Geriatric Nursing 40 (2019) 320–326

Contents lists available at ScienceDirect

Geriatric Nursing

journal homepage: www.gnjournal.com

Feature Article

Frailty and its association with the Mediterranean diet, life-space, and social participation in community-dwelling older people

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ARTICLE INFO

Article history:
Received 2 October 2018
Received in revised form 17 December 2018
Accepted 20 December 2018
Available online 15 February 2019

Keywords:
Frailty
Mediterranean diet
Life-space
Social participation
Older people

ABSTRACT

Frailty is a common and vulnerable state in older people, which leads to a higher risk of adverse health outcomes. This cross-sectional study examined the association between frailty and its phenotypic components with the Mediterranean diet, life-space, and social participation in community-dwelling older people. 263 community-dwelling older people recruited from three community centers in Hong Kong completed the study (robust = 85, pre-frail = 120, frail = 58). The results showed that the Mediterranean diet (OR = 0.29), life-space (OR = 0.32), and social participation (OR = 0.31) were associated with frailty. All factors were preferentially associated with slowness. The Mediterranean diet and social participation were additionally associated with weakness and low activity, respectively. To reduce the risk of frailty among diverse populations of older people in community settings, eliminating foods considered detrimental in the Mediterranean diet is advocated. Older people's satisfaction with social participation should be taken into consideration. Environmental designs should accommodate slow-walking older people to maximize their life-space

Introduction

Background

Frailty is a geriatric syndrome manifesting as reduced strength and physiologic malfunctioning, which increases susceptibility to dependency, vulnerability, and death.[1] Frailty is comprised of five phenotypical components: weight loss, exhaustion, low physical activity, slowness, and weakness. Frailty is progressive, with people going from being robust to pre-frail, and then to frail.[2] The progression of frailty is slow; thus frailty can be reversible.[3] Among community-dwelling older people, the prevalence of frailty is 10.7% globally, 7% in China, and 16.6% in Hong Kong.[4-6] Frailty of increased severity is associated with higher mortality and morbidity (e.g., dementia), and with the need to provide more informal care.[7-9]

Previous studies have shown that sociodemographic factors (e.g., age, socioeconomic status), physical factors (e.g., body mass index [BMI], functional status), biological factors (e.g., hormones, inflammation), lifestyle factors (e.g., dietary patterns, drinking), and psychological factors (e.g., depression, cognition) can moderate the transition to frailty and its progression.[10] However, many of these factors are either non-modifiable or perceived by older people as unimportant in preventing frailty.[11] Understanding the social and lifestyle factors most salient to older people is important to developing effective interventions and shaping future health policies.

The Mediterranean diet is characterized by a high intake of vegetables, legumes, fruits, nuts, cereals, olive oil, and fish; a low intake of saturated fats, dairy products, meat, and poultry; and a regular but moderate intake of ethanol.[12] Numerous studies with diverse populations have demonstrated that a Mediterranean diet is associated with a lower risk of frailty.[13] However, the Mediterranean diet has not been observed to be protective of frailty in Chinese populations.[14] It has been argued that traditional Chinese diets include relatively small amounts of beneficial foods (e.g., legumes, nuts, and olive oil).[15] Nevertheless, Chinese dietary patterns have changed in recent decades to more closely resemble the Mediterranean diet.[16] It is not known whether evidence of the greater adoption of the Mediterranean diet among contemporary Chinese populations supports the argument that such a diet has a protective effect on frailty. If so, such evidence may inform dietary recommendations on combatting frailty in populations whose traditional dietary patterns are unlike those of the Mediterranean.

Life-space refers to the spatial area in which a person moves in daily life.[17] It is associated with many health outcomes in older people, including cognitive function and frailty.[18,19] However, there is a

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https://doi.org/10.1016/j.gerinurse.2018.12.011
0197-4572/$ – see front matter © 2019 Elsevier Inc. All rights reserved.

dearth of studies on which phenotypic component(s) of frailty are preferentially associated with life-space. Knowledge of these associations is necessary for developing specific environmental design strategies to help frail older people maximize their life-space.

