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Dietary patterns and sarcopenia in elderly adults: the Tianjin Chronic Low-grade Systemic Inflammation and Health (TCLSIH) study

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Abstract

Sarcopenia is a core contributor to several health consequences, including falls, fractures, physical limitations and disability. The pathophysiological processes of sarcopenia may be counteracted with the proper diet, delaying sarcopenia onset. Dietary pattern analysis is a whole diet approach used to investigate the relationship between diet and sarcopenia. Here, we aimed to investigate this relationship in an elderly Chinese population. A cross-sectional study with 2423 participants aged more than 60 years was performed. Sarcopenia was defined based on the guidelines of the Asian Working Group for Sarcopenia, composed of low muscle mass plus low grip strength and/or low gait speed. Dietary data were collected using a FFQ that included questions on 100 food items along with their specified serving sizes. Three dietary patterns were derived by factor analysis: sweet pattern, vegetable pattern and animal food pattern. The prevalence of sarcopenia was 16·1 %. The higher vegetable pattern score and animal food pattern score were related to lower prevalence of sarcopenia ($P_{trend} = 0·006$ and $< 0·001$, respectively); the multivariate-adjusted OR of the prevalence of sarcopenia in the highest *v.* lowest quartiles were 0·54 (95 % CI 0·34, 0·86) and 0·50 (95 % CI 0·33, 0·74), separately. The sweet pattern score was not significantly related to the prevalence of sarcopenia. The present study showed that vegetable pattern and animal food pattern were related to a lower prevalence of sarcopenia in Chinese older adults. Further studies are required to clarify these findings.

Key words: Dietary patterns: Sarcopenia: Elderly adults: Muscle

Sarcopenia is an age-related syndrome characterised by a progressive loss of muscle mass combined with reduced muscle strength and/or physical performance[1]. Accumulating evidence suggests that sarcopenia predisposes older individuals to many adverse outcomes, such as falls, fractures, disability, hospitalisation and mortality[2–5]. It is estimated that the overall prevalence of sarcopenia was 10 % in older adults in the world[6]. In Asia, the prevalence of sarcopenia according to the Asian Working Group of Sarcopenia (AWGS) definition was estimated at 9·6–22·1 % in older men and 7·7–21·8 % in older women[1,7]. Asian people appear to have a higher prevalence of sarcopenia than other regions[7]. Due to the escalation of the reported prevalence of sarcopenia in elderly populations, sarcopenia has emerged as a major health issue in the elderly population and an important burden for health systems[7].

Abbreviation: AWGS, Asian Working Group of Sarcopenia.

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The aetiology and underlying mechanisms of sarcopenia are complicated and multifactorial, reportedly involving nutrition status, insulin resistance, chronic inflammation and oxidative stress[8–11]. Dietary interventions, such as protein, amino acids and antioxidants, may delay or prevent the onset of sarcopenia by counteracting some of these pathological processes[12,13]. Moreover, individual nutrient supplements, such as protein, vitamin D and *n*-3 fatty acids[14–17], have been shown to be beneficial for slowing down or preventing the age-dependent changes in muscle. However, compared with the monitoring of single nutrients, dietary patterns account for the complexity of dietary intake, the interaction of various nutrients and the synergy between foods and nutrients. Thus, this type of monitoring may be more effective to examine the dietary influence on ageing muscle and may facilitate translation of findings into public health recommendations[18].

Studies of the relationship between dietary patterns and sarcopenia in elderly adults are rare and have predominantly focused on Western dietary patterns and Mediterranean diets[19–22]. One study has previously examined this relationship in a Hong Kong (a city in southern China) population[23]. Another study investigated the relationship between dietary patterns and sarcopenia in older Chinese people from three cities, located in the north, east and south of China[24]. However, habitual diets of subjects in northern China and southern China are heterogeneous. The southern Chinese diet is characterised by a high consumption of seasonal vegetables and fruits, freshwater fish and shrimp, legumes, and a moderate consumption of whole grain rice, plant oils (mainly rapeseed oil) and red meat[25]. Northern Chinese people have a higher consumption of wheat flour, starch, tubers, other cereals and animal foods, and a lower consumption of vegetables and fruits[25]. Dietary components, styles or patterns may be one of the major contributors to the chronic non-communicable disease prevalence discrepancy between the two parts of China[25]. Therefore, we conducted a community-based cross-sectional study to explore the relationship between dietary patterns and sarcopenia in a large-scale elderly population in northern China.

