distribution i.e. a lower android/gynoid ratio. Females may also have better diet quality compared to males which is in agreement with recent research that states that the presence of a female in the household improves the household's overall diet quality (45, 46).

There are gender differences in body composition and these difference can impact physical function, for example individuals with greater fat mass have decreased physical function and increased disability (47). Given this relationship between body composition and physical function and the results presented here, where in females, diet quality is associated with body composition, it is of note that females' diet quality does not appear to be related to physical function. This is likely to be due to the smaller sample size with a cohort of females with potentially higher physical function. Conversely, other than A/G ratio, males' diet quality was not related to any body composition measures. The relationship with physical function and self-reported falls risk does indicate a link between diet and health outcomes, and that diet quality, is age related.

An unexpected finding of this study, when controlling for age, was the increased fat mass and lower lean mass identified in females, who had better diet quality. This finding warrants further investigation. Another interesting outcome was the increase in concern about falling, associated with better diet quality in females, when controlling for age. Previous research has demonstrated that the fear-of-falling increases with age (48, 49) therefore it may be this advancement in age and not diet quality impacting their perceived falls risk. This indicates that age is an important confounder when considering both diet and healthy aging outcomes.

These results, in community-dwelling individuals, builds on recently published work which has indicated that undernourished individuals in residential care facilities are likely to have poorer physical performance, have depression and a greater risk of falls (50). It does appear, however, that the relationships observed are dependent on the diet quality scale used. From the results presented here, it appears that the dichotomous scale of the HDI provides evidence that elucidates stronger relationships with falls risk, physical function and body composition characteristics relative to the HEI total score.

In addition to poor diet, physical inactivity increases the risk for many costly medical conditions including falls and hip fractures (51). Furthermore these modifiable lifestyle factors have a substantial financial and health burden in the community (51). It could therefore be asked if a combination of improved diet quality and physical activity could synergistically reduce the risk of falling in older adults. It has recently been reported that older adults are increasingly seeking health information and are willing to make behavioral changes to maintain their health and independence into advanced old age more than any other age group, with the most important self-care behaviours being diet and physical activity (52) . This may explain the positive/beneficial relationship between better diet quality and ageing, body composition, self-reported falls risk and physical function.

A primary goal of Healthy People 2020, as identified by the US Department of Health and Human Services, is to improve the health, function and quality of life of older adults (52). Older adults are among the fastest growing age groups, and are at a high risk for developing chronic illnesses and related disabilities (53), it is therefore imperative to identify preventative health strategies and advice to assist older adults in maintaining quality of life and independence. Each year one-in-three older adults fall (3, 54), leading to potential severe disability (55), fear of recurrent falling (56), sedentary behavior (57), which in turn leads to impaired physical function (58) and reduced quality of life (59). Nutritional intake can influence the onset and progression of a range of chronic diseases. Osteoporosis and sarcopenia are two conditions that are influenced through lifestyle factors such as diet and exercise, and are linked to a reduced physical functionality, increased risk of falling and reduced quality of life (60).

This paper is one of the first to examine diet quality in relation to falls risk, physical function and body composition. This line of inquiry warrants further investigation, with larger sample size and a more diverse cohort to tease out these relationships and also investigate, longitudinally the impact of age and diet quality on future health outcomes. Gender differences are apparent and clinically relevant as this is important and will aide health professionals in delivering appropriately targeted interventions.

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Conflict of Interest: The authors report no conflict of interest.

Ethical Standards: The protocol for this research project was approved by the Committee for Ethics in Human Research, protocol number 12-39 and the undertaking of the research conformed to the Declaration of Helsinki.

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