Social participation is the extent to which people participate in daily activities and engage in social roles.[20] It is associated with better cognitive function[21] and more physical activity.[22] A previous study showed that infrequent social participation (e.g., volunteer work) is associated with worsening frailty.[23] However, social participation extends beyond attending social activities; it also involves how engaged a person feels towards both daily activities (e.g., leisure activities, personal care) and social events (e.g., recreational activities) in fulfilling their basic social needs.[23] There is a lack of understanding of how perceived satisfaction with social participation is associated with frailty. Knowledge of these associations is important for developing methods of identifying frailty risk and evaluating frailty care.

Objectives

The objective of this study was to test the hypotheses that in community-dwelling Chinese older people, 1) frailty is negatively associated with the Mediterranean diet, life-space, and social participation; and 2) the five phenotypic components of frailty are negatively associated with the Mediterranean diet, life-space, and social participation.

Methods

Study design

A cross-sectional study was employed. The reporting format of this study followed the STrengthening the Reporting of Observational studies in Epidemiology (STROBE) statement.[24]

Setting

From May 2017 to May 2018, subjects were recruited from three non-government community centers serving around 4000 older people in Hong Kong. The primary function of these centers is to provide social and recreational activities for community-dwelling older people.

Participants

Convenience sampling was employed. All of the participants in this study were recruited through different methods (e.g., posters and announcements in regular meetings of the members of the community centers). Interested members were enrolled through the centers. They were subsequently screened by a trained research assistant according to the following eligibility criteria.

Inclusion criteria

1. Age ≥ 60 years, and
2. Community-dwelling and non-institutionalized.

Exclusion criteria

People with cognitive impairment and depression were excluded to prevent the possible confounding of the effects of the factors to be tested in this study.[25]

1. Cognitive impairment was defined by the participants' age- and education-adjusted Montreal Cognitive Assessment (MoCA) score,[26] and
2. Depression was defined by a score of ≥ 8 in the 15-item Geriatric Depression Scale (GDS-15).[27]

Variables and measurement

Outcome

Frailty, as a dependent variable, was measured using the Fried Frailty Index (FFI),[2] which quantifies phenotypes of frailty by five components: weight loss, exhaustion, low physical activity, slow gait, and weakness. The FFI shows a good ability to predict the incidence of major geriatric outcomes over three to seven years including falls, worsening mobility, hospitalizations, and death (HR=1.82–4.46).[2] FFI scores range from 0 to 5, with one point assigned for the presence of one component. A higher FFI score indicates greater frailty. Those with 0, 1–2, or 3–5 point(s) are classified respectively as robust, pre-frail, or frail.[2] As there are no endorsed methods for operationalizing any of the phenotypes, each phenotype was operationally defined in this study using the following measurement methods:

1. Weight loss was defined as an unintentional loss of 5% of body weight in the preceding year as reported by the subject.
2. Exhaustion was identified using two questions from the Center for Epidemiological Studies Depression (CES-D) scale.[28]
3. Low physical activity was defined using the Chinese version of the Physical Activity Scale for the Elderly (PASE),[29] following the cut-off points for older people in Hong Kong.[30]
4. Slowness was defined by a slower than the maximum gender-adjusted walking speed of the lowest quintile in the population of older people in Hong Kong (i.e., 0.89 m/s for men and 0.79 m/s for women),[30] as measured in a 5-m walking test.
5. Weakness was identified by the handgrip strength of the dominant hand (measured using a Jamar dynamometer)[31] being lower than the maximum age- and-gender-adjusted handgrip strength of the lowest quintile in the population of older people in Hong Kong.[30]