Methods

Study population

Participants in this cross-sectional study were recruited from the Tianjin Chronic Low-grade Systemic Inflammation and Health Cohort Study, which is a large prospective dynamic cohort study focusing on the relationships between chronic low-grade systemic inflammation and the health status of a population living in Tianjin, China. Tianjin Chronic Low-grade Systemic Inflammation and Health Cohort Study was initiated in 2007. The inclusion criteria for this Tianjin Chronic Low-grade Systemic Inflammation and Health Cohort Study were men and women who were 18 years and older living in Tianjin, China for at least 5 years. Participants were recruited from health management centres and community management centres. They all had received annual health examinations and completed questionnaires regarding their smoking and drinking habits and disease history. Moreover, a detailed lifestyle questionnaire survey (which collected information about educational level, employment status, marital status and household income, physical activity, dietary habits, history of diseases and depressive symptoms) and measurements of handgrip strength and gait speed were administered to participants since 2013. Participants further received bioelectrical impedance analysis since 2017. The study protocol was approved by the Institution Review Board of Tianjin Medical University. All participants provided written informed consent.

This cross-sectional study used baseline data from the Tianjin Chronic Low-grade Systemic Inflammation and Health, ranging from the year of 2017–2019. Participants aged above 60 years who had received health examinations, bioelectrical impedance analysis, handgrip strength, gait speed test and questionnaire survey were included (*n* 2698). We excluded participants who did not complete data collection on FFQ or measurements of muscle mass, grip strength and gait speed (*n* 275). Owing to these exclusions, the final cross-sectional study population comprised 2423 participants.

Assessment of sarcopenia

Muscle mass was assessed using Direct Segmental Multi-Frequency Bioelectrical Impedance Analysis (In-Body 720; Bio space Co., Ltd). The participants were asked to wear light clothing, remove their shoes and socks, and stand over the electrodes on the machine for 3–5 min. The relative skeletal mass index was calculated by dividing the appendicular skeletal muscle mass (kg) by the square of height (m).

Handgrip strength (kg) was measured using an adjustable hydraulic hand-held dynamometer (EH101; CAMRY; range 0–90 kg; accuracy 0·1 kg). Participants were tested by the trained evaluators with standardised verbal instructions. The dynamometers were calibrated before testing and adjusted for optimal fit for each participant according to instructions on the dynamometer. Participants were instructed to hold the dynamometer beside but not against their body while standing upright with the arm vertical and then grip the dynamometers as hard as they could. Handgrip strength was measured twice for each hand and the greatest recorded value was considered the maximal grip strength.

Gait speed over a distance of 4 m was measured to assess muscle performance. Participants were directed to wear flat, comfortable walking shoes, and walk for 4 m at their regular speed. The gait speed test was performed only once. The trained evaluators recorded the time using a stopwatch as second (s).

Based on the consensus of the AWGS, sarcopenia was defined by low muscle mass simultaneously with either low grip strength or low gait speed[1]. Low muscle mass was defined as relative skeletal mass index $< 7{\cdot}0$ kg/m^2 in men and $< 5{\cdot}7$ kg/m^2 in women. Low grip strength was defined as handgrip strength < 26 kg in men and < 18 kg in women. Low gait speed was defined as walking speed < 1 m/s in both men and women, which was made an adjustment for the participants[26].

Assessment of dietary intake

Dietary intake was assessed by a modified version of the self-administered semi-quantitative FFQ, which consisted of 100 food items (the initial version of the FFQ included eighty-one food items[27]) with their specified serving sizes. Participants

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were instructed to indicate their mean frequency of consumption over the past month by checking one of the seven levels of frequency for foods, ranging from 'almost never eat' to 'twice or more per day' and one of the eight levels of frequency for beverages ranging from 'almost never drink' to 'four or more times per day'. The mean daily intake of nutrients was calculated using an *ad hoc* computer programme developed to analyse the questionnaire. The Chinese food composition tables were used as the nutrient database. The reproducibility and validity of the questionnaire were assessed in a random sample of 150 participants from our cohort using data from repeated measurements of the FFQ approximately 3 months apart and 4-d weighed diet record. Spearman rank correlation coefficient for energy intake between two FFQ administered 3 months apart was 0·68. Correlation coefficients for food items (fruits, vegetables, fish, meat and beverages) between two FFQ administered 3 months apart ranged from 0·62 to 0·79. Spearman's rank correlation coefficient for energy intake by the weighed diet record and the FFQ was 0·49. Correlation coefficients for nutrients (vitamin C, vitamin E, PUFA, SFA, carbohydrate and Ca) by the weighed diet record and the FFQ ranged from 0·35 to 0·54. Subjects also were asked whether or not they had changed their eating habits during the past 5 years.

