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Associations between dietary patterns and physical fitness among Chinese elderly

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Abstract
Objective: To explore the relationship between dietary patterns and physical fitness among older Chinese (≥60 years) individuals.
Design: Cross-sectional survey. Dietary data were collected by a simplified semi-quantitative FFQ. The 30-s Chair Stand test (30sCST), 30-s Arm Curl test (30sACT), 8-foot Time Up-and-Go test (8fTUAGT) and 6-min Walking test (6mWT) were used to assess physical fitness. Dietary patterns were obtained by factor analysis. The association between dietary patterns and physical fitness was explored by multiple logistic regression.
Setting: Six communities (villages) of three districts in Liaocheng City (Shandong Province, China).
Participants: A total of 596 residents were recruited from April to May 2017.
Results: Among 556 residents who were finally enrolled, 196 were men (35 %) and 360 were women (65 %). Three dietary patterns were identified: 'Western', 'Vegetarian' and 'Modern'. The 30sACT revealed that men in the fourth quartile of the Western pattern were less likely to be classified in the 'high-level' group, but men in the fourth quartile of the Vegetarian pattern were classified in the high-level group. The 6mWT revealed that men in the fourth quartile of the Modern pattern were classified in the high-level group. These associations were independent of confounding factors.
Conclusions: Adherence to the Vegetarian pattern and Modern pattern may be protective factors for maintaining good physical fitness in older Chinese individuals. The Western pattern may lead to poor physical fitness in this population.

Keywords
The elderly
Dietary patterns
Physical fitness
Chinese

China is facing the rapid ageing of its population: the total number of older people reached ~176 million (~13 % of the entire population) in 2019[1]. 'Biological ageing' is the gradual loss of physiological integrity. Almost every organ in the human body is affected by the detrimental effects of ageing, including skeletal muscle[2]. The mass and function of skeletal muscle decline with ageing[3]. Age-related decrease of the mass and function of skeletal muscle[4] leads to physical fitness decline in older people. This phenomenon is manifested as an increase in the prevalence of osteoporosis, sarcopenia and frailty[5–7] and can be followed by falls, delirium, fractures and increased medical burden[8,9]. Therefore, maintenance of good physical fitness for older people can aid avoidance of adverse outcomes. Early detection and treatment of physical decline has a crucial role in preventing or delaying the onset of physical disability[10].

A balanced diet and good physical fitness are the keys to healthy ageing, and they are closely related. Studies have suggested that diet is a major factor affecting muscle mass[11] and muscle function[12]. Healthy eating habits may contribute to increased skeletal muscle mass and help maintain good function[11,12].

Tests of physical fitness can be used to evaluate several abilities (e.g., lower and upper body strength, aerobic endurance and motor agility/dynamic balance) objectively, which support the behaviours necessary to undertake everyday activities. Several studies have explored the

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association between food nutrients and physical fitness[13], including protein, dietary fibre, vitamin D and some antioxidants[14–17]. The daily diet is often a combination of various foods, and there are often complex interactions between foods and nutrients[18]. Therefore, a food-based dietary pattern is better than nutrients in analysing the association between overall diet and physical fitness. Some studies have also explored this association. Close adherence to the 'Mediterranean diet' is associated with better physical fitness, whereas a Western dietary pattern may contribute to frailty[19,20]. One study based on an Asian population showed that a better overall quality of the diet may be associated with improved physical fitness[21]. However, dietary structures among countries are quite different, and few studies have demonstrated this association among older people in China.

We analysed the dietary patterns and tested the physical fitness of older people residing in Liaocheng City (Shandong Province, China). In particular, we investigated the association between dietary patterns and physical fitness to explore a practicable dietary pattern to maintain better physical fitness and improve health and well-being in older Chinese people.

Methods

Study population

The individuals in the current study were from Shandong Province and part of the Formative Health Assessment Instrument and Parameters for the Elderly project. This is a cross-sectional study carried out across China since 2015. It includes assessment instruments and parameters for physical fitness, mental health, social health, diet and nutrition health, and chronic diseases in older people. The goal of this project is to create a national 'healthy ageing' strategy that helps to decrease the prevalence of chronic non-communicable diseases and slows down the loss of skeletal muscle function.

Using cluster sampling, six communities were selected from the urban, suburban and rural areas in Liaocheng City from April to May 2017. The exclusion criteria were age <60 years, suffering from severe mental illness, chronic disease or limitation of daily activities which would restrict responses to questionnaires or completion of physical fitness tests. Finally, 596 participants were recruited: 214 men (36 %) and 382 women (64 %) aged 60–93 years.

