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A CROSS SECTIONAL STUDY TO EXAMINE THE ASSOCIATION BETWEEN DIETARY PATTERNS AND COGNITIVE IMPAIRMENT IN OLDER CHINESE PEOPLE IN HONG KONG

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Abstract: *Background:* Dietary patterns can be identified using a priori and a posterior approaches. Few studies have related dietary patterns with cognitive impairment in Chinese population. This study examined the risk of cognitive impairment associated with dietary patterns identified by both approaches. *Methods:* Baseline data on 1,926 Chinese men and 1,744 Chinese women aged > 65 years participating in a cohort study examining the risk factors for osteoporosis in Hong Kong were analyzed. Dietary data were collected using a validated food frequency questionnaire. Adherence to a priori dietary patterns, namely the Mediterranean Diet Score (MDS) was assessed. Factor analysis (FA) identified three a posterior dietary patterns: "vegetables-fruits" pattern which was rich in vegetables, fruits, soy products and legumes, "snacks-drinks-milk products" pattern which was a mixture of healthy and unhealthy food groups including fast food, sweets and desserts, nuts, milk products and whole grains, and "meat-fish" pattern which included frequent intake of meat, fish and seafood. Cognitive function was assessed by the Community Screening Instrument for Dementia (CSI-D). Multivariate logistic regression examined the risk of cognitive impairment with adjustment for potential confounders. *Results:* A total of 221 men and 656 women was classified as cognitive impaired. Neither the MDS nor the dietary patterns identified by FA were associated with risk of cognitive impairment in men. In women, higher "vegetables-fruits" pattern score was associated with reduced risk of cognitive impairment [Adjusted OR=0.73 (95% CI: 0.54-1.00) of the highest quartile of "vegetables-fruits" pattern score compared with the lowest quartile, ptrend=0.018]. Similar inverse trend was observed for "snacks-drinks-milk products" pattern score [Adjusted OR=0.65 (95% CI: 0.47-0.90) of the highest quartile of "snacks-drinks-milk products" pattern score compared with the lowest quartile, ptrend=0.003]. There was no association of "meat-fish" pattern or the MDS with risk of cognitive impairment in women. *Conclusion:* Higher "vegetables-fruits" and "snacks-drinks-milk products" pattern scores were associated with reduced risk of cognitive impairment in Chinese older women in Hong Kong.

Key words: Dietary pattern, cognitive impairment, chinese, mediterranean diet .

Introduction

Nutrition plays an important role in the ageing process of brain. The examination of diet as a risk factor for cognitive function has traditionally focused on the effect of single foods and nutrients (1-3). Since diet is a combination of food and nutrients, there has been an increasing interest in using dietary pattern analysis in epidemiological studies (1, 4).

There are two main approaches to define dietary patterns (4, 5). One approach is the a priori approach in which dietary indices are constructed based on prevailing dietary recommendations. Investigators measure individuals' compliance with a preexisting diet quality index or current dietary guidelines and assign diet scores that reflect the level of adherence. The Mediterranean Diet Score (MDS) is one of the dietary indices used to measure the diet quality and has been used to associate with diseases, especially for cardiovascular disease (CVD) (6, 7). It is also a common dietary index used to investigate the association with cognitive decline or dementia (1). Another approach is the a posterior approach in which dietary patterns are derived from statistical modeling, such as factor analysis, using data from dietary records or food frequency questionnaires (FFQ).

Previous studies examining the association between dietary patterns and cognitive function using these two approaches have mainly been carried out in Caucasians (8-11). Tangney et al. examined the association of cognitive decline with the adherence to a Mediterranean dietary pattern or to the Healthy Eating Index–2005 (HEI-2005) in older adults in the Chicago Health and Aging Project. Higher adherence to a Mediterranean diet as measured by a Mediterranean diet index was associated with slower rates of cognitive decline whereas such association was not observed for the HEI-2005 (9). Scarmeas and colleagues reported similar results in a multiethnic community study in New York. Higher adherence to a Mediterranean diet was associated with slower cognitive decline, reduced risk of progression from mild cognitive impairment (MCI) to Alzheimer's disease (AD), and reduced risk of AD (10, 11).

To our knowledge, few studies have investigated the association between cognitive function and diet in Chinese. However, all these studies focused on the effect of single foods and nutrients (12-14), and none examined the association of dietary patterns with the risk of cognitive impairment. In this cross sectional analysis, we aimed to examine the association of

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dietary patterns derived by both a priori and a posterior approaches with the risk of cognitive impairment in older Chinese people in Hong Kong. We hypothesized that dietary patterns derived by these two distinct approaches are associated with the risk of cognitive impairment in this population.

