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ASSOCIATION OF FRUIT AND VEGETABLE INTAKE AND FRAILTY AMONG CHINESE ELDERS: A CROSS-SECTIONAL STUDY IN THREE CITIES

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Abstract: *Objectives:* To examine the association of FVI and frailty in Chinese elders. *Design:* A sectional study was conducted in three cities (Shanghai, Zhengzhou, and Baoji) in China from June 2017 to June 2018. *Participants:* A total of 5699 participants from 49 districts were included in the current study by two-stage sampling methods. *Measurements:* Frailty was measured by a validated Chinese version of the FRAIL scale. FVI per day was measured by two single questions. *Results:* The sample proportion with sufficient fruit intake was 36.7%, and 44.7% reported sufficient vegetable intake. The sample proportions that were robust, pre-frail, and frail were 43.6%, 38.3%, and 18.1%, respectively. Compared with low FVI, after including covariates, the odds ratio (OR) of frailty was 0.84 (95% CI: 0.73–0.97) for moderate fruit intake and 0.81 (95% CI: 0.70–0.94) for enough fruit intake; the OR of frailty was 0.83 (95% CI: 0.68–0.91) for moderate vegetable intake and 0.77 (95% CI: 0.64–0.93) for enough vegetable intake. *Conclusion:* High FVI was negatively associated with the OR of frailty in Chinese elders. This finding implies it is important to promote FVI among adults to prevent frailty.

Key words: Frailty, elders, nutrition, fruit and vegetable intake.

Introduction

Frailty is a non-specific state with diminished strength and endurance and reduced physiologic function. Frailty increases an individual's susceptibility to (i) becoming increasingly dependent on others and (ii) death (1). The global prevalence of frailty among elders is approximately 3.5–59.1%; the large variation among these estimates is partly due to the usage of varying screening instruments (2, 3). Frailty can predict serious negative health-related events such as falls, hospitalizations, disability, institutionalization, and death (4). Frailty is a modern geriatric giant (3) and the most problematic manifestation (2) among the aging population. Frailty is caused by multiple contributors, which include socio-demographic, physical, biological, psychological, and behavioral factors (5).

Poor nutrition may result in nearly all widely accepted symptoms of frailty, including low muscle strength, unintentional weight loss, feeling of exhaustion, poor physical performance, and reduced physical activity (6, 7). Nutrition is presumably an important factor that can contribute to the development of frailty, but it is not a hot topic in clinical practice and research (8). Recently, three approaches were used to explore the effects of diet on frailty (7, 9). Some micronutrients (vitamins D, E, and C, α-carotene, and β-carotene) and macronutrients (protein or amino acid) were found to be associated with frailty. Because people eat food (rather than mere nutrients) and nutrients may interact with each other, more attention was paid to dietary patterns consisting of specific food items. The results of four studies indicated that the Mediterranean diet can reduce the risk of frailty (10). However, it remains to be elucidated which dietary components reduce the incidence of frailty. Fruit and vegetable intake (FVI) offers life-long health benefits, including lower risk of cardiovascular disease (11, 12) and non-cardiovascular diseases (13), cancer (12), and death (12, 13). Fruits and vegetables are important sources of vitamins, minerals, fiber, anti-oxidants, and anti-inflammatory agents, which are suggested to contribute to the prevention of frailty. However, the literature on the association between frailty and FVI is scarce, and results are conflicting (7, 14). In order to fill this gap, we conducted a cross-sectional study to examine the association between FVI and frailty among Chinese elders.

Methods

Design and participants

This cross-sectional study was conducted in Shanghai (Eastern China), Zhengzhou (central China), and Baoji (Western China) from June 2017 to June 2018. Residents from 49 districts were randomly selected by multi-stage sampling. All 16 districts in Shanghai, all 28 districts in Zhengzhou, and 5 districts randomly selected from Baoji were selected as clusters. Then, 5% of the population aged ≥15 years were randomly selected from each district. In total, 22,073 community residents were randomly selected. Data were collected by an anonymously self-administered "Health City needs assessment questionnaire." A sub-sample (5703/20,953) of participants aged 60 years or older was selected after excluding 1,120 community residents without completed questionnaires. The participants flowchart in this study was shown in Figure 1. This study has been approved by the Institutional Review Board of Fudan University.