Covariate assessment and anthropometric measurement

Participants were required to complete a questionnaire during a face-to-face interview. The questionnaire contained information on age, sex, residential area, occupation, marital status, education level, income and medical history of 28 diseases (e.g., high blood pressure, CHD and diabetes mellitus). Height measurement was corrected to 0·1 cm and weight measurement was corrected to 0·1 kg. We used the International Physical Activity Questionnaire Short Form to evaluate physical activity, and its reliability and validity have been evaluated in the Chinese population[22]. According to Gao and colleagues, the question of frequency and duration of low physical activity were supplemented[23].

Assessment of dietary intake

Information on dietary intake was measured using a simplified semi-quantitative FFQ, which has been tested for reliability and validity in a population of older Chinese people[24]. Participants were asked by trained investigators to recall average consumption per serving for each food item and eating times over the previous year. The frequency of consumption was divided into five categories: 'never or seldom', 'per day', 'per week', 'per month' or 'per year'. According to the Chinese Food Composition Table[25], the food items in the questionnaire were divided into 14 groups (refined cereals, coarse cereals, potatoes, mixed beans, vegetables, fruits, red meat, poultry, fish/sea food, eggs, dairy products, soyabeans, nuts and alcoholic beverages). We calculated the amount consumed (g/d) of each group and energy intake. We excluded people whose energy intake <2510·4 KJ or >16 736·0 KJ or individuals whose food intake exceeded the mean plus 6 SD. The final number of participants evaluated was 556.

Test of physical fitness

Assessment of physical fitness was based on four tests: 30-s Chair Stand test (30sCST), 30-s Arm Curl test (30sACT), 8-foot Time Up-and-Go test (8fTUAGT) and 6-min Walking test (6mWT)[26].

The 30sCST assesses lower body strength. Each participant sat in the middle of a chair with his/her feet separated, and arms folded cross the chest. The investigator recorded the number of times the participant stood up and then sat down within 30 s.

The 30sACT assesses upper body strength. The participant sat on a chair holding a hand weight (women, 2·3 kg; men, 3·6 kg), with the other arm close to the body. The investigator recorded the number of bicep curls within 30 s. Both arms were tested, and the one with the higher number of bicep curls was documented.

The 8fTUAGT assesses agility/dynamic balance. Each participant was required to arise from a seated position without the use of arms, walk around a landmark placed 2·45 m from the chair and then return to the original sitting position. The investigator recorded the time spent on the 8fTUAGT.

The 6mWT assesses aerobic endurance. Each participant was in the standing posture and walked at his/her usual pace along a prescribed route. The investigator recorded the walking distance within 6 min.

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Test results were divided into four quartiles according to sex or age (<70 or ≥70 years). The fourth quartile (Q4) was defined as the 'high-level group', and the other three quartiles were defined as the 'low-level group'[10].

Statistical analyses

Continuous variables are presented as the mean and SD. Categorical variables are expressed as sums and percentages. According to the classification of variables, the differences between men and women were compared using the Student's *t*-test or χ^2 test, and the differences among quartile categories of dietary patterns were compared using ANOVA or χ^2 test. Principal component analysis was employed to identify dietary patterns and determine factor loadings for consumed amounts (g/d) of the 14 food groups. The Kaiser–Meyer–Olkin test and Bartlett's test of sphericity were used to evaluate whether the correlation matrix was suitable for factor analysis. The varimax rotation function was used to obtain a simple correlation matrix. The factor score coefficients were estimated by the regression method. Factor scores were used to represent the dietary pattern for each participant, and a higher factor score indicated higher adherence to a dietary pattern. Scores for dietary patterns were categorised into quantiles. Q1 was considered as the reference ('low adherence') and Q4 denoted 'high adherence'. OR and 95 % CI were calculated. Multiple logistic regression was used to examine the possible association between physical fitness and adherence to each dietary pattern after adjustment for potential confounders (age, sex, BMI, physical activity, energy intake, total number of diseases, residential area, occupation, marital status, education level and income). Analyses were undertaken using SPSS v21·0 (IBM). $P < 0·05$ was considered significant.