Methods

Study population

Subjects were participants of a cohort study examining the risk factors for osteoporosis in Hong Kong (15). 2,000 men and 2,000 women aged 65 years and over living in the community were recruited between 2001 and 2003. Participants were volunteers and were able to walk or take public transport to the study site. They were recruited using a stratified sample so that approximately 33% would be in each of these age groups: 65-69, 70-74, 75+. Compared with the general population in this age group, participants had higher educational level (12–18% vs. 3–9% with tertiary education in the age groups 80+, 75–79,70–74, and 65–69 years) (16).

We excluded participants who did not have dietary data (n=5), those with extreme daily energy intake at the first- and last-half percentiles of the sex-specific range (n=33), and those who had missing data for the variables included for the analyses (n=292). The analyses were performed on 3,670 participants. This study was conducted in accordance with the Declaration of Helsinki. This study was approved by the Clinical Research Ethics Committee of the Chinese University of Hong Kong. Written informed consent was obtained from all participants.

Demographic and overall health characteristics

A standardized interview was performed to collect information on age, gender, education level, self-perceived social status, smoking habit, alcohol use and medical history. Data on self-perceived socioeconomic status (SES) were included since psychosocial factors are also important in addition to material conditions for determining health (17, 18). Self-perceived SES was assessed by asking participants to place a mark on a picture of an upright ladder with ten rungs, with the lowest rung being the most undesirable and the highest the most desirable state with respect to their standing in the community (community ladder). Participants were also asked to rate themselves by placing a mark on a picture of another ladder, the top rung representing people who have the most money, the most education, and the most respected jobs, and the bottom rung representing people at the other extreme (Hong Kong ladder). The scores were dichotomized as high and low, using their median as cut-point (8 for the community ladder and 5 for the Hong Kong ladder) (18).

Information on the duration and level of past and current use of cigarettes, cigars and pipes was obtained. Smoking history was classified in terms of former smoking (at least 100 cigarettes smoked in a lifetime), current smoking and never smoking. Drinking status was defined as never, former or current drinker. Baseline disease status was obtained by self-report of their doctors' diagnoses, supplemented by the identification of drugs brought to the interviewers.

Anthropometric data

Body weight was measured to the nearest 0.1 kg with participants wearing a light gown, using the Physician Balance Beam Scale (Healthometer, Illinois, USA). Height was measured to the nearest 0.1 cm using the Holtain Harpenden stadiometer (Holtain Ltd, Crosswell, UK). Body mass index (BMI) was calculated as body weight in kg / (height in m)2.

Physical activity assessment

Physical activity was assessed by the Physical Activity Scale for the Elderly (PASE) (19). This is a 12-item scale measuring the average number of hours per day spent in leisure, household, and occupational physical activities over the previous 7-day period. Activity weights for each item were determined based on the amount of energy spent, and each item score was calculated by multiplying the activity weight with daily activity frequency. A composite PASE score of all the items was yielded. A higher PASE score reflects higher physical activity level.

Number of activities of daily living (ADLs) were also assessed by noting any impairment in walking two to three blocks outdoors on level ground, climbing 10 steps without resting, preparing own meals, doing heavy housework like scrubbing floors or washing windows, and shopping for groceries or clothes. A summed score from 0 to 5 was calculated from these activities as the degree of impairment in ADLs, with higher score indicating greater impairment.

Assessment of cognitive function

Cognitive function was assessed by trained research staff using the cognitive part of the Community Screening Instrument for Dementia (CSI-D) (20), validated in different cultural and educational settings (20). The cognitive part of the CSI-D consists of 32 items in six cognitive domains: orientation to time, orientation to place, praxis, abstract thinking, language and memory. A summary score ranged from 0 to 33 was generated, with higher score meaning better cognitive function. The cutoff point for probable dementia is $\leq$28.4.

Assessment of depression

Since depression may be associated with cognitive impairment, in the analysis of factors associated with cognitive impairment, the presence of depression was adjusted for as a confounding factor. Depression was diagnosed by face-to-face interviews using a validated Chinese version of the Geriatric Depression Scale (GDS) (21, 22). The GDS short form was found to be a highly reliable (reliability coefficient of 0.90) and valid screening device (sensitivity of 96.3% and specificity of 87.5%) for assessing geriatric depression in Hong Kong

Chinese (22). The GDS short form consists of 15 questions relevant to depression, such as motivation, self-image, losses, agitation and mood. A yes/no format was designed for each question. A summary score ranged from 0 to 15 was generated, with depression being defined as a cut-off of 8 or more.