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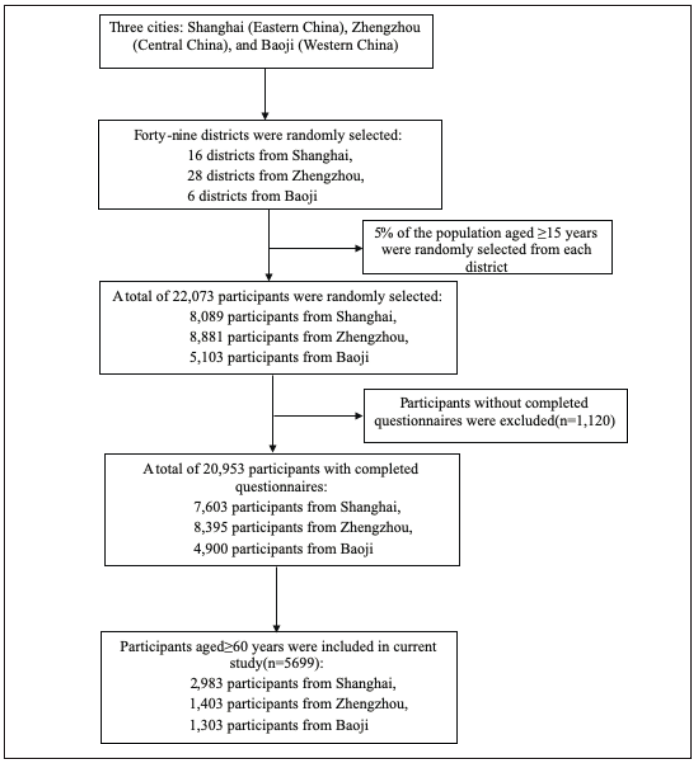
Figure 1
The participant flowchart in the study



Measurements

Fruit and vegetable intake

The question "On average, how much fruit do you eat per day?" was used to measure fruit intake. The participants responded one of the following choices: 50–100, 100–200, 200–300, and 300–400 g. The answers were classified as low (50–100), moderate (100–200), and enough (200–300, 300–400). The question "On average, how much vegetable do you eat per day?" was used to measure vegetable intake. The participants responded one of the following choices: 100–200, 200–300, 300–500, and 600–800 g. The answers were classified as low (100–200), moderate (200–300), and enough (300–500, 600–800), following the Chinese Dietary Guidelines (15).

Frailty

The Chinese version of the FRAIL scale was used to measure frailty (16), which consists of five dichotomous (yes/no) items (fatigue, resistance, ambulation, illness, and loss of weight) from both the Frailty Index (FI) and Freid's Frailty Phenotype (FP) and which is widely used in the Asia-Pacific region (3). The FRAIL scores range from 0 to 5 (i.e., 1 point for each component; 0 = best, 5= worst) and represent frail (3–5), pre-frail (1–2), and robust (0) health status.

Covariates

The following covariates were included in this study: gender, age (10-year categories), educational level (elementary school or lower, junior high school, senior high school, and college or higher), marital status (recoded into married and other [including unmarried, divorced, and widowed]), self-rated health (categorized as excellent, good[including very good and good], poor[including general and poor]), smoking (yes/no), and physical activity (categorized as no, irregular, and regular). The methods used to measure the above covariates were described in detail elsewhere (17).

Statistical analyses

The $\chi 2$ trend test was used to determine the prevalence of frailty by binary variables including gender, marital status, and smoking status. Spearman regression analysis was used to show the linear correlation of frailty and ordinal multiple-category variables such as age group, education level, self-rated health, physical activity, and problematic drinking with fruit intake and vegetable intake. Secondly, ordinal regression analysis was used to explain the association between FVI and frailty after controlling for covariates. We estimated the adjusted ORs and their 95% confidence intervals (CIs) of independent variables for frailty. The STATA version 13.0 program (StataCorp LP., College Station, TX, USA) was used to carry out all analyses.