Results

Among 556 participants, 196 (35 %) were men and the mean age was 69·3 ± 6·4 years; 360 (65 %) were women and the mean age was 69·5 ± 6·2 years. The energy intake of men was higher than that of women, and men had fewer diseases than women. Marital status ($P < 0·001$) and education level ($P < 0·001$) between sexes were significantly different. 6mWT results showed that men walked further than women in 6 min ($P < 0·001$) (Table 1). Characteristics of participants by quartile categories of three dietary patterns are shown in online supplementary material, Supplemental Table 1.

Statistical analyses showed that Kaiser–Meyer–Olkin = 0·65 and that $P < 0·05$ for Bartlett's test[27]. Three factors of eigenvalue >1·0 were selected and accounted for 34·4 % of the total variance. Food groups with a factor loading ≥0·35 on a dietary pattern were considered to be substantial contributors to the dietary pattern (Table 2).

The first pattern (named 'Western') was characterised by a high intake of red meat, alcoholic beverages, refined cereals, eggs, poultry and fish/sea food. The second pattern (named 'Vegetarian') was directly associated with consumption of coarse cereals, mixed beans, vegetables and soyabeans. The third pattern (named 'Modern') was associated with a high intake of dairy products, nuts and fruits.

The association between dietary patterns and physical fitness (according to quartiles of dietary pattern scores) stratified by sex is provided in online supplementary material, Supplemental Table 2. Table 3 shows the OR of Q4 *v.* Q1. We adjusted according to age, BMI, physical activity, energy intake and total number of diseases. For the 30sACT, logistic regression showed that participants (men) with higher adherence to a Western pattern (Q4 *v.* Q1) were less likely to be classified in the high-level group (OR = 0·21, 95 % CI = 0·06, 0·74), thereby reflecting worse upper body strength. Participants with higher adherence to the Vegetarian pattern (men) or Modern pattern (women) were more likely to appear in the high-level group (OR = 3·51, 95 % CI = 1·10, 11·19 and OR = 2·33, 95 % CI = 1·10, 4·93, respectively), thereby reflecting better upper body strength. For the 6mWT, participants with higher adherence to the Modern pattern (men) were more likely to be classified in the high-level group (OR = 3·02, 95 % CI = 1·09, 8·37), thereby reflecting better aerobic endurance. After further controlling for residential area, occupation, marital status, education level and income, the association remained significant in men but not in women.

The results of the analysis by age group are shown in online supplementary material, Supplemental Table 3. All 556 participants were divided into two groups: group 1 (age <70 years) and group 2 (age ≥70 years). Compared with participants in Q1 of the Western pattern, participants in Q4 were less likely to be classified in the high-level group for the 30sACT (group 1) and 8fTUAGT (group 2) after adjustments for age, sex, BMI, physical activity, energy intake and total number of diseases, thereby reflecting worse upper body strength and agility/dynamic balance. However, after further controlling for confounding factors, this association ceased to be significant.

Discussion

We observed three dietary patterns: Western, Vegetarian and Modern. Adherence to the Modern pattern was associated with better aerobic endurance in men and stronger upper body strength in women. Adherence to the Vegetarian pattern was associated with stronger upper body strength in men. In contrast, adherence to the Western pattern was associated with weaker upper body strength in men and younger participants and was associated with worse agility/dynamic balance in older participants.

Table 1 Characteristics of male and female participants in the current study*

Variables	Total (*n* 556) *n*	%	Male (*n* 196) *n*	%	Female (*n* 360) *n*	%	*P*†
Age (years)							0·725
Mean	69·4		69·3		69·5		
SD	6·3		6·4		6·2		
BMI (kg/m^2)							0·054
Mean	25·7		25·2		25·9		
SD	3·9		3·6		4·0		
Physical activity (METs-h/week)							0·905
Mean	73·6		74·1		73·4		
SD	65·3		74·1		66·1		
Energy intake (KJ)							<0·001
Mean	6389·8		7479·3		5796·5		
SD	2349·3		2560·6		1992·4		
Total number of diseases							<0·05
Mean	2·2		1·9		2·3		
SD	1·7		1·5		1·8		
Residential area (%)							
Urban area	163	29·4	50	25·5	113	31·4	0·146
Rural area	393	70·6	146	74·5	247	68·6	
Occupation (%)							
Vigorous intensity	499	89·7	170	86·7	329	91·4	0·107
Low or moderate intensity	57	10·3	26	13·3	31	8·6	
Marital status (%)							
Uncoupled	142	25·5	28	14·3	114	31·7	<0·001
Coupled	414	74·5	168	85·7	246	68·3	
Education level (%)							
Uneducated	235	42·3	38	19·4	197	54·7	<0·001
Primary or secondary	284	51·1	138	70·4	146	40·6	
High school or college	37	6·7	20	10·2	17	4·7	
Income (%)							
<1000 RMB/month	417	75·0	137	69·9	280	77·8	0·051
≥1000 RMB/month	139	25·0	59	30·1	80	22·2	
30-s Chair Stand (no. of stands)							0·465
Mean	13·6		13·7		13·5		
SD	3·6		3·8		3·6		
30-s Arm Curl (no. of bicep curls)							0·769
Mean	14·6		14·5		14·6		
SD	3·5		3·6		3·5		
8-foot Time Up-and-Go (s)							0·244
Mean	6·8		6·7		6·9		
SD	1·7		1·8		1·7		
6-min Walking test (min)							<0·001
Mean	432·9		453·0		421·9		
SD	90·7		93·5		87·3		