Dietary assessment

Baseline dietary intake was assessed using a validated FFQ developed in a population survey (23). Daily nutrient intake was calculated using food tables derived from McCance and Widdowson (24) and the Chinese Medical Sciences Institute (25). The FFQ consisted of 280 food items. Each participant reported the food item, the size of each portion, the number of times of consumption each day and each week, using the past 12 months prior to the interview as a reference period. Portion size was explained to participants using a catalogue of pictures of individual food portions. For seasonally consumed vegetables and fruits, participants were asked about the months of food consumption over the past year. The amount of cooking oil was estimated according to the usual cooking methods of preparing standardized portion of different foods and the usual portion of different foods consumed by the participants.

Dietary patterns derived by factor analysis

Details of dietary pattern scores derived by the factor analysis have been described elsewhere (26). In brief, individual food items from the FFQ were aggregated into 32 food groups based on similarity of type of food and nutrient composition. The food groups were energy adjusted by dividing the energy intake from each food group by total energy intake and multiplying by 100, and were expressed as percentage contribution to total energy (27). Factor analysis was conducted with varimax rotation using the 32 food groups (4). Factors were retained based on an eigenvalues greater than 1.0, a scree plot, and the interpretability (28). The factor scores for each pattern were calculated for each participant by summing intakes of food items weighted by their factor loadings. A higher score indicated greater conformity with the pattern being calculated.

The Mediterranean Diet Score (MDS)

Adherence to the Mediterranean diet was calculated using the revised method described by Trichopoulou et al. (29). Essentially, adherence is represented by a scale where a value of 1 was assigned to consumption of food groups considered beneficial to health at or above the sex-specific median (vegetables, legumes, fruits and nuts, cereal, fish and monosaturated to saturated lipids ratio) and below the median for food groups presumed to be detrimental to health (meat, poultry and dairy products). For ethanol consumption, a value of 1 was assigned to men who consumed between 10 and 50 g per day and to women who consumed between 5 and 25 g per day. The total MDS ranged from 0 (minimal adherence) to 9 (maximal adherence).

Statistical analysis

Statistical analyses were performed using the statistical package SPSS version 16.0 (SPSS Inc., Illinois, US). Data were checked for normality and logarithmic transformation was applied to the variables that were skewed. Dietary pattern scores derived by factor analysis were stratified into quartiles based on the distribution of each sex. The MDS was divided into three levels of adherence, namely low (0-3), medium (4-5) and high (≥6) (29, 30). Partial correlation was used to examine the correlation between each dietary pattern score derived by factor analysis and intakes of various nutrients controlling for daily energy intake. Independent t test and chi square test were used to examine baseline differences in mean age, BMI, PASE, energy intake, and also differences in the distribution of education level, Hong Kong ladder, community ladder, smoking status, alcohol use, number of ADLs, GDS category, self-reported disease status, quartiles of each dietary pattern score, and three levels of MDS between participants with cognitive impairment and participants without cognitive impairment.

Multivariate logistic regression was used to estimate the odds ratio (OR) and 95% confidence intervals (CIs) for risk of cognitive impairment according to quartiles of each dietary pattern score or three levels of MDS. Model 1 was adjusted for age (years), BMI, PASE, daily energy intake (kcal), education level (no education, primary or below, secondary or matriculation, University or above), Hong Kong ladder (<5 vs. >=5), community ladder (<8 vs. >=8), smoking habit (never, past, current), alcohol use (never or past vs. current), no. of ADLs (no difficulty vs. some difficulties), and GDS category (<8 vs. >=8). Model 2 was further adjusted for self-reported history of diabetes (yes vs. no), hypertension (yes vs. no), and CVD or stroke (yes vs. no). Test for trend was examined by entering quartiles of each dietary pattern score or three levels of MDS as a continuous variable in all models. An α level of 5% was used as the level of significance. Interaction between sex and quartiles of each factor analysis derived dietary pattern score or three levels of MDS was tested by addition of cross-product terms to the multivariate models. Interactions were significant between some dietary patterns and sex, thus data were analyzed and presented separately for men and women.