Factors

Adherence to the Mediterranean diet, as an independent variable, was measured by the MedDietScore (MDS).[32] The MDS covers two categories of items: beneficial foods (i.e., non-refined cereals, potatoes, fruits, vegetables, legumes, fish, and olive oil) and detrimental foods (i.e., red meat and products, poultry, full-fat dairy products, and alcohol). The MDS has demonstrated good criterion validity, showing a strong association with plasma and dietary fatty acids,[33] and cardiovascular risks.[32] Each MDS item is scored on a Likert scale from 0 to 5 to indicate the frequency of consumption, ranging from "never" to "daily" Summed MDS scores range from 0 to 55. A higher MDS indicates closer adherence to the Mediterranean diet.[32]

Life-space was measured as an independent variable using the Life-Space Assessment (LSA).[34] LSA measures life-space at five specific levels by proximity from level 1 (inside the home) to level 5 (outside a district). At each level of life-space, visit frequency and activity independence are rated on Likert scales. LSA has been validated as having good test-retest reliability (ICC = 0.76)[35] and good criterion validity, with LSA showing a strong association with physical performance ($r = 0.595$) and function ($r = 0.567$).[34] The total score is the multiple of life-space level, visit frequency, and activity independency. The LSA ranges from 0 to 120, with a higher LSA score indicating that a person lives in a larger life-space.

Social participation, as an independent variable, was measured by the Reintegration to Normal Living Index (RNLI).[36] The RNLI measures social participation under the concept of reintegration proposed by the World Health Organization's International Classification of Functioning, Disability, and Health (WHO-ICF) framework.[37] It contains 11 items categorized into two factors: physical and social. The RNLI has been validated as having good test-retest reliability (Kappa = 0.61) and good criterion validity, with RNLI showing a strong association with depression ($r = -0.61$), daily activity ($r = 0.69$), and quality of life ($r = -0.74$).[38] Each RNLI item is rated on a Likert scale from 0 to 10 to

indicate the level of satisfaction with the social and physical activities involved in daily living. RNLI scores are summed and converted to a percentage ranging from 0 to 100, with higher scores indicating better social participation.

Confounders

Age, gender, education level, body mass index (BMI), nutrition, and comorbidity were considered potential confounders, as reported in other studies. Education was classified into four levels: no formal education, primary, secondary, and tertiary and above. The BMI for the Hong Kong Chinese population was classified as follows: underweight (<18.5 kg/m^2), normal (18.5–22.9 kg/m^2), overweight (23–24.9 kg/m2), and obese (≥25 kg/m^2).[39] Comorbidities were measured by the number of chronic illnesses listed in the Charlson Comorbidity Index.[40] Nutrition was measured using the Mini Nutritional Assessment Short Form (MNA-SF).[41]

Research assistants administered questionnaires through face-to-face interviews. All interviews were conducted in private rooms in the community centers, and took an average of 45 min to complete. Regarding the MedDietScore questions, food pictures were shown to subjects to facilitate their understanding of food types and portions to determine their MedDietScore.

Study size

Previous work has shown that the Mediterranean diet has an effect size of OR: 0.43–0.59 on frailty in community-dwelling older people in Spain,[13] which is a mild-to-moderate association.[42] The effect sizes of other factors (i.e., life-space and social participation) are not known. We assumed that all factors bore a similar strength of association with frailty. We conducted a power analysis using G*Power and employing a linear multiple regression (fixed model, R^2 increase) test with a mild-to-moderate effect size (i.e., $f^2 = 0.05$), a significance set at 0.05, and a power of 0.8 to determine a sample size of 223 subjects. Since a previous study of people with frailty living in the community involved an uneven distribution of participants among the different states of frailty,[19] we employed a quota sampling method to equally represent subjects across each category of frailty (e.g., 60–120 subjects per frailty state).

Statistical methods

A statistical analysis was performed with IBM SPSS version 23.0. Descriptive statistics were used to characterize the study population. A mean value was used if less than 5% of the data for a variable was missing.