MET, metabolic equivalents.
*Continuous variables are presented as the mean and SD, and categorical variables are presented as sums and percentages.
†Student's *t*-test for continuous variables and χ^2 test for categorical variables.

The Vegetarian pattern (coarse cereals, mixed beans, vegetables, soyabeans and potatoes) and the Modern pattern (dairy products, nuts, fruits, fish/sea food and soyabeans) were beneficial to the physical fitness of the older participants in the current study, and they were similar to other diets that have been reported to be healthy. Such examples include the Mediterranean diet, Nordic diet and other healthy diets of which the common characteristics are a high intake of fish/seafood, fruit, vegetables, nuts, legumes, whole grain/cereal products, dairy and low intake of red meat/meat products[20,28,29].

Studies have shown that healthy dietary patterns have positive effects on physical fitness of older people. A cross-sectional study conducted among older adults in Spain showed that the Mediterranean pattern was associated with faster gait speed in men[20]. Based on several cohort studies[28–30], participants with higher adherence to the Mediterranean diet at baseline have faster walking speed over 8 years[30]. Perala and colleagues showed that the Nordic diet helped older women perform better in the 6mWT, 30sACT and 30sCST, which reflected better aerobic endurance and upper and lower body strength[28]. Granic and coworkers showed that participants classified in a 'Low Meat' pattern showed overall better performance in the 8fTUAGT in the entire cohort[29]. Our results confirmed the findings stated above. Meanwhile, a healthy diet has also been associated with stronger grip strength,[21,31–33] which is the most frequently used indicator of muscle

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Table 2 Dietary patterns and factor loading matrix of older adults*

	Western	Vegetarian	Modern
Red meat	**0·605**	–	–
Alcohol beverages	**0·573**	–	–
Refined cereals	**0·538**	0·233	–0·282
Eggs	**0·469**	–	–
Poultry	**0·450**	–	–
Fish/seafood	**0·431**	–	0·265
Coarse cereals	–	**0·653**	–0·317
Mixed beans	–	**0·604**	–
Vegetables	–	**0·556**	–
Soyabeans	–	**0·481**	0·321
Potatoes	0·223	0·331	0·260
Dairy products	–	–	**0·662**
Nuts	0·236	–	**0·554**
Fruits	–	–	**0·409**

*Absolute values <0·20 were excluded for simplicity, absolute values ≥0·35 are emboldened.

functional capacity for clinical purposes (though this indicator was not used in our study). In addition to the muscle strength measured by physical fitness tests, decreased muscle mass in older people (an important symptom of sarcopenia and frailty) is also closely related to skeletal muscle health. A cross-sectional study in South Korea observed that older men with a healthy dietary pattern had higher appendicular muscle mass[34]. Similarly, the results of longitudinal studies have demonstrated that a better quality of diet or adherence to a healthy diet is associated with a lower risk of sarcopenia in older people[35–37]. The findings of a meta-analysis suggested that a diet high in fruit, vegetables and whole grains may be associated with a reduced risk of frailty[38]. Our research did not involve muscle mass but, overall, it is clear that a balanced and healthy diet is essential for the skeletal muscle health of older people. Long-term adherence to a healthy dietary pattern can prevent sarcopenia and frailty.