Results

A posterior dietary patterns of the participants

Factor analysis identified three a posterior dietary patterns (Table 1). The first factor (vegetables-fruits pattern) was dominated by frequent intake of vegetables, fruits, soy and soy products, and legumes. The second factor (snacks-drinks-milk products pattern) was composed of a mixture of healthy and unhealthy food groups. It was characterized by frequent intake of condiments, drinks, fast food, French fries, potato chips, sweets and desserts, nuts, milk products, and whole grains. The third factor (meat-fish pattern) included frequent intake of dim sum, red and processed meats, poultry, fish and seafood, and wine.

Table 1
Food group factor loading[a] for three dietary patterns

Food groups	Dietary patterns		
	Factor 1: Vegetables-fruits	Factor 2: Snacks-drinks-milk products	Factor 3: Meat-fish
Other vegetables	**0.58**	-0.06	0.02
Tomatoes	**0.49**	0.03	-0.01
Dark green and leafy vegetables	**0.43**	-0.26	-0.02
Cruciferous vegetables	**0.43**	-0.05	-0.06
Starchy vegetables	**0.42**	0.03	0.00
Soy	**0.42**	0.08	0.11
Fruits	**0.40**	0.03	-0.01
Legumes	**0.34**	-0.01	0.02
Mushroom and fungi	**0.22**	0.06	-0.07
Fats and oils	**-0.37**	-0.21	0.15
Condiments	-0.05	**0.48**	-0.13
Coffee	-0.15	**0.42**	-0.17
Fast food	-0.03	**0.37**	0.04
Nuts	0.12	**0.37**	-0.03
French fries and potato chips	-0.03	**0.37**	0.09
Milk and milk products	0.08	**0.31**	-0.14
Whole grains	0.14	**0.30**	-0.17
Sweets and desserts	0.02	**0.29**	0.08
Beverages	-0.03	**0.22**	0.09
Dim sum	-0.17	-0.11	**0.56**
Red and processed meats	-0.07	0.06	**0.46**
Poultry	0.06	0.11	**0.45**
Fish and seafood	0.22	-0.17	**0.37**
Wine	-0.14	0.10	**0.20**
Refined grains	-0.25	-0.50	**-0.69**
Cakes, cookies, pies and biscuits	0.06	0.14	0.19
Eggs	0.07	0.19	0.05
Organ meats	-0.08	0.15	0.12
Others	0.01	0.07	0.03
Preserved vegetables	-0.02	0.08	0.00
Soups	0.00	0.00	-0.01
Tea	0.00	0.15	0.03
% variance explained	6.2	5.4	5.1

a. Factor loadings with absolute value $\geq$ 0.2 are shown in bold. For food group loads more than one dietary pattern, only the highest absolute value of loading is bolded (28).

For both men and women, total energy intake was weakly positively associated with each dietary pattern score. Similar associations of each dietary pattern score with nutrient intakes were observed in men and women (Table 2). 'Vegetables-fruits' dietary pattern scores were inversely associated with saturated fat, monounsaturated fat and polyunsaturated fat intakes, and positively associated with intakes of carbohydrates, protein, cholesterol, fiber, isoflavones, most vitamins and minerals. 'Snacks-drinks-milk products' dietary pattern scores were inversely associated with intakes of polyunsaturated fat and vitamin K, positively associated with intakes of carbohydrates, protein, total fat, saturated fat, monounsaturated fat, cholesterol and vitamin D. Whilst 'snacks-drinks-milk products' dietary pattern scores were also positively associated with intakes of fiber, most minerals and isoflavones, the associations were less strong than those with 'vegetables-fruits' dietary pattern scores. 'Meat-fish' dietary pattern scores were weakly positively associated with intakes of polyunsaturated fat and most micronutrients, moderately positively associated with intakes of protein, total fat and monounsaturated fat, and strongly positively associated with saturated fat and cholesterol intakes. The positive associations of protein, total fat, different kinds of fat and cholesterol with 'meat-fish' dietary pattern scores were stronger than those with 'snacks-drinks-milk products' dietary pattern scores.

Participants' characteristics by cognitive impairment status

There were 221 (11.5%) men and 656 (37.6%) women who were classified as cognitive impaired. The characteristic of participants with cognitive impairment and participants without

Table 2
Pearson's correlations between each dietary pattern score and nutrient intakes in 3,670 Hong Kong Chinese older people