Results

Descriptive results

Only complete questionnaires were included in the study, reaching a total of 5699 participants, with a mean age of 66.4 years (SD = 5.2). As shown in Table 1, the proportions of men and women were about the same (49.3% vs 50.7%); most of them (74.9%) were 60–69 years old and married (87.9%). Many participants (37.3%) had achieved an educational level of junior high school, 11.5% finished university education. Over 40% of the participants rated their health status as "poor," while 21.3% rated their health status as "good." The prevalence of smoking and problematic drinking was 18.3% and 8.2%, respectively. Only 22.2% of participants undertook physical activity regularly. A sufficient FVI, the focus of this study, was reported by 36.7% (fruit) and 44.7% (vegetable) of participants.

Univariate analyses

In total, the proportions of robust, pre-frail, and frail were 43.6%, 38.3%, and 18.1%. Univariate analysis shows that the proportion of elders describing themselves as "robust" was highest (48.4%) among participants aged 60–65 years, and the prevalence of frailty was highest (21.2%) among participants aged 70–74 years; the prevalence of frailty significantly decreased with increasing education level ($P < 0.001$) and with increasing self-rated health ($P < 0.001$); the prevalence of frailty among unmarried elders (26.4%) was higher than among married elders (17.0%). The frailty distribution patterns were significantly different among all health behaviors except smoking. The prevalence of frailty decreased with increasing levels of physical activity; elders regularly undertaking physical

Table 1
Characteristics of participants and distribution of frailty(n,%)

	N (%)	Frail status			$\chi 2$	P-value
		Robust	Pre-frail	Frail		
Total	5699 (100)	2483(43.6)	2183(38.3)	1033(18.1)		
Sex						
Male	2808(49.3)	1267 (45.1)	1041 (37.1)	500 (17.8)	5.57	0.062
Female	2891 (50.7)	1216 (42.1)	1142 (39.5)	533 (18.4)		
Age (years)						
~65	2412 (42.3)	1167 (48.4)	885 (36.7)	360 (14.9)	79.84	<0.001
65~	1859 (32.6)	780 (42.0)	740 (39.8)	339 (18.2)		
70~	1087 (19.1)	417 (38.4)	440 (40.5)	230 (21.2)		
75~	341 (6.0)	413 (45.4)	348 (38.3)	148 (16.3)		
Education level						
Elementary school	1522 (26.7)	672 (44.2)	494 (32.5)	356 (23.4)	66.60	<0.001
Junior high school	2127 (37.3)	900 (42.3)	838 (39.4)	389 (18.3)		
Senior high school	1395 (24.5)	632 (45.3)	560 (40.1)	203 (14.6)		
University	655 (11.5)	279 (42.6)	291 (44.4)	85 (13.0)		
Marital status						
Married	5010 (87.9)	2207 (44.1)	1952 (38.9)	851 (17.0)	36.60	<0.001
Unmarried	689 (12.1)	276 (40.1)	231 (33.5)	182 (26.4)		
Self-rated health						
Excellent	1215 (21.3)	814 (67.0)	316 (26.0)	85 (7.0)	754.66	<0.001
Good	1927 (33.8)	984 (51.1)	754 (39.1)	189 (9.8)		
Poor	2557 (44.9)	685 (26.8)	1113 (43.5)	759 (29.7)		
Smoking						
Yes	1041 (18.3)	453 (43.5)	406 (39.0)	182 (17.5)	0.45	0.798
No	4658 (81.7)	2030 (43.6)	1777 (38.2)	851 (18.3)		
Physical activity						
No	1834 (32.2)	766 (41.8)	672 (36.6)	396 (21.6)	56.44	<0.001
Irregular	2598 (45.6)	1083 (41.7)	1031 (39.7)	484 (18.6)		
Regular	1267 (22.2)	634 (50.0)	480 (37.9)	153 (12.1)		
Drinking						
No	4418 (77.5)	1949 (44.1)	1693 (38.3)	776 (17.6)	32.36	<0.001
Non-problematic	816 (14.3)	362 (44.4)	325 (39.8)	129 (15.8)		
Problematic drinking	465 (8.2)	172 (37.0)	165 (35.5)	128 (27.5)		
Fruit intake						
Low	1492 (26.2)	557 (37.3)	585 (39.2)	350 (23.5)	52.50	<0.001
Moderate	2200 (38.6)	994 (45.2)	830 (37.7)	376 (17.1)		
Enough	2007 (36.7)	932 (46.4)	768 (38.3)	307 (15.3)		
Vegetable intake						
Low	914 (16.0)	337 (36.9)	335 (36.7)	242 (26.5)	56.57	<0.001
Moderate	2239 (39.3)	1028 (45.9)	838 (37.4)	373 (16.7)		
Enough	2546 (44.7)	1118 (43.9)	1010 (39.7)	418 (16.4)		