Several mechanisms could explain the associations observed in the present study. Studies have demonstrated that oxidative damage[39] and inflammation[40] can lead to poor muscle function in older adults. Appropriate intake of vegetables and fruits rich in antioxidants can maintain healthy muscle activity and have a protective effect on age-related oxidative stress. Diets rich in dietary fibre can lower levels of C-reactive protein, which is associated with inflammation[41]. *n*-3 PUFA, levels of which are high in some fish and nuts, exert anti-inflammatory effects on muscle function by reducing production of inflammatory mediators and expression of adhesion molecules[42]. Furthermore, individuals who have high consumption of dairy products have stronger grip strength and lower body muscle strength[43]. Studies have shown that the synthesis and metabolism of protein in muscles in older people are affected by negative changes in the homeostasis of proteins and amino acids. Also, the supply of proteins or amino acids (especially legume proteins) is beneficial to this process[44]. We postulate that Vegetarian (whole cereals, soyabeans, mixed beans and vegetables) and Modern (dairy products, nuts, fruits, soyabeans and fish/sea food) patterns may prevent oxidative damage and inflammation and have the beneficial effects of proteins and, thus, have a positive effect on physical fitness in older people.

Older individuals with high adherence to the Western pattern (as characterised by high consumption of red meat, alcoholic beverages, refined cereals, eggs, poultry and fish/sea food) showed worse upper body strength and agility/dynamic balance. Bibiloni and colleagues observed that the Western dietary pattern was associated with slower gait speed and lower body strength, agility and aerobic endurance and may be a contributor to frailty[20]. Intake of fat and red/processed meat has been shown to be related

Table 3 Association between physical fitness and adherence to three dietary patterns among male and female participants*

	Male						Female					
	OR1†	95 % CI	*P*	OR2‡	95 % CI	*P*	OR1†	95 % CI	*P*	OR2‡	95 % CI	*P*
30-s Chair Stand (no. of stands)												
WP	1·25	0·29, 5·30	0·767	1·06	0·23, 4·84	0·937	0·91	0·38, 2·19	0·831	0·97	0·40, 2·38	0·954
VP	2·36	0·67, 8·38	0·184	2·21	0·61, 8·05	0·229	0·84	0·38, 1·89	0·676	0·86	0·38, 1·95	0·718
MP	0·94	0·37, 2·42	0·900	0·76	0·28, 2·12	0·603	1·25	0·61, 2·54	0·543	0·95	0·45, 2·03	0·898
30-s Arm Curl (no. of bicep curls)												
WP	0·21	0·06, 0·74	<0·05	0·22	0·06, 0·82	<0·05	0·78	0·31, 1·94	0·590	0·78	0·31, 1·99	0·601
VP	3·51	1·10, 11·19	<0·05	4·30	1·28, 14·42	<0·05	0·60	0·26, 1·36	0·219	0·63	0·27, 1·46	0·280
MP	1·18	0·48, 2·95	0·717	1·03	0·40, 2·68	0·956	2·33	1·10, 4·93	<0·05	1·76	0·81, 3·84	0·157
8-foot Time Up-and-Go (s)												
WP	0·61	0·18, 2·13	0·440	0·58	0·16, 2·09	0·407	0·65	0·25, 1·71	0·380	0·74	0·28, 1·97	0·546
VP	0·50	0·15, 1·64	0·250	0·51	0·15, 1·74	0·284	1·17	0·49, 2·78	0·720	1·39	0·56, 3·41	0·475
MP	1·22	0·45, 3·33	0·697	1·04	0·37, 2·95	0·941	1·99	0·91, 4·34	0·085	1·40	0·60, 3·28	0·433
6-min Walking (m)												
WP	0·55	0·14, 2·21	0·398	0·50	0·12, 2·06	0·334	0·75	0·29, 1·92	0·548	0·82	0·32, 2·14	0·691
VP	1·27	0·40, 4·10	0·687	1·36	0·41, 4·52	0·612	0·55	0·23, 1·36	0·196	0·56	0·22, 1·43	0·227
MP	3·02	1·09, 8·37	<0·05	3·17	1·10, 9·13	<0·05	1·14	0·51, 2·55	0·784	1·06	0·45, 2·53	0·894

WP, Western pattern; VP, Vegetarian pattern; MP, Modern pattern.
*Factor scores of each dietary pattern were categorised into quantiles. Q1: lowest quartile of dietary patterns. Q4: highest quartile of dietary patterns. Q4 *v.* Q1 (reference).
†Model 1 was adjusted for age, BMI, physical activity, energy intake and total number of diseases.
‡Model 2 was adjusted for age, BMI, physical activity, energy intake, total number of diseases, residential area, occupation, marital status, education level and income.