Nutrients	Men (n=1,926)						Women (n=1,744)					
	Vegetables-fruits		Snacks-drinks-milk products		Meat-fish		Vegetables-fruits		Snacks-drinks-milk products		Meat-fish	
	r	p	r	p	r	p	r	p	r	p	r	p
Energy (kcal)	0.06	*	0.21	***	0.12	***	0.11	***	0.27	***	0.16	***
Carbohydrates (g)	0.09	***	0.12	***	-0.23	***	0.11	***	0.17	***	-0.16	***
Protein (g)	0.22	***	0.27	***	0.31	***	0.26	***	0.32	***	0.36	***
Fat (g)	-0.04	ns	0.19	***	0.43	***	0.00	ns	0.26	***	0.45	***
SFA (% energy)	-0.15	***	0.19	***	0.51	***	-0.16	***	0.19	***	0.57	***
MUFA (% energy)	-0.09	***	0.08	***	0.35	***	-0.02	ns	0.10	***	0.36	***
PUFA (% energy)	-0.15	***	-0.11	***	0.17	***	-0.13	***	-0.10	***	0.21	***
Cholesterol (mg) †	0.13	***	0.18	***	0.50	***	0.12	***	0.25	***	0.51	***
Fiber (g) †	0.64	***	0.20	***	-0.06	**	0.62	***	0.18	***	0.08	**
Vitamin A (IU) †	0.59	***	0.08	***	0.08	**	0.57	***	0.12	***	0.12	***
Vitamin C (mg) †	0.57	***	0.04	ns	0.06	*	0.52	***	0.08	***	0.14	***
Calcium (mg)	0.40	***	0.37	***	-0.07	**	0.40	***	0.28	***	0.03	ns
Phosphorus (mg)	0.26	***	0.37	***	-0.02	ns	0.27	***	0.35	***	0.05	*
Iron (mg) †	0.34	***	0.32	***	0.09	***	0.38	***	0.31	***	0.15	***
Potassium (mg) †	0.30	***	0.09	***	0.29	***	0.37	***	0.19	***	0.29	***
Magnesium (mg) †	0.44	***	0.12	***	-0.05	*	0.35	***	0.09	***	0.00	ns
Sodium (mg) †	0.22	***	0.28	***	0.22	***	0.19	***	0.26	***	0.30	***
Zinc (mg)	0.29	***	0.19	***	0.21	***	0.34	***	0.25	***	0.23	***
Isoflavones (mg) †	0.34	***	0.15	***	0.10	***	0.40	***	0.14	***	0.14	***
Vitamin K (μg) †	0.53	***	-0.09	***	0.06	**	0.53	***	-0.07	**	0.11	***
Vitamin D (IU) †	0.11	***	0.31	***	0.06	*	0.08	**	0.28	***	0.02	ns

SFA, Saturated fatty acids; MUFA, Monounsaturated fatty acids; PUFA, Polyunsaturated fatty acids; *p<0.05; **p<0.01: ***p<0.001; †log transformed nutrient intake

cognitive impairment is shown in Table 3. Those who were cognitive impaired were generally older and of lower education level, had lower PASE, lower energy intake, more impairments in ADLs, and higher GDS score. Women who were cognitive impaired showed lower 'vegetables-fruits' dietary pattern scores and lower 'snacks-drinks-milk products' dietary pattern scores. No such association was observed for men.

Dietary patterns and risk of cognitive impairment

Neither the MDS nor the dietary patterns identified by factor analysis were associated with the risk of cognitive impairment in men (Table 4). In women, higher "vegetables-fruits" pattern score was associated with reduced risk of cognitive impairment [Adjusted OR=0.73 (95% CI: 0.54-1.00) of the highest quartile of "vegetables-fruits" pattern score compared with the lowest quartile, ptrend=0.018]. Similar inverse trend was observed for "snacks-drinks-milk products" pattern score [Adjusted OR=0.65 (95% CI: 0.47-0.90) of the highest quartile of "snacks-drinks-milk products" pattern score compared with the lowest quartile, ptrend=0.003]. There was no association of "meat-fish" pattern or the MDS with risk of cognitive impairment in women (Table 4).

Discussion

Our study showed that higher "vegetables-fruits" pattern scores and higher "snacks-drinks-milk products" pattern scores, but not the MDS were associated with reduced risk of cognitive impairment in Hong Kong Chinese older women. In contrast, neither the MDS nor the dietary patterns identified by factor analysis were associated with the risk of cognitive impairment in men. The smaller number of men with cognitive impairment (11.5%) as compared to women (37.6%) in this study may explain the absence of association in men.