To test hypothesis #1, because the dependent variable is frailty, which is an ordinal variable, an ordinal regression controlling for potential confounders was performed to calculate the odds ratios with a 95% confidence interval. Because the range of scores of the independent variable instruments was large, their odds ratios on frailty for every increase of one point in the scale would be small and hard to interpret. Following the method of statistical analysis employed in a similar study, we classified all independent variables into tertiles, and the lowest tertile was used as a reference to compute the odds ratio of the middle and highest tertiles on frailty.[13] Three logistic models were built separately on three independent variables: the first was unadjusted; the second was adjusted for age, gender, and education; and the third was additionally adjusted for the remainder of the potential confounders described above.

To test hypothesis #2, binary logistic regression models with the same set of independent variables and confounders were employed to identify whether the independent variables were significantly and negatively associated with any of the five phenotypic components of frailty.

Ethics

All of the participants provided their informed consent to participate in the study, and were informed of their rights as research participants. The participants were incentivized with cash coupons to compensate them for their time and travel costs. This project was approved by the Institutional Review Board of The Hong Kong Polytechnic University (reference number: HSEARS20170412004). [Blinded for review purpose]

Results

As shown in Fig. 1, 477 community-dwelling older people were screened for eligibility. Ninety-five of them were ineligible and 105 refused to participate. The main reason for refusal was concern over the time involved in answering questionnaires. Fourteen eligible subjects who had consented to take part were screened out because the quota for their category of frailty had been reached. In the end, 263 participants completed the data collection process. Of these, 85 were robust (32.3%), 120 pre-frail (45.6%), and 58 frail (22.1%).

As shown in Table 1, the participants' mean age was 77.1 ± 7.5. The mean Montreal Cognitive Assessment score was 21.8 ± 4.9, the mean Geriatric Depression Scale score was 2.4 ± 2.8, and the mean Mini-nutrition Assessment score was 12.5 ± 1.6. The majority of the participants were female (83.7%), educated at the primary level (52.1%), married (56.7%), financially sufficient (46.8%), non-smokers (90.5%), non-drinkers (89.7%), had one chronic disease (62.2%), and normal BMI (39.2%).

Frailer people tended to be older ($p < 0.001$), female ($p = 0.01$), less educated ($p < 0.001$), nutritionally poorer ($p < 0.001$), have more chronic illnesses ($p < 0.001$), and a higher body mass ($p = 0.010$). The mean MedDietScore was 30.5 ± 4.9, the mean Life Space Assessment score was 79.1 ± 21.6, and the mean Reintegration to Normal Living Index score was 80.8 ± 15.2. Missing data for all variables was less than 2%.

As shown in Table 2, the mean Fried Frailty Index score was 1.37 ± 1.3 and the majority of the participants were pre-frail (45.6%). The most commonly seen component of frailty was weakness (53.2%).

In the multiple ordinal regression with frailty as the dependent variable adjusted for all potential confounders, as shown in Table 3, the Mediterranean diet, life-space, and social participation were all negatively associated with frailty. Adherence to the Mediterranean diet was associated with a significantly reduced risk of frailty only at the 3rd tertile when compared with the lowest tertile. Life-space and social participation were more significantly associated with a reduced risk of frailty at both the 2nd and 3rd tertiles when compared with the 1st tertile. There was no difference in the significance of the factors associated with frailty between the unadjusted model (Model 1, $R^2 = 0.352$), the model adjusted for age, gender, and education (Model 2, $R^2 = 0.391$), or the model adjusted additionally for nutrition, body mass, and comorbidity (Model 3, $R^2 = 0.521$).