Assessment of other variables

The socio-demographic variables including age, sex, educational level, employment status, marital status and household income, health behaviours including physical activity, smoking status and drinking status were collected using a standardised health-related questionnaire. The personal history of diseases (hypertension, hyperlipidaemia, diabetes, CHD, stroke and cancer) was assessed according to the responses to relevant questions, the personal health records [28] and annual health check. Total energy intake was calculated according to the response of the FFQ, combined with the food composition table. Anthropometric measurements (including body height and body weight) were measured by trained personnel using a standard protocol, and the BMI was computed as the body weight (in kg) divided by height squared (in m^2). Depressive symptoms were evaluated by the Chinese version of the Zung Self-Rating Depression Scale.

Statistical analysis

Statistical analyses were performed using the Statistical Analysis System 9.3 edition for Windows (SAS Institute). We categorised the food items and beverages from the FFQ into forty-two predefined food groups, which were used to derive dietary patterns and determine factor loadings via factor analysis (principal component analysis). Factors were rotated with Varimax rotation to maintain uncorrelated factors and enhance interpretability. After the evaluation of eigenvalues (> 1·0) and the scree test, three factors were determined. Food groups with a factor loading > |0·30| were the main contributors to dietary patterns and representative of the character of each pattern.

For participant characteristics, the continuous variables were presented as mean (95 % CI), and categorical variables were presented as percentages. The association between quartile categories of dietary pattern scores and the presence of sarcopenia was analysed using multiple logistic regression models. The linear trend cross-increasing quartiles were tested using the median value of each quartile as a continuous variable based on linear regression. OR and 95 % CI were calculated. The model 1 was the unadjusted model and the model 2 was adjusted for age, sex and BMI. The model 3 was further adjusted for physical activity, smoking status, drinking status, individual history of diseases (CHD, stroke, cancer, diabetes, hypertension and hyperlipidaemia), total energy intake, depressive symptoms, household income, marital status, educational level and employment status. The model 4 was additionally adjusted for scores of other dietary patterns with each other. Moreover, we did stratified analyses to assess potential effect modification by sex (men or women), BMI (< or ≥ 24·0 kg/m^2), physical activity (< or ≥ 23 MET-h/week), diabetes (yes or no), hypertension (yes or no) and hyperlipidaemia (yes or no). The potential interactions between dietary pattern scores and the stratifying factors were tested by the addition of the cross-product term to the multivariable model, separately. All tests were two-tailed, and *P* values < 0·05 were considered statistically significant.

Results

Dietary patterns

Factor analysis revealed three main dietary patterns for the population in the present study. Food groups and factor loadings are presented in Table 1. Dietary patterns were descriptively named according to the nature of the food groups showing high loading (absolute value) for each of the factors. The first factor was defined as the sweet pattern because it was characterised by greater consumption of fruits and some root vegetables which tasted sweet. The second factor, named the vegetable pattern, was typified by frequent consumption of vegetables, coarse cereals and soya products. The third factor represented frequent consumption of poultry, meat and fish, which was identified as the animal food pattern. The first to third dietary patterns accounted for 7·19, 6·87 and 6·44 %, respectively, of the variance in food intakes and totally explained 20·5 % of the variability.

Characteristics of participants

A total of 2423 participants were enrolled in the present study. The prevalence of sarcopenia was 16·1 % (391/2423) in all participants, 14·0 % (134/959) in men and 17·6 % (258/1464) in women. The characteristics of the participants are shown in Table 2. The proportion of men was 39·6 % (959/2423). The mean age was 67·6 (95 % CI 67·4, 67·9) years. Compared with participants without sarcopenia, those with sarcopenia were older (*P* values < 0·0001), were more likely to be females (*P* values = 0·02), have lower BMI (*P* values < 0·0001), have a higher Self-Rating Depression Scale score (*P* values < 0·001) and have a history of hypertension (*P* values = 0·04), hyperlipidaemia (*P* values < 0·001), diabetes (*P* values = 0·02) and stroke (*P* values < 0·001). The individuals with sarcopenia were significantly more likely to be have lower levels of physical activity

Table 1. Principal component analysis Varimax-rotated forty-two food groups factor loading scores (*n* 2423)