Our observation that higher "vegetables-fruits" dietary pattern scores were associated with lower risk of cognitive impairment in older women was consistent with the findings in the literature. The preventive effect of high vegetable and fruit consumption against cognitive function has been well studied. Existing evidence generally support that higher intake of vegetables was associated with reduced risk of cognitive impairment, slower rate of cognitive decline , and reduced risk of dementia (12, 13, 31-33). In contrast, the role of fruit consumption in the prevention of cognitive decline or dementia is less certain (33). There is also evidence to suggest that vegetables and fruit might have a differential effect on cognition according to groups of vegetables and fruit and type of cognitive function (34, 35). In our study, the "vegetables-fruits" pattern was characterized by frequent intake of plant-based foods including vegetables, fruits, soy and soy products, and legumes. Compared to the "snacks-drinks-milk products" pattern and the "meat-fish" pattern, the "vegetables-fruits" pattern also showed highest correlations with fiber and other nutrients, such as isoflavones, vitamins A and C, potassium, calcium and magnesium that are considered as beneficial for brain health. It is possible that the "vegetables-fruits" pattern is

Table 3
Baseline characteristics between participants with and without cognitive impairment

Characteristics	Men					Women				
	No cognitive impairment (n=1,705)		Cognitive impairment (n=221)			No cognitive impairment (n=1,088)		Cognitive impairment (n=656)		
	Mean / n	SD / %	Mean / n	SD / %	P[a]	Mean / n	SD / %	Mean / n	SD / %	P[a]
Age (years)	72.0	4.8	75.2	5.7	<0.001	71.6	4.8	73.6	5.7	<0.001
PASE score	98.7	50.0	93.1	53.2	0.118	87.6	33.8	84.3	33.2	0.047
Energy intake (kcal)	2109.5	560.4	2030.5	578.3	0.050	1623.4	439.3	1523.6	429.3	<0.001
BMI (kg/m2)	23.5	3.1	23.2	3.3	0.158	23.8	3.4	24.1	3.5	0.086
Education (%)										
No education	65	3.8	27	12.2	<0.001	239	22.0	373	56.9	<0.001
Primary	908	53.3	154	69.7		561	51.6	253	38.6	
Secondary	479	28.1	31	14.0		181	16.6	26	4.0	
University or above	253	14.8	9	4.1		107	9.8	4	0.6	
Hong Kong ladder (%)										
<5	763	44.8	105	47.5	0.438	409	37.6	264	40.2	0.270
>=5	942	55.2	116	52.5		679	62.4	392	59.8	
Community ladder (%)										
<8	1150	67.4	143	64.7	0.414	501	46.0	300	45.7	0.898
>=8	555	32.6	78	35.3		587	54.0	356	54.3	
Current smoker (%)										
Never	621	36.4	75	33.9	0.215	995	91.5	586	89.3	0.306
Past	890	52.2	112	50.7		76	7.0	59	9.0	
Current	194	11.4	34	15.4		17	1.6	11	1.7	
Current drinker (%)										
Never or past	1292	75.8	173	78.3	0.412	1055	97.0	645	98.3	0.080
Current	413	24.2	48	21.7		33	3.0	11	1.7	
No. of ADLs (%)										
0	1447	84.9	173	78.3	0.012	764	70.2	404	61.6	<0.001
>=1	258	15.1	48	21.7		324	29.8	252	38.4	
GDS category (%)										
<8	1577	92.5	191	86.4	0.002	1007	92.6	574	87.5	<0.001
>=8	128	7.5	30	13.6		81	7.4	82	12.5	
DM (%)	248	14.5	31	14.0	0.837	131	12.0	124	18.9	<0.001
Hypertension (%)	706	41.4	95	43.0	0.654	463	42.6	305	46.5	0.108
CVD/Stroke (%)	387	22.7	42	19.0	0.214	211	19.4	123	18.8	0.741
Vegetables-fruits pattern (%)										
Q1	428	25.1	59	26.7	0.941	241	22.2	193	29.4	<0.001
Q2	425	24.9	53	24.0		256	23.5	178	27.1	
Q3	423	24.8	56	25.3		294	27.0	147	22.4	
Q4	429	25.2	53	24.0		297	27.3	138	21.0	
Snacks-drinks-milk pattern (%)										
Q1	415	24.3	70	31.7	0.073	223	20.5	214	32.6	<0.001
Q2	425	24.9	55	24.9		248	22.8	185	28.2	
Q3	427	25.0	52	23.5		293	26.9	144	22.0	
Q4	438	25.7	44	19.9		324	29.8	113	17.2	
Meat-fish pattern (%)										
Q1	430	25.2	57	25.8	0.641	272	25.0	168	25.6	0.425
Q2	429	25.2	48	21.7		265	24.4	172	26.2	
Q3	419	24.6	61	27.6		285	26.2	149	22.7	
Q4	427	25.0	55	24.9		266	24.4	167	25.5	
MDS levels (%)										
0-3	576	33.8	70	31.7	0.371	393	36.1	247	37.7	0.592
4-5	805	47.2	115	52.0		495	45.5	282	43.0	
6-9	324	19.0	36	16.3		200	18.4	127	19.4	