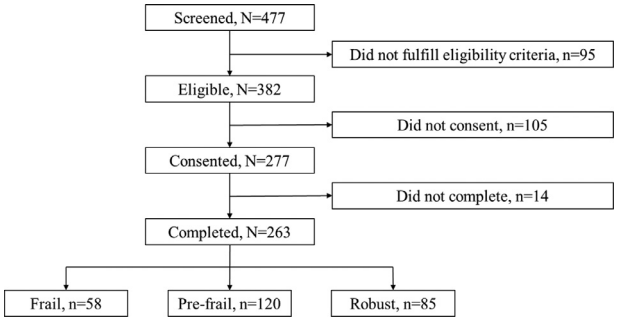

Fig. 1. Participant flow chart and results of the screening for frailty status.

Table 1
Demographic profile of the participants.

		Mean (SD)/Frequency (%)		Frail $N = 58$	p-value
	All	Robust $N = 85$	Pre-frail $N = 120$		
Age	77.1 (7.5)	73.4 (6.3)	77.6 (7.8)	81.0 (6.3)	<0.001***
Nutrition (MNA-SF, range: 0–14)	12.5 (1.6)	13.1 (0.9)	12.6 (1.7)	11.3 (1.5)	<0.001***
Gender					0.010*
Male	43 (16.3)	18 (21.2)	23 (19.2)	2 (3.4)	
Female	220 (83.7)	67 (78.8)	97 (80.8)	56 (96.6)	
Education					<0.001***
Tertiary	14 (5.3)	5 (5.9)	8 (6.7)	1 (1.7)	
Secondary	59 (22.4)	31 (36.5)	22 (18.3)	6 (10.3)	
Primary	137 (52.1)	41 (48.2)	67 (55.8)	29 (50.0)	
Nil	53 (20.0)	8 (9.4)	23 (19.2)	22 (37.9)	
Marital status					0.301
Not married	14 (5.3)	2 (2.4)	10 (8.3)	2 (3.4)	
Married	149 (56.7)	58 (68.2)	60 (50.0)	31 (53.4)	
Divorced	3 (1.1)	1 (1.2)	2 (1.7)	0 (0)	
Widow	97 (36.9)	24 (28.2)	48 (40)	25 (43.1)	
Financial sufficiency					0.064
Very sufficient	3 (1.1)	5 (5.9)	12 (10.0)	2 (3.4)	
Sufficient	123 (46.8)	40 (47.1)	59 (49.2)	24 (41.4)	
Normal	73 (27.8)	25 (29.4)	32 (26.7)	16 (27.6)	
Insufficient	45 (17.1)	13 (15.3)	16 (13.3)	16 (27.6)	
Very insufficient	19 (7.2)	2 (2.4)	1 (0.8)	0 (0)	
Smoking					0.065
Smoker/Ex-smoker	25 (9.5)	9 (10.6)	15 (12.5)	1 (1.7)	
Non-smoker	238 (90.5)	76 (89.4)	105 (87.5)	57 (98.3)	
Alcohol					0.155
Drinker/Ex-drinker	27 (10.2)	10 (11.7)	15 (12.5)	2 (3.4)	
Non-drinker	236 (89.7)	75 (88.2)	105 (87.5)	56 (96.6)	
No. of chronic diseases					0.001**
>2	73 (27.8)	14 (16.5)	37 (30.8)	22 (37.9)	
2	25 (9.5)	9 (10.6)	4 (3.3)	12 (20.7)	
1	163 (62.2)	60 (70.6)	79 (65.8)	24 (41.4)	
0	2 (0.8)	2 (2.4)	0 (0)	0 (0)	
Body mass index					0.010*
≥ 25	92 (35.0)	23 (27.1)	44 (36.7)	25 (43.1)	
23.0–24.9	56 (21.3)	15 (17.6)	31 (25.8)	10 (17.2)	
18.5–22.9	103 (39.2)	45 (52.9)	38 (31.7)	20 (34.5)	
< 18.5	12 (4.6)	2 (2.4)	7 (5.8)	3 (5.2)	

MNA-SF, mini nutritional assessment short form.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

Table 2
Dependent and Independent Variables.