Food groups	Sweet pattern	Vegetable pattern	Animal food pattern
Refined grains	−0·16	0·58*	−0·12
Noodles	0·19	0·18	0·18
Bread	0·25*	0·01	0·11
Rice	0·15	0·21*	0·15
Whole grains	−0·15	0·60*	−0·09
Dairy products	0·15	−0·04	0·18
Poultry	0·11	−0·03	0·59*
Red meats	−0·06	−0·03	0·58*
Organ meats	0·35*	−0·09	0·32*
Sausage	0·19	0·12	0·31*
Chicken egg	−0·08	0·19	0·28*
Preserved egg	0·31*	−0·05	0·08
Seafood (Squid, octopus, lobster, shellfish)	0·37*	0·03	0·25*
Fish (fish bone and all, dried fish, fatty fish and less-fat fish)	0·16	0·09	0·40*
Dark green and leafy vegetables	0·28*	0·61*	0·14
Solanaceous vegetables	0·29*	0·44*	0·25*
Carotenoid vegetables	0·54*	0·20	0·02
Starchy vegetables	0·34*	0·44*	0·03
Mushroom and fungi	0·48*	0·28*	0·27*
Hot and sweet peppers	0·13	0·27*	0·24*
Tomato	−0·20	0·47*	0·19
Bulb vegetable	0·15	0·47*	0·18
Ginger	0·01	0·28*	0·34*
Seaweed	0·40*	0·09	0·18
Legumes and soya products	0·22*	0·29*	0·34*
Preserved vegetables	0·10	0·36*	0·28*
Salted eggs	0·04	0·28*	0·27*
Fruits (citrus fruits)	0·53*	0·07	−0·10
Fruits (all kinds except for citrus fruits, persimmon, strawberry and kiwi fruit)	0·60*	0·23*	−0·01
Fruits (persimmon, strawberry, kiwi fruit)	0·58*	0·05	−0·13
Dim sum (cakes, cookies and biscuits)	0·21*	0·06	0·17
Sweets and desserts	0·26*	−0·02	0·01
Honey	0·09	0·01	0·22*
Nuts	0·12	0·32*	0·26*
Tea	0·03	0·12	0·27*
Coffee	0·02	0·07	−0·04
Soda and sweetened beverages	0·12	−0·06	0·11
Fruits or vegetables juice	0·06	−0·06	0·03
Alcohol consumption	−0·04	0·01	0·33*
Fried foods	0·32*	0·21*	0·32*
Bean vermicelli	0·19	0·07	0·29*
Sesame and sesame products	0·06	0·06	0·37*

*Loadings with an absolute value more than 0·20.

(P values < 0·001), education (P values < 0·001) and household income (P values = 0·005).

Dietary patterns and sarcopenia

As shown in Table 3, the sweet pattern score was not statistically significantly related to the prevalence of sarcopenia before and after adjustment. Higher vegetable pattern score was related to a lower prevalence of sarcopenia before and after adjustment for multiple confounders and the scores of the other two dietary patterns (P for trend < 0·001 and 0·006, respectively). Multivariate-adjusted OR of the prevalence of sarcopenia across quartile of the vegetable pattern score were 1·00 (reference), 0·87 (95 % CI 0·62, 1·21), 0·68 (95 % CI 0·47, 0·99) and 0·54 (95 % CI 0·34, 0·86). Higher animal food pattern score was also related to a lower prevalence of sarcopenia before and after adjustment (P for trend < 0·0001 and < 0·001, respectively). Multivariate-adjusted OR of the prevalence of sarcopenia across quartile of the animal food pattern score were 1·00 (reference), 0·86 (95 % CI 0·63, 1·18), 0·79 (95 % CI 0·57, 1·10) and 0·50 (95 % CI 0·33, 0·74).

Stratified analyses

In stratified analyses, the relationship between quartiles of factor scores and sarcopenia is shown in Table 4. All interactions were not statistically significant (P for interaction > 0·05), except for animal food pattern score and BMI (P for interaction < 0·05, Table 4).

Discussion

In this large-scale cross-sectional study of an elderly Chinese population, we identified three major dietary patterns: sweet pattern, vegetable pattern and animal food pattern. These dietary patterns were similar to those reported in previous studies that also analysed dietary patterns in the general population in

Table 2. Participant characteristics by sarcopenia status
(Mean values and 95 % confidence intervals, *n* 2423)

Characteristics	Without sarcopenia Mean	Without sarcopenia 95 % CI	With sarcopenia Mean	With sarcopenia 95 % CI	*P**
No. of subjects	2032		391		–
Sex (males, %)	40·6		34·3		0·02
Age (years)	67·2	66·9, 67·4†	70·2	69·7, 70·7	< 0·0001
BMI (kg/m^2)	25·4	25·2, 25·5	23·9	23·5, 24·2	< 0·0001
Total energy intake (kcal/d)	2057·8	2029, 2086·6	1991·9	1926·2, 2057·6	0·07
Self-Rating Depression Scale score	33·8	33·4, 34·2	35·6	34·7, 36·5	< 0·001
Physical activity (Mets × h/week)	93·2		88·0		< 0·001
Smoking status (%)					
Smoker	37·8		32·6		0·24
Ex-smoker	50·6		59·0		0·06
Non-smoker	11·6		8·33		0·25
Drinking status (%)					
Everyday	14·1		11·3		0·14
Sometime	7·52		6·92		0·68
Ex-drinker	1·82		1·03		0·28
Non-drinker	76·6		80·8		0·07
Educational level (≥ college grade, %)	5·81		1·28		< 0·001
Managers (%)	17·3		16·1		0·56
Marital status (married, %)	98·2		98·2		0·98
Household income (≥ 10 000 Yuan, %)	11·8		6·91		0·005
Individual history of diseases (%)					
Hypertension	52·8		58·6		0·04
Hyperlipidaemia	42·4		52·9		< 0·001
Diabetes	12·6		17·1		0·02
CVD	11·5		14·1		0·15
Stroke	4·23		8·70		< 0·001
Cancer	0·64		0·26		0·38