a. P tested by independent t test for continuous variables and chi square test for categorical variables; PASE: Physical Activity Scale for the Elderly; BMI: Body Mass Index; ADL: Activities of Daily Living; GDS: Geriatric Depression Scale; DM: Diabetes, CVD: Cardiovascular Diseases; MDS: Mediterranean Diet Score

Table 4
Logistic regression linking each dietary pattern to risk of cognitive impairment in 3,670 Hong Kong Chinese older men and women

Dietary patterns		Men (n=1,926)					Women (n=1,744)				
		Case/ Control	Model 1[a] OR	95%CI	Model 2[b] OR	95%CI	Case/ Control	Model 1[a] OR	95%CI	Model 2[b] OR	95%CI
'Vegetables fruits' pattern	Q1	59/428	1	(reference)	1	(reference)	193/241	1	(reference)	1	(reference)
	Q2	53/425	0.99	0.65-1.50	0.97	0.64-1.48	178/256	0.98	0.73-1.33	0.99	0.73-1.33
	Q3	56/423	1.11	0.73-1.68	1.10	0.73-1.67	147/294	0.77	0.57-1.05	0.77	0.57-1.04
	Q4	53/429	1.09	0.71-1.66	1.09	0.72-1.67	138/297	0.74	0.54-1.00	0.73	0.54-1.00
	P trend		0.593		0.564			0.020		0.018	
'Snacks-drinks-milk products' pattern	Q1	70/415	1	(reference)	1	(reference)	214/223	1	(reference)	1	(reference)
	Q2	55/425	0.85	0.57-1.27	0.86	0.57-1.28	185/248	0.91	0.68-1.22	0.92	0.68-1.23
	Q3	52/427	1.00	0.66-1.52	1.02	0.67-1.55	144/293	0.70	0.52-0.95	0.71	0.53-0.97
	Q4	44/438	0.93	0.59-1.44	0.94	0.60-1.47	113/324	0.63	0.45-0.86	0.65	0.47-0.90
	P trend		0.892		0.962			0.001		0.003	
'Meat-fish' pattern	Q1	57/430	1	(reference)	1	(reference)	168/272	1	(reference)	1	(reference)
	Q2	48/429	0.81	0.53-1.25	0.82	0.54-1.27	172/265	1.17	0.86-1.58	1.16	0.86-1.57
	Q3	61/419	0.99	0.66-1.49	1.00	0.66-1.51	149/285	0.99	0.72-1.34	0.96	0.71-1.31
	Q4	55/427	0.83	0.54-1.27	0.84	0.55-1.29	167/266	1.27	0.93-1.72	1.23	0.90-1.68
	P trend		0.584		0.625			0.283		0.380	
MDS	0-3	70/576	1	(reference)	1	(reference)	247/393	1	(reference)	1	(reference)
	4-5	115/805	1.26	0.89-1.76	1.25	0.89-1.76	282/495	0.92	0.72-1.18	0.90	0.71-1.16
	6-9	36/324	0.90	0.57-1.42	0.89	0.56-1.41	127/200	1.05	0.76-1.43	1.02	0.75-1.41
	P trend		0.910		0.882			0.925		0.952	

a. Mode1: Adjusted for age, BMI, PASE, energy intake, education level, Hong Kong ladder, community ladder, smoking status, alcohol use, no. of ADLs, GDS category; b. Model 2: Further adjusted for self-reported history of DM, hypertension, CVD/ stroke; BMI: Body Mass Index; PASE: Physical Activity Scale for the Elderly; ADL: Activities of Daily Living; GDS: Geriatric Depression Scale; DM: Diabetes, CVD: Cardiovascular Diseases; MDS: Mediterranean Diet Score

associated with reduced oxidative stress, higher anti-inflammatory property, and higher antioxidant capacity, the potential biological mechanisms that are linked with better cognitive function and brain health (36, 37).