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to increased oxidation as well as inflammation[45], data which may support our findings. However, studies based on South Korean populations have drawn different conclusions from ours. They found that in metropolitan areas, the group eating more meat (high intakes of beverages and alcohol, eggs, meats, meat products and low intakes of vegetables) had better grip strength because of the adequate intake of protein[46]. In our study, most of the participants came from rural areas with low economic status and education level. Therefore, in addition to the quality of the diet, there may have been other health-related behavioural issues that affected their physical fitness. Dietary patterns are usually closely related to lifestyle, and the Western pattern is related to less healthy behaviours[47]. Dietary patterns are also associated with obesity, systemic inflammation, CVD, poor cognitive function and depression, all of which may increase the risk of frailty[47], and lead to further decline in physical fitness in older people. The impact of healthy behaviours on diet and physical fitness merits further exploration.

In the present study, one of the characteristics of the Western pattern was high intake of fish/seafood, which, in general, is regarded as an optimal food for maintaining muscle mass and preventing sarcopenia[38] and usually denotes a healthy diet[11,48]. However, dietary pattern represents the overall diet; there may be complex interactions between food. Although the Western dietary pattern contains favourable food factors, the whole Western pattern shows an adverse effect on physical fitness.

Our study had several strengths. Similar studies have been carried out in European populations, but, to our knowledge, this is the first study to focus on the association between dietary patterns and physical fitness among an older Chinese population. In addition, dietary pattern analyses can highlight the impact of the overall diet on physical fitness rather than that of a certain food. Moreover, studies[12] have mostly used the Short Physical Performance Battery test, walking speed or grip strength to measure physical fitness. Compared with those tests, the physical fitness indicators selected in our study can reflect the overall physical fitness, including upper body strength, lower body strength, agility/dynamic balance and aerobic endurance.

Our study had four main limitations. First, due to its cross-sectional design, we could not ascertain a causal relationship between dietary patterns and physical fitness. Second, the sample size of the current study was small (especially for males). This small size hampered use of more age groups when carrying out subgroup analyses for age, but age is an important factor for the physical fitness in older individuals. Third, urban and rural samples were distributed unevenly, and all participants came from Shandong Province, so the results may not be a good representation for all older people from China. Fourth, even though we adjusted for possible confounding factors, such as physical activity, energy intake and socio-demographic characteristics, we could not control the residual confounding or effect modifications caused by other unmeasured covariates. Further studies need to be continued in other provinces in China, and more attention should be paid to the balance of sex and region of residence of participants.

Conclusions

Our study indicated that the Modern pattern was associated with better aerobic endurance and stronger upper body strength, the Vegetarian pattern was associated with stronger upper body strength and the Western pattern was associated with weaker upper body strength and worse agility/dynamic balance. Adherence to a dietary pattern characterised by high consumption of coarse cereals, mixed beans, vegetables, soyabeans, dairy products, nuts and fish/sea food may be helpful to maintenance of good physical fitness, whereas adherence to the Western dietary pattern may result in poor physical fitness among older adults. Even small improvements in physical fitness can have a considerable impact on the quality of later life, so carrying out dietary health education and physical fitness training for older individuals is needed.

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Supplementary material

For supplementary material accompanying this paper visit https://doi.org/10.1017/S136898002000333X