* ANOVA or logistic regression analysis.
† Mean (95 % confidence interval) (all such values).

Table 3. Relationship between quartiles of factor scores and sarcopenia
(Odds ratios and 95 % confidence intervals, *n* 2423)

	Quartiles of factor scores (range)							
Dietary patterns	OR	OR	95 % CI	OR	95 % CI	OR	95 % CI	*P* for trend*
Sweet pattern	Level 1 (–2·55, –0·59)	Level 2 (–0·59, –0·24)		Level 3 (–0·23,0·33)		Level 4 (0·33,9·7)		–
No. of sarcopenia	91	105		92		103		–
Model 1†	1·00 (reference)	1·19 (0·87, 1·61)‡		1·02	0·74, 1·39	1·16	0·85, 1·58	0·53
Model 2§	1·00 (reference)	1·15	0·84, 1·59	1·03	0·74, 1·42	1·08	0·78, 1·49	0·85
Model 3‖	1·00 (reference)	1·12	0·80, 1·56	1·06	0·75, 1·48	1·17	0·84, 1·65	0·42
Model 4¶	1·00 (reference)	1·05	0·75, 1·48	1·01	0·71, 1·42	1·06	0·74, 1·50	0·87
Vegetable pattern	Level 1 (–3·13, –0·72)	Level 2 (–0·71, –0·1)		Level 3 (–0·1,0·56)		Level 4 (0·57,5·19)		–
No. of sarcopenia	120	105		87		79		–
Model 1†	1·00 (reference)	0·85	0·63, 1·13	0·68	0·50, 0·92	0·61	0·44, 0·83	< 0·001
Model 2§	1·00 (reference)	0·92	0·68, 1·24	0·76	0·55, 1·04	0·70	0·50, 0·96	0·02
Model 3‖	1·00 (reference)	0·95	0·69, 1·31	0·79	0·56, 1·12	0·70	0·46, 1·06	0·07
Model 4¶	1·00 (reference)	0·87	0·62, 1·21	0·68	0·47, 0·99	0·54	0·34, 0·86	0·006
Animal food pattern	Level 1 (–3·28, –0·65)	Level 2 (–0·65, –0·21)		Level 3 (–0·21,0·47)		Level 4 (0·47,7·85)		–
No. of sarcopenia	124	103		94		70		–
Model 1†	1·00 (reference)	0·80	0·60, 1·06	0·72	0·53, 0·96	0·51	0·37, 0·70	< 0·0001
Model 2§	1·00 (reference)	0·88	0·65, 1·19	0·77	0·56, 1·05	0·55	0·39, 0·78	< 0·001
Model 3‖	1·00 (reference)	0·88	0·65, 1·21	0·84	0·60, 1·16	0·58	0·40, 0·85	0·006
Model 4¶	1·00 (reference)	0·86	0·63, 1·18	0·79	0·57, 1·10	0·50	0·33, 0·74	< 0·001

* Analysis by multiple logistic regression model.
† Model 1 was crude model.
‡ OR (95 % confidence interval) (all such values).
§ Model 2 was adjusted for age, sex and BMI.
‖ Model 3 was adjusted for variables in model 2 plus physical activity, smoking status, drinking status, individual history of diseases (CHD, stroke, cancer, diabetes, hypertension and hyperlipidaemia), total energy intake, depressive symptoms, household income, marital status, educational level, employment status.
¶ Model 4 was adjusted for variables in model 3 plus the scores of other two dietary patterns.