In our study, women with higher "snacks-drinks-milk products" dietary pattern scores showed decreased risk of cognitive impairment. Such an inverse association was less easy to interpret. In comparison to the 'vegetable-fruit' dietary pattern, the positive association of this pattern with intakes of fiber, vitamins, most minerals and isoflavones was less strong. However, this pattern was composed of healthy and unhealthy food groups. This pattern was dominated by intake of condiments, drinks, sweets and desserts, fast food, French fries, potato chips, nuts, milk and milk products, and whole grains. Past studies have examined the role of these food groups in cognitive function (1, 3, 36, 38, 39). Higher sugar intake, especially those from dessert, cakes and sweets, and sugar-sweetened beverages appeared to be associated with lower cognitive function (3, 38, 39). The actions of high sugar intakes on cognition may be possibly through the metabolic changes associated with the metabolic syndrome, such as increased glycogenesis, oxidative stress and uric acid production, which in turn may lead to cognitive decline and AD (40-42). In contrast, there is accumulating evidence to suggest that increased intake of nuts, whole grains, milk and dairy products, in particular the low-fat milk and dairy products is associated with better cognitive function and lower risk of AD (1, 36, 43).

Our study did not find any association between MDS and the risk of cognitive impairment in Chinese older men and women. Few studies investigating the role of MDS in brain function generally showed that higher adherence to a Mediterranean diet was associated with lower risk of cognitive impairment, slower rates of cognitive decline and decreased risk of AD in older persons (44). In the Washington Heights-Inwood Columbia Aging Project (WHICAP), higher adherence to a Mediterranean diet was associated with slower cognitive decline, reduced risk of progression from MCI to AD, and reduced risk of AD in a multiethnic community-based sample (10, 11). Similar observations were reported by three recent prospective studies in the US population (9, 32) and in French (45). Accumulating evidence has suggested several possible biological mechanisms between adherence to a Mediterranean diet and cognitive function. These mechanisms include effects on vascular function, structural integrity of neuronal membranes, as well as reduced oxidative stress and higher anti-inflammatory and antioxidant capacity (1, 44).

There are several reasons to explain the absence of association between MDS and cognitive function. The MDS was calculated using a method that has been extensively used in previous studies with non-Mediterranean populations (10, 11, 32). However, the method may lead to bias because the MDS calculation is based on cohort- and sex-specific median values across nine food categories of the studied sample. Although the Chinese diet has many similar features with the Mediterranean diet, in that vegetable and fruit consumption is high, and fat and meat consumption is low (46), the consumption of legumes, milk and milk products, and wine was less in our cohort than the traditional Mediterranean diet (data not shown). Most of our participants had MDS of 5 or below whereas only 18% of the participants had MDS between 6 to 9. However, based on existing evidence suggesting that the Mediterranean-type diet is transposable to non-Mediterranean regions (47, 48), it would be of particular interest to examine this pattern as a predisposing factor to cognitive function in our population.

Our study had several limitations. First, our study design was cross sectional in nature. We cannot exclude the possibility that our subjects' nutritional habits would have changed as a result of various factors when their dementia symptoms start. Such factors may include changes in social environment, changes in olfaction, taste and physical activity status, and medications affecting weight. Therefore, the causal relationship between nutrition and cognition cannot be determined in the present study, and prospective data are needed to shed more light on this area. Second, the use of the self-reported measures of cognitive impairment (CSI-D) and depression (GDS), and the lack of neuropsychological battery for cognitive assessment in the present study may be the limitations. Due to the limited score range of CSI-D, there may also be a concern of some possible psychometric disadvantages, such as ceiling effect of its application. However, the sensitivity of these measures is high and has been validated in Chinese population (20, 22). The CSI-D is also commonly used in population studies, and has been considered as a better screening tool for dementia as compared to other scales (49, 50). Furthermore, although we controlled for various common factors and major chronic conditions in the analysis, residual potential confounding from some other factors related to the risk of cognitive impairment might still be present. In addition, the derived dietary patterns accounted for 16.7% of the total variance. Although this is higher than that reported in some studies (51, 52), it is in general lower than that reported in most studies (53, 54). Finally, our sample was of a higher educational standard compared with the general Hong Kong population and the results may not be extrapolated to the general population.

Conclusion

Higher "vegetables-fruits" and "snacks-drinks-milk products" pattern scores were associated with reduced risk of cognitive impairment in Chinese older women in Hong Kong. Although we did not find an association between adherence to a Mediterranean diet and risk of cognitive impairment, our data suggested that a diet characterized by frequent intake of vegetables, fruits, legumes and soy may help prevent against cognitive impairment in older Chinese population. The exact role of food groups in the "snacks-drinks-milk products" pattern in cognitive function however remains to be determined.

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