activity exhibited the lowest prevalence of frailty (12.1%). Compared with non-drinkers, the prevalence of frailty among non-problematic drinkers was lower (15.8%), while it was higher among problematic drinkers (27.5%). The prevalence of frailty was negatively associated with both fruit and vegetable intake (both P < 0.001); see Table 2.

Table 2
Ordinal regression analyses of risk factors associated with frailty

	OR (95% CI)	P value
Sex		
Male	1	
Female	1.13 (1.01–1.26)	0.036
Age(year)		
~65	1	
65~	1.19 (1.06–1.34)	0.002
70~	1.33 (1.16–1.53)	<0.001
75~	1.69 (1.36–2.11)	<0.001
Education level		
Elementary school	1	
Junior high school	1.02 (0.89–1.16)	0.790
Senior high school	0.91 (0.79–1.05)	0.205
University	0.95 (0.79–1.13)	0.549
Marital status		
Married	1	
Unmarried	1.19 (1.01–1.39)	0.034
Self-rated health		
Excellent	1	
Good	1.86 (1.60–2.15)	<0.001
Poor	5.45 (4.71–6.29)	<0.001
Smoking		
No	1	
Yes	0.99 (0.86–1.15)	0.928
Physical activity		
No	1	
Irregular	1.02 (0.91–1.15)	0.708
Regular	0.78 (0.67–0.89)	<0.001
Drinking		
No	1	
Non-problematic	1.04 (0.89–1.21)	0.637
Problematic drinking	1.60 (1.32–1.96)	<0.006
Fruit intake		
Low	1	
Moderate	0.84 (0.73–0.97)	0.014
Enough	0.81 (0.70–0.94)	0.006
Vegetable intake		
Low	1	
Moderate	0.83 (0.68–0.91)	0.038
Enough	0.77 (0.64–0.93)	0.008

Multivariate analysis

The results of the ordinal regression analyses are presented in Table 2. Contrary to the univariate analyses, the OR of frailty among female elders was higher than among male elders (OR = 1.13, 95% CI: 1.01–1.26); the education level has no association with OR of frailty. Compared with physical inactivity, regular physical activity can reduce the OR of frailty (OR = 0.78, 95% CI: 0.67–0.89), but irregular physical activity cannot (OR = 1.02, 95% CI: 0.91–1.15). Similarly, problematic drinking can increase the OR of frailty (OR = 1.60, 95% CI: 1.32–1.96), but non-problematic drinking cannot (OR = 1.04, 95% CI: 0.89–1.21) compared with non-drinking. As regards the focus of this study, higher FVIs were negatively associated with the OR of frailty after controlling for all covariates. Compared with low FVI, the OR of frailty was 0.84 (95% CI: 0.73–0.97)/0.83 (95% CI: 0.68–0.91) and 0.81 (95% CI: 0.70–0.94)/0.77 (95% CI: 0.64–0.93) for moderate and enough fruit/vegetable intake, respectively.