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Table 4. Relationship between quartiles of factor scores and sarcopenia stratified by major covariates
(Odds ratios and 95 % confidence intervals)

	Quartiles of factor scores (range)								
		OR	95 % CI	OR	95 % CI	OR	95 % CI	*P* for trend*	*P* for interaction†
Sweet pattern	Level 1 (–2·55,–0·59)	Level 2 (–0·59,–0·24)		Level 3 (–0·23,0·33)		Level 4 (0·33,9·70)			
Sex									
Men	1·00 (reference)	1·18 (0·65, 2·16)‡		1·24	0·66, 2·30	1·29	0·71, 2·34	0·40	0·47
Women	1·00 (reference)	0·98	0·65, 1·49	0·89	0·58, 1·36	0·90	0·57, 1·41	0·55	
BMI (kg/m^2)									
< 24·0	1·00 (reference)	1·04	0·64, 1·68	1·04	0·64, 1·70	0·95	0·58, 1·55	0·70	0·33
≥ 24·0	1·00 (reference)	1·00	0·61, 1·64	0·94	0·56, 1·56	1·15	0·68, 1·95	0·55	
Physical activity (MET × hour/week)									
≥ 23·0	1·00 (reference)	1·05	0·74, 1·50	1·00	0·70, 1·43	1·15	0·79, 1·66	0·51	0·27
< 23·0	1·00 (reference)	1·66	0·38, 7·64	1·55	0·34, 7·31	0·62	0·14, 2·68	0·31	
Diabetes									
Yes	1·00 (reference)	1·56	0·64, 3·84	1·46	0·58, 3·65	1·33	0·50, 3·52	0·86	0·28
No	1·00 (reference)	1·03	0·71, 1·49	0·92	0·63, 1·35	1·04	0·71, 1·53	0·85	
Hypertension									
Yes	1·00 (reference)	0·83	0·53, 1·32	0·86	0·54, 1·36	0·92	0·58, 1·47	0·79	0·87
No	1·00 (reference)	1·49	0·89, 2·54	1·21	0·70, 2·09	1·20	0·68, 2·11	0·79	
Hyperlipidaemia									
Yes	1·00 (reference)	1·08	0·65, 1·80	1·44	0·88, 2·40	1·21	0·72, 2·03	0·52	0·14
No	1·00 (reference)	1·00	0·63, 1·60	0·70	0·42, 1·14	0·89	0·53, 1·48	0·55	
Vegetable pattern	Level 1 (–3·13, –0·72)	Level 2 (–0·71,–0·10)		Level 3 (–0·1,0·56)		Level 4 (0·57,5·19)			
Sex									
Men	1·00 (reference)	0·73	0·39, 1·35	0·62	0·32, 1·19	0·49	0·23, 1·03	0·054	0·41
Women	1·00 (reference)	0·92	0·62, 1·37	0·66	0·42, 1·05	0·54	0·29, 0·98	0·03	
BMI (kg/m^2)									
< 24·0	1·00 (reference)	1·21	0·77, 1·93	0·66	0·39, 1·12	0·61	0·31, 1·16	0·055	0·71
≥ 24·0	1·00 (reference)	0·64	0·39, 1·05	0·70	0·41, 1·19	0·49	0·25, 0·95	0·06	
Physical activity (MET × hour/week)									
≥ 23·0	1·00 (reference)	0·85	0·60, 1·20	0·68	0·46, 1·00	0·56	0·34, 0·90	0·01	0·44
< 23·0	1·00 (reference)	0·51	0·12, 2·08	0·35	0·07, 1·68	0·16	0·02, 1·12	0·06	
Diabetes									
Yes	1·00 (reference)	1·77	0·68, 4·67	1·36	0·52, 3·61	0·93	0·28, 3·12	0·75	0·33
No	1·00 (reference)	0·76	0·53, 1·09	0·59	0·39, 0·89	0·49	0·29, 0·81	0·005	
Hypertension									
Yes	1·00 (reference)	0·93	0·59, 1·47	0·68	0·41, 1·11	0·51	0·28, 0·92	0·02	0·59
No	1·00 (reference)	0·78	0·48, 1·27	0·65	0·37, 1·16	0·57	0·27, 1·18	0·10	
Hyperlipidaemia									
Yes	1·00 (reference)	0·94	0·58, 1·51	0·66	0·39, 1·13	0·49	0·26, 0·91	0·01	0·48
No	1·00 (reference)	0·80	0·50, 1·30	0·72	0·42, 1·22	0·62	0·31, 1·24	0·20	
Animal foods pattern	Level 1 (–3·28,–0·65)	Level 2 (–0·65,–0·21)		Level 3 (–0·21,0·47)		Level 4 (0·47,7·85)			
Sex									
Men	1·00 (reference)	0·67	0·34, 1·30	0·67	0·36, 1·26	0·39	0·20, 0·76	0·01	0·79
Women	1·00 (reference)	0·93	0·65, 1·33	0·81	0·54, 1·21	0·55	0·32, 0·92	0·02	
BMI (kg/m^2)									
< 24·0	1·00 (reference)	0·87	0·54, 1·38	1·06	0·66, 1·71	0·83	0·47, 1·45	0·51	0·003
≥ 24	1·00 (reference)	0·93	0·60, 1·45	0·66	0·41, 1·07	0·32	0·17, 0·58	< 0·001	
Physical activity (MET × h/week)									
≥ 23·0	1·00 (reference)	0·91	0·65, 1·27	0·90	0·63, 1·28	0·60	0·39, 0·91	0·02	0·23
< 23·0	1·00 (reference)	0·37	0·09, 1·38	0·07	0·01, 0·32	0·09	0·02, 0·40	0·001	
Diabetes									
Yes	1·00 (reference)	0·97	0·39, 2·41	0·76	0·29, 1·95	0·32	0·10, 0·99	0·04	0·52
No	1·00 (reference)	0·78	0·55, 1·10	0·78	0·54, 1·12	0·53	0·34, 0·82	0·01	
Hypertension									
Yes	1·00 (reference)	0·89	0·58, 1·37	0·77	0·49, 1·21	0·62	0·37, 1·04	0·051	0·81
No	1·00 (reference)	0·76	0·47, 1·22	0·75	0·45, 1·24	0·35	0·18, 0·66	0·002	
Hyperlipidaemia									
Yes	1·00 (reference)	1·05	0·67, 1·65	0·90	0·55, 1·46	0·50	0·28, 0·89	0·02	0·07
No	1·00 (reference)	0·66	0·42, 1·05	0·67	0·41, 1·07	0·47	0·26, 0·84	0·01	