	$N = 263$, mean (SD)/frequency (%)
Dependent variable	
Frailty	
Robust	85 (32.3)
Pre-frail	120 (45.6)
Frail	58 (22.1)
Frailty components	
Weight loss	64 (24.3)
Exhaustion	30 (11.4)
Low activity	33 (12.5)
Slow gait	93 (35.4)
Weakness	140 (53.2)
Frailty (FFI, range: 0–5)	1.37 (1.3)
Independent variables	
Mediterranean diet (MDS, range: 0–55)	30.5 (4.9)
MDS-beneficial score (range: 0–35)	12.9 (4.9)
MDS-detrimental score (range: 0–20)	17.6 (2.9)
Life-space (LSA, range: 0–120)	79.1 (21.6)
Social participation (RNLI, range: 0–100)	80.8 (15.2)

FFI, fried frailty index; LSA, life-space assessment; MDS, MedDietScore; RNLI, reintegration to normal living index.

In the binary regression with the Fried Frailty Index phenotypic components as the dependent variables, as shown in Table 4, lifestyle and social factors have preferentially negative associations with different phenotypic components of frailty. The Mediterranean diet was only negatively associated with weakness and slowness. Social participation was negatively associated with slowness and low activity. Life-space was negatively associated with slowness only.

Discussion

To our knowledge, this is the first study to show that a Mediterranean diet is associated with a reduced risk of frailty in the Chinese population, whose diets are traditionally unlike the Mediterranean diet. This study gives new information suggesting that the Mediterranean diet can exert its protective effect through the elimination of food considered detrimental in the Mediterranean diet, although not necessarily through the increased consumption of beneficial food. Also, the level of adherence to the Mediterranean diet must be high if it is to exert its protective effect. Our results showed that social participation and life-space are also negatively associated with frailty. Furthermore, protective factors are preferentially and negatively associated with particular phenotypical components of frailty. Exhaustion and weight loss were not associated with any factors. Slowness was negatively associated with all three factors. Weakness was negatively associated only with the Mediterranean

Table 3
Multiple ordinal regression model on frailty.

	Model 1 (R^2 = 0.352)		Model 2 (R^2 = 0.391)		Model 3 (R^2 = 0.521)	
N = 263	OR	95%CI	OR	95%CI	OR	95%CI
Mediterranean diet, MDS						
Tertile 1	Ref		Ref		Ref	
Tertile 2	0.68	0.39–1.17	0.66	0.38–1.14	0.62	0.35–1.01
Tertile 3	0.25**	0.14–0.45	0.28**	0.15–0.50	0.29**	0.15–0.54
Life-space, LSA						
Tertile 1	Ref		Ref		Ref	
Tertile 2	0.39**	0.23–0.67	0.43*	0.25–0.75	0.38**	0.21–0.66
Tertile 3	0.23**	0.12–0.45	0.29**	0.15–0.58	0.32**	0.16–0.64
Social participation, RNLI						
Tertile 1	Ref		Ref		Ref	
Tertile 2	0.29**	0.17–0.51	0.35**	0.20–0.62	0.45*	0.25–0.81
Tertile 3	0.16**	0.09–0.32	0.23**	0.12–0.45	0.31**	0.15–0.63

Model 1: Unadjusted, Model 2: Adjusted for age, gender, and education, Model 3: Additionally adjusted for nutrition, body mass index, and comorbidity.
LSA, life-space assessment; MDS, MedDietScore; RNLI, reintegration to normal living index.
* $p < 0.05$.
** $p < 0.001$.

Table 4
Multiple binary logistic regression model on the phenotypic components of frailty.