References

1. Yang W, Wu B, Tan SY *et al.* (2020) Understanding health and social challenges for aging and long-term care in

China. *Res Aging*. Published online: 17 July 2020. doi: 10.1177/0164027520938764.
2. Nelke C, Dziewas R, Minnerup J *et al.* (2019) Skeletal muscle as potential central link between sarcopenia and immune senescence. *EBio Med* **49**, 381–388.
3. Dodds RM, Syddall HE, Cooper R *et al.* (2014) Grip Strength across the life course: normative data from twelve British studies. *PLoS One* **9**, 15.
4. McGregor RA, Cameron-Smith D & Poppitt SD (2014) It is not just muscle mass: a review of muscle quality, composition and metabolism during ageing as determinants of muscle function and mobility in later life. *Longev Healthspan* **3**, 9.
5. Yoo JE & Park HS (2018) Prevalence and associated risk factors for osteoporosis in Korean men. *Arch Osteoporos* **13**, 88.
6. Buford TW, Anton SD, Judge AR *et al.* (2010) Models of accelerated sarcopenia: critical pieces for solving the puzzle of age-related muscle atrophy. *Ageing Res Rev* **9**, 369–383.
7. Pan B, Li H, Wang Y *et al.* (2019) Physical activity and the risk of frailty among community-dwelling healthy older adults: a protocol for systematic review and meta-analysis. *Medicine (Baltimore)* **98**, e16955.
8. Clegg A, Young J, Iliffe S *et al.* (2013) Frailty in elderly people. *Lancet* **381**, 752–762.
9. Xia W, Cooper C, Li M *et al.* (2019) East meets West: current practices and policies in the management of musculoskeletal aging. *Aging Clin Exp Res* **31**, 1351–1373.
10. Rikli RE & Jones CJ (1999) Functional fitness normative scores for community-residing older adults, ages 60–94. *J Aging Phys Activ* **7**, 162–181.
11. Jang BY & Bu SY (2019) A vegetable and fish dietary pattern is positively associated with skeletal muscle mass in Korean Men. *Clin Nutr Res* **8**, 1–16.
12. Granic A, Sayer AA & Robinson SM (2019) Dietary patterns, skeletal muscle health, and sarcopenia in older adults. *Nutrients* **11**, 745.
13. Aparicio-Ugarriza R, Luzardo-Socorro R, Palacios G *et al.* (2019) What is the relationship between physical fitness level and macro- and micronutrient intake in Spanish older adults? *Eur J Nutr* **58**, 1579–1590.
14. Fanelli Kuczmarski M, Pohlig RT, Stave Shupe E *et al.* (2018) Dietary protein intake and overall diet quality are associated with handgrip strength in African American and White Adults. *J Nutr Health Aging* **22**, 700–709.
15. Wu IC, Chang HY, Hsu CC *et al.* (2013) Association between dietary fiber intake and physical performance in older adults: a nationwide study in Taiwan. *PLoS One* **8**, e80209.
16. Aloia JF, Mikhail M, Fazzari M *et al.* (2019) Physical performance and vitamin D in elderly black women – the PODA randomized clinical trial. *J Clin Endocrinol Metab* **104**, 1441–1448.
17. Passerieux E, Hayot M, Jaussent A *et al.* (2015) Effects of vitamin C, vitamin E, zinc gluconate, and selenomethionine supplementation on muscle function and oxidative stress biomarkers in patients with facioscapulohumeral dystrophy: a double-blind randomized controlled clinical trial. *Free Radic Biol Med* **81**, 158–169.
18. Hu FB (2002) Dietary pattern analysis: a new direction in nutritional epidemiology. *Curr Opin Lipidol* **13**, 3–9.
19. Fougere B, Mazzuco S, Spagnolo P *et al.* (2016) Association between the Mediterranean-style dietary pattern score and physical performance: results from TRELONG Study. *J Nutr Health Aging* **20**, 415–419.
20. Bibiloni MDM, Julibert A, Argelich E *et al.* (2017) Western and Mediterranean dietary patterns and physical activity and fitness among Spanish older adults. *Nutrients* **9**, 704.
21. Jeong GW, Kim YJ, Park S *et al.* (2019) Associations of recommended food score and physical performance in Korean elderly. *BMC Public Health* **19**, 128.
22. Macfarlane DJ, Lee CC, Ho EY *et al.* (2007) Reliability and validity of the Chinese version of IPAQ (short, last 7 days). *J Sci Med Sport* **10**, 45–51.
23. Gao J (2012) Association of dietary patterns and physical activities with total body fat proportions and metabolic syndrome among middle-aged and elderly people: a cross-sectional study. Doctoral dissertation, Fudan University.
24. Gao J, Fei J, Jiang L *et al.* (2011) Assessment of the reproducibility and validity of a simple food-frequency questionnaire used in dietary patterns studies. *Acta Nutrimenta Sinica* **33**, 452–456.
25. Yang Y, Wang G & Pan X (2002) *China Food Composition*. Beijing: Peking University Medical Press.
26. Rikli RE & Jones CJ (2013) *Senior Fitness Test Manual*. Champaign: Human Kinetics.
27. Castro MA, Baltar VT, Selem SS *et al.* (2015) Empirically derived dietary patterns: interpretability and construct validity according to different factor rotation methods. *Cad Saude Publica* **31**, 298–310.
28. Perala MM, von Bonsdorff M, Mannisto S *et al.* (2016) A healthy Nordic diet and physical performance in old age: findings from the longitudinal Helsinki Birth Cohort Study. *Br J Nutr* **115**, 878–886.
29. Granic A, Jagger C, Davies K *et al.* (2016) Effect of dietary patterns on muscle strength and physical performance in the very old: findings from the Newcastle 85+ Study. *PLoS One* **11**, e0149699.
30. Shahar DR, Houston DK, Hue TF *et al.* (2012) Adherence to Mediterranean diet and decline in walking speed over 8 years in community-dwelling older adults. *J Am Geriatr Soc* **60**, 1881–1888.
31. Barrea L, Muscogiuri G, Di Somma C *et al.* (2019) Association between Mediterranean diet and hand grip strength in older adult women. *Clin Nutr* **38**, 721–729.
32. Xu B, Houston DK, Locher JL *et al.* (2012) Higher healthy eating index-2005 scores are associated with better physical performance. *J Gerontol A Biol Sci Med Sci* **67**, 93–99.
33. Perala MM, von Bonsdorff MB, Mannisto S *et al.* (2017) The healthy Nordic diet predicts muscle strength 10 years later in old women, but not old men. *Age Ageing* **46**, 588–594.
34. Lee JY & Lee S (2019) Dietary patterns related to appendicular skeletal muscle mass: the Korea National Health and Nutrition Examination Survey 2008–2011. *J Am Coll Nutr* **38**, 358–363.
35. Isanejad M, Sirola J, Mursu J *et al.* (2018) Association of the Baltic Sea and Mediterranean diets with indices of sarcopenia in elderly women, OSPTRE-FPS study. *Eur J Nutr* **57**, 1435–1448.
36. Karlsson M, Becker W, Michaelsson K *et al.* (2020) Associations between dietary patterns at age 71 and the prevalence of sarcopenia 16 years later. *Clin Nutr* **39**, 1077–1084.
37. Chan R, Leung J & Woo J (2016) A prospective cohort study to examine the association between dietary patterns and sarcopenia in Chinese community-dwelling older people in Hong Kong. *J Am Med Dir Assoc* **17**, 336–342.
38. Rondanelli M, Rigon C, Perna S *et al.* (2020) Novel insights on intake of fish and prevention of sarcopenia: all reasons for an adequate consumption. *Nutrients* **12**, 307.
39. Cesari M, Pahor M, Bartali B *et al.* (2004) Antioxidants and physical performance in elderly persons: the Invecchiare in Chianti (InCHIANTI) study. *Am J Clin Nutr* **79**, 289–294.
40. Cesari M, Penninx BW, Pahor M *et al.* (2004) Inflammatory markers and physical performance in older persons: the InCHIANTI study. *J Gerontol A Biol Sci Med Sci* **59**, 242–248.