MET, metabolic equivalent.
* Obtained using multiple logistic regression model. Adjusted for age, sex, BMI, physical activity, smoking status, drinking status, individual history of diseases (CHD, stroke, cancer, diabetes, hypertension and hyperlipidaemia), total energy intake, depressive symptoms, household income, marital status, educational level, employment status and the scores of other two dietary patterns.
† *P* for interaction was calculated using likelihood ratio test.
‡ OR (95 % confidence interval) (all such values).

Tianjin, China[29]. The present results demonstrated that higher vegetable pattern score and animal food pattern score were related to a lower prevalence of sarcopenia in elderly adults, whereas sweet pattern score was not related to the prevalence of sarcopenia in older people.

In the present study, the prevalence of sarcopenia using the AWGS criteria was 14·0 % in men and 17·6 % in women over 60 years of age, which was higher than the previously reported international prevalence of sarcopenia (10 %) in older adults[6]. It was estimated that the prevalence in older Asian adults using the AWGS definition varied from 9·6 to 22·1 % in men and 7·7 to 21·8 % in women[1,7]. A previous longitudinal study reported that older Chinese people in a community setting had less muscle mass, weaker grip strength and slower gait speed than Black or White people of the same age[30]. The prevalence of sarcopenia differed among measurement methods. Although the AWGS has recommended the use of dual energy X-ray absorptiometry and BIA to assess muscle mass, previous studies found that the BIA-based measurement of sarcopenia was higher than the dual energy X-ray absorptiometry-based approach[6].

Recently, the analysis of dietary patterns has emerged as a useful tool for elucidating the role of diet in sarcopenia. Of all the dietary patterns, the Mediterranean diet has drawn the greatest focus because of its ties to various beneficial health outcomes[31]. In a cross-sectional study performed in elderly Iranians, a greater adherence to a Mediterranean diet resulted in a lower prevalence of sarcopenia[19]. A separate cross-sectional study conducted in menopausal Iranian women also identified a favourable role of a Mediterranean diet in the prevention of sarcopenia[20]. Furthermore, a cohort study of elderly community-dwelling Swedish males (mean age 71) indicated that a Mediterranean diet decreased the risk for sarcopenia progression over 16 years[22]. The vegetable pattern shares several similarities with the Mediterranean diet, such as higher consumption of vegetables, legumes and cereals, and a low intake of meat. Likewise, the present study shows an adherence of the vegetable pattern is related to a lower prevalence of sarcopenia. Oxidative stress plays an important role in the pathogenesis of sarcopenia [10]. The vegetable pattern, particularly rich in vegetables, provides abundant antioxidants which may contribute to reduced oxidative stress[32]. Besides, the vegetable pattern is also characterised by higher consumption of legumes such as soyabeans and cowpeas. These have high levels of leucine, which increases protein anabolism and decreases protein breakdown[14,33]. Leucine and its metabolite, β-hydroxy-β-methylbutyrate, are considered important components in combating sarcopenia[14,33]. Finally, the alkaline-forming property of the vegetable pattern rich in plant foods (vegetables, legumes and cereals) could inhibit protein degradation in muscle[34]. However, more evidence is required to conclusively link the vegetable pattern and sarcopenia.