	Weakness		Slowness		Low activity		Exhaustion		Weight loss	
N = 263	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Mediterranean diet, MDS										
Tertile 1	Ref		Ref		Ref		Ref		Ref	
Tertile 2	0.97	0.50–1.91	0.38*	0.17–0.84	0.44	0.10–0.90	0.46	0.12–1.72	0.88	0.29–2.62
Tertile 3	0.42*	0.21–0.85	0.17**	0.06–0.44	0.86	0.27–2.72	0.78	0.28–2.16	0.69	0.26–1.86
Life-space, LSA										
Tertile 1	Ref	0.38–1.41	Ref		Ref		Ref		Ref	
Tertile 2	0.73	0.29–1.35	0.50	0.19–1.30	N/A		0.32	0.06–1.78	0.38	0.10–1.47
Tertile 3	0.62		0.36*	0.17–0.80	0.38	0.13–1.15	0.38	0.13–1.13	0.46	0.17–1.21
Social participation, RNLI										
Tertile 1	Ref		Ref		Ref		Ref		Ref	
Tertile 2	1.79	0.88–3.62	0.34*	0.13–0.87	0.23	0.04–1.30	0.24	0.05–1.29	0.52	0.15–1.80
Tertile 3	0.87	0.39–1.93	0.25**	0.11–0.56	0.14*	0.04–0.52	0.43	0.15–1.20	0.65	0.24–1.78

All models are adjusted for age, gender, education, nutrition, body mass index, and comorbidity.
LSA, life-space assessment; MDS, MedDietScore; RNLI, reintegration to normal living index.
* $p < 0.05$.
** $p < 0.001$.

diet, and low activity was only negatively associated with social participation. These findings extend our understanding of frailty and provide insights for developing future interventions.

The reasons why the Mediterranean diet is associated with a lower risk of frailty are not fully known. A recent systematic review reported that sarcopenia, a biological substrate of frailty,[43] is associated with elevated inflammatory markers (e.g., C-reactive protein).[44] It is well known that the Mediterranean diet attenuates inflammation[45] and oxidative stress.[46] Therefore, the Mediterranean diet's protective role against frailty may exert itself through the attenuation of oxidative stress and chronic inflammation, leading to better muscle function. This present study aligns with previous findings that the Mediterranean diet is preferentially and negatively associated with two phenotypic components of frailty that are closely related to muscle function: walking speed and muscle strength. Our results offer new evidence to support the notion that the Mediterranean diet may reduce the risk of frailty by optimizing muscle function.

Obesity is associated with increased oxidative stress.[47] Oxidative stress may damage muscles at the mitochondrial level.[48] A recent study showed that sarcopenic obesity is associated with a higher risk of frailty than obesity alone.[49] A recent systematic review showed that the Mediterranean diet can effectively reduce obesity.[50] Our study found that people with higher body mass and concurrently lower adherence to the Mediterranean diet are at a higher risk of frailty. Therefore, the Mediterranean diet may exert its protective effect at the physiological level through improving people's allometric results (i.e., increasing muscle tissue and reducing fat).

A recent study conducted among Chinese in Taiwan showed that some foods that are classified as beneficial in the Mediterranean diet (e.g., fresh fruits, nuts, and milk) are associated with a reduced risk of frailty.[51] However, our study showed that the MedDietScore beneficial score of this population is low, while their MedDietScore detrimental score is very high. This suggests that in the Chinese population, the Mediterranean diet's protective effect may be exerted through the reduced consumption of detrimental food (e.g., meat and poultry), and not necessarily through the increased consumption of beneficial foods (e.g., dairy products, olive oil). As such, this evidence supports the case for developing a culturally adjusted Mediterranean dietary intervention.

Our study finds that the Mediterranean diet is associated with a reduced risk of frailty in community-dwelling older Chinese people, which contradicts the results of a study conducted among Hong Kong Chinese in 2001–2003.[14] Furthermore, we found that only those in the 3rd tertile (i.e., those who adhered most closely to the Mediterranean diet) had a reduced risk of frailty. Adherence to the Mediterranean diet needs to be at a high threshold for it to exert its protective effect. This observation supports the hypothesis that the level of adherence to the Mediterranean diet among the Chinese population

15 years ago may have been too low to demonstrate its protective effect towards frailty. These ambiguous results are also possibly due to the different methods of measuring dietary patterns used in the different studies.