Discussion

FVI is considered an important part of a healthy diet for all ages, yet high-quality studies on the association of FVI and frailty are scarce (14). To the best of our knowledge, this is the first study to examine the association of FVI and frailty in mainland China; one previous study, which found no association between high FVI and the incidence of frailty, has been conducted in Hong Kong (18). We found that high FVI is negatively associated with the OR of frailty, which is consistent with a previous prospective study (19) and a cross-sectional study (20). However, other studies found no associations between FVI and the OR of frailty (18, 21, 22). One of the reasons for the conflicting results may be the methods used to measure the FVI. The former studies (19, 20) and the current study measured the quantity of FVI, while the latter studies (18, 21, 22) measured the frequency of FVI.

There are several explanations for the associations between FVI and the incidence of frailty. First, oxidative stress plays an important role in the development of frailty (23, 24); fruit and vegetables contain antioxidants (e.g., vitamin C, vitamin E, β-carotene) and trace minerals that are needed for antioxidant enzymes to function correctly (9, 10, 25). Second, inflammation is considered to be closely associated with frailty; frail individuals have higher levels of inflammatory markers (2, 26), such as interleukin-6 (IL-6), C-reactive protein (CRP), and tumor necrosis factor-α (TNFα). A longitudinal study showed that a more proinflammatory diet was associated with a higher incidence of frailty (27); phytochemicals (e.g., phenolics and triterpenoids) in fruits and vegetables have strong anti-inflammatory properties (28). Third, sarcopenia, defined as progressive loss of skeletal muscle mass, strength, and power, is regarded as a key component of frailty (2). Carotenoids, vitamin C, vitamin E, and potassium, which are found in fruits and vegetables, benefit muscle strength (29, 30) and muscle

mass (31), so high FVI is negatively associated with a lower OR of sarcopenia (32, 33). Finally, FVI during older adulthood is associated with a reduced likelihood of chronic disease, such as hypertension, coronary heart disease, atherosclerosis, stroke, and geriatric-associated conditions (34), which in turn act as risk factors of frailty.

Another interesting finding of the current study is that problematic drinking is associated with a higher OR of frailty, but non-problematic drinking is not, compared with non-drinking. However, a recent meta-analysis including three prospective studies found that the highest alcohol consumption was associated with a lower frailty risk (35). Other studies found moderate drinking can reduce the incidence of frailty (36, 37). Several cohort studies and experimental studies have shown that moderate drinking can decrease the CRP levels and that the decrease in CRP could protect people from frailty (38, 39). Given alcohol can cause diabetes mellitus, cardiovascular diseases, and digestive diseases (40) and especially heavy drinking can cause functional and cognitive impairment among elders (41), drinking is presumably a risk factor of frailty. These conflicting findings may be due to unadjusted effect measures, residual confounding, the "sick quitter" effect, or survival bias (35), which need to be controlled by well-designed prospective studies in the future.

Some potential limitations should be noted in this study. First, this is a cross-sectional study, so it is difficult to accurately elucidate causal relationships. Additional longitudinal studies, such as cohort studies or nested case-control studies, are essential. Moreover, FVI was measured by simple self-reported questions, so some recall and desirability bias may have affected the results. Third, we only assessed FVI; however, participants eat many food items, and those items may interact, which may confound our results. Finally, although we did control for many covariates, we cannot exclude the possibility of some residual confounding caused by unmeasured factors.

Conclusions

In this study, we found a negative association between FVI and frailty in Chinese elders for the first time. Previous studies showed older adults consume more fruit and vegetables than younger ones, yet more than half of older adults do not eat the recommended quantity of fruit and vegetables per day (34). Among the participants of the current study, only 36.7% reported enough fruit intake and 44.7% reported enough vegetable intake. Based on these findings, we conclude it is important for the prevention of frailty to promote fruit and vegetable intake among older adults.

Ethical Standards: This study has been approved by the Institutional Review Board of Fudan University. The design and procedures of the study were performed in accordance with the principles of the Declaration of Helsinki.

Statement of Potential Conflict of Interest: No potential conflict of interest was reported by the authors.

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