The consumption of the animal food pattern, typified by high intakes of poultry, meat and fish, was found to protect from sarcopenia in this analysis. One possible factor thought to contribute to the relationship between the animal food pattern and a lower risk of sarcopenia is the rich protein of this dietary pattern. The protein intake was positively related to the meat-product consumption in both the elderly and young individuals[35]. An adequate level of protein intake above the RDA (approximately 25–30 g of protein per meal) is required to maximise muscle protein synthesis and to prevent or mitigate sarcopenia[14]. Higher dietary protein is correlated with reduced loss of lean mass in older, community-dwelling men and women[36]. Evidence from a systematic review concluded that protein supplementation may improve muscle strength and muscle function, as measured by walking speed[37]. However, a cross-sectional study has identified a 'cereals–tubers–animal oils' pattern, a 'mushrooms–fruits–milk' pattern and an 'animal foods' pattern in community-dwelling older people from three regions of China, located in the north, east and south of China, respectively[24]. The 'animal foods' pattern, typified by eggs, pork, poultry and animal viscera, showed no significant association with sarcopenia in that study[24]. The wide variations in habitual diets and disease prevalence discrepancy among subjects from different regions of China may attenuate the relationship between derived dietary patterns and sarcopenia. We also observed a significant interaction between BMI and the animal food pattern score. Stratified analysis showed the negative correlation between the animal food pattern score and sarcopenia only exists in old adults with BMI above 24 kg/m^2. A previous study reported that increased BMI and a diet with adequate dietary protein were both protective factors for sarcopenia[38]. Therefore, the animal food pattern might be a modifiable factor for sarcopenia, especially in older adults with a higher BMI, and further studies are required to explain this relationship.

Unlike the other two dietary patterns, the sweet pattern was not related to sarcopenia prevalence in the present study. This contradicts a Hong Kong study, which found that higher consumption of vegetables and fruits was related to a lower prevalence of sarcopenia in men over 65 years old[23]; the antioxidant nutrients which are found in abundance in fruits may defend against the negative effects of oxidative stress and thus reduce the risk for sarcopenia[39]. However, besides the high consumption of fruits, the sweet pattern in the present study was also characterised by high sugar content. Dietary sugar consumption contributes to increased inflammatory processes in humans[40], and higher levels of inflammatory markers play a role in sarcopenia genesis[10]. Therefore, the beneficial effect of fruits may be counteracted by sugar. Future mechanism studies are required to shed further light on this topic.

The strengths of our study include the large study sample of community-dwelling older adults, the definition of sarcopenia based on Asian-specific criteria and the adjustment of a wide set of important confounders, such as demographic variables, socio-economic status, lifestyle factors, physical activity, individual history of diseases and depression and cognition. Furthermore, we use factor/principal component to derive the dietary patterns, which used all available dietary data and may therefore better define the usual diet in a population.

The present study has several limitations. First, this study had a cross-sectional design, which makes the inference of causality difficult. Second, all participants were from Tianjin, China, providing northern Chinese representation. Therefore, the results might not apply to other populations. Third, due to the nature of the self-reporting questionnaire, dietary intake assessment using FFQ is subject to recall bias. Although studies have indicated reasonable reproducibility and validity of the major dietary patterns derived by factor analysis (principal component analysis) using data from the FFQ[41], the measurement error could attenuate relationships between diet and sarcopenia. Fourth, the three dietary patterns derived by factor analysis (principal component analysis) explained the small natural variation in the present study. Regarding factor analysis (principal component analysis), a larger number of input variables included in the procedure explain a smaller percentage of the variance in intake[42]. Usually, the factors derived by factor analysis (principal component analysis) only have a low to moderate proportion of intake explained[43]. Similar to the present study, a previous study, also conducted in Chinese community-dwelling older adults, identified three dietary patterns using principal component analysis, which explained only 16·7 % of intake variance[23]. Dietary patterns usually capture only a fraction of variation in food intake, which leaves a large space of potential effects related to foods not included as components of the pattern[43]. As a result, other potential dietary patterns beneficial to sarcopenia might not have been identified in the present study. Finally, we cannot rule out the possibility that unmeasured factors might contribute to the association observed.

In conclusion, the present study found that the vegetable pattern and animal food pattern were related to a lower prevalence of sarcopenia in older adults, but there is no relationship between sweet pattern and sarcopenia. Higher-level evidence is needed to explore optimal diet for the prevention of sarcopenia.

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The authors declare that they have no competing interests.

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