A previous longitudinal study found that frailty is associated with a faster decline in life-space.[19] Reduced life-space in older people can be a result of reduced mobility and physical capacity.[52] Our findings are consistent with those of others, but they also highlight that life-space is preferentially and negatively associated with slowness. Reduced life-space may result from a poor age-supportive environment that does not offer convenient access to resources or recreational facilities, social support, transportation, neighborhood security, and a user-friendly walking environment.[53] Frail older people who walk slowly may find it difficult to navigate in a city. Thus, helping slow-walking older people to maximize their life-space through environmental design (e.g., giving them priority access to public transport) may possibly reduce their frailty.

Previous work examining actual participation in social activities (e.g., music groups, social clubs) organized by social groups (e.g., churches, political/trade unions) and its association with frailty yielded ambiguous results.[23,54] This study conceptualized social participation as the degree of one's satisfaction with participating in social events in order to fulfill one's social needs. Our finding first showed that perceived satisfaction with social participation is associated with lower frailty. This implies that the perception of satisfaction with social participation may be more important than how much a person actually participated in the social events. Therefore, when planning for social activities, older people should be actively involved in deciding upon and selecting activities that are important to the community. Such strategies, which increase ownership over the communal activities and events, may increase overall satisfaction.

Strengths and limitations

Attempts were made in this study to minimize the risk of biases that are common in cross-sectional studies.[55] In particular participants with cognitive impairment and severe depressive symptoms were screened out to avoid recall bias. To minimize the risk of confounding bias, common confounding factors were included in the regression model for adjustment. The use of validated instruments minimized the risk of measurement bias. All of the research assistants were either registered nurses or nursing students who had undergone training and who had pilot-tested the study instruments with older volunteers. Research assistants were deemed qualified to collect data only after attaining an inter-rater reliability index score of 1.0.

Despite the positive results, there are several limitations to this study. This study employed a cross-sectional design, so conclusions on causality cannot be made. Although we attempted to employ quota sampling, the number of subjects in each category was uneven. The study did not employ random sampling because of the lack of a sampling frame and accessibility. Finally, the regression was adjusted to only the known potential confounders.

Conclusion

In conclusion, high adherence to the Mediterranean diet (particularly by eliminating the consumption of detrimental food), life-space, and social participation were associated with a reduced risk of frailty in Chinese populations. In terms of the phenotypes of frailty, slowness was negatively associated with adherence to the Mediterranean diet, life-space, and social participation. Weakness and low levels of activity were negatively associated with adherence to the Mediterranean diet and social participation, respectively.

Conflicts of interest

The authors declare that they have no conflicts of interest.

Funding

This work was partially supported by the Centre for Gerontological Nursing, School of Nursing, The Hong Kong Polytechnic University (#5-697 W), Hong Kong.

Ethical approval

This project was approved by the Institutional Review Board of The Hong Kong Polytechnic University (reference number: HSEARS20170412004)

Acknowledgments

The authors would like to thank all the participants and the staff from the participating organizations (particularly Mr. Gary Sham, St. James' Settlement, Mr. Larry LEE, Windshield Charitable Foundation). We are also grateful to our students (Chan Chun Wing, Chan Ka Wai, TSANG Sai Tat, Wong Hiu Ching, Wong Kin, Wong Tung Tung, YAU Lok Yan, and YEUNG Fong Wun) who helped the data collection.

Authors' contributions

Study concept and design: RYCK, DSKC, SKLL, LYWH, CK, YYC, JYWL; Acquisition of data: RYCK, DSKC, SKLL, LYWH, JYWL; Analysis and interpretation of data: RYCK, DSKC, SKLL, LYWH, JYWL; Drafting of the manuscript: RYCK; Critical revision of the manuscript for important intellectual content: RYCK, DSKC, SKLL, LYWH, CK, YYC, JYWL.

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