41. King DE, Egan BM, Woolson RF *et al.* (2007) Effect of a high-fiber diet vs a fiber-supplemented diet on C-reactive protein level. *Arch Intern Med* **167**, 502–506.
42. Calder PC (2006) n-3 polyunsaturated fatty acids, inflammation, and inflammatory diseases. *Am J Clin Nutr* **83**, 1505S–1519S.
43. Radavelli-Bagatini S, Zhu K, Lewis JR *et al.* (2013) Association of dairy intake with body composition and physical function in older community-dwelling women. *J Acad Nutr Diet* **113**, 1669–1674.
44. Timmerman KL & Volpi E (2008) Amino acid metabolism and regulatory effects in aging. *Curr Opin Clin Nutr Metab Care* **11**, 45–49.
45. Calder PC, Ahluwalia N, Brouns F *et al.* (2011) Dietary factors and low-grade inflammation in relation to overweight and obesity. *Br J Nutr* **106**, Suppl. 3, S5–S78.
46. Seo AR, Kim MJ & Park KS (2020) Regional differences in the association between dietary patterns and muscle strength in Korean older adults: data from the Korea National Health and Nutrition Examination Survey 2014–2016. *Nutrients* **12**, 1377.
47. Leon-Munoz LM, Garcia-Esquinas E, Lopez-Garcia E *et al.* (2015) Major dietary patterns and risk of frailty in older adults: a prospective cohort study. *BMC Med* **13**, 11.
48. Pilleron S, Ajana S, Jutand MA *et al.* (2017) Dietary patterns and 12-year risk of frailty: results from the Three-City Bordeaux Study. *J Am Med Dir Assoc* **18**, 169–175.

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