ORIGINAL ARTICLE

Dietary Inflammatory and Its Association with Cognitive Frailty Among Community-Dwelling Older Adults in Klang Valley

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ABSTRACT

Introduction: Dietary inflammation is a significant risk factor for age-related cognitive impairments among older adults. However, information related to the relationship between Empirical Dietary Inflammatory Index (eDII) score and cognitive frailty (CF) among Malaysian community-dwelling older adults is still limited. The objective of this study is to determine the association between dietary inflammatory risk and CF among community-dwelling older adults. **Method:** This is a cross sectional study involving community-dwelling older adults in Klang Valley. The Fried's Criteria and Clinical Dementia Rating (CDR) were used to determine CF status. Subjects were also interviewed using the Dietary History Questionnaire (DHQ) and eDII food checklist to assess the food intake and dietary inflammatory risk. Data collected was analyzed using SPSS version 26.0. **Results:** A total of 158 older adults (66.7 ± 5.2 years old) residing in Klang Valley were involved. Energy and macronutrients have a weak positive association with pro-inflammatory score ($p<0.05$). There is no significant mean difference between CF older adults consumed a more pro-inflammatory diet (mean 2.07 ± 1.10) compared to non CF (mean 2.06 ± 1.14). However, white rice food item significantly consumed by CF people (22.4%) than non CF (8.5%) ($p<0.05$). **Conclusion:** CF older adults were more likely to consume a pro-inflammatory diet particularly from the rice food group. There is a need to further assess the risk of consuming a pro-inflammatory diet using larger sample size and appropriate biomarkers.
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Keywords: eDII score, Pro-inflammatory diet, Anti-inflammatory diet, Cognitive frailty, Community-dwelling elderly

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INTRODUCTION

Cognitive frailty is characterized by presence of both physical frailty and cognitive impairment among older adults without dementia (1). The prevalence of cognitive frailty and pre-cognitive frailty in the Malaysian population are 2.2 percent and 36.2 percent, respectively (2). In addition, risk factors for cognitive frailty include cardiovascular disease, depression, hypertension and poor eating habits particularly (3). Previous research stated that reversing of cognitive frailty can be accomplished through lifestyle changes in areas such as nutrition, psychosocial, physical activity, cognitive and metabolic health, and vascular risk management (4,5).

Other than that, nutrition has been identified as the modifiable variable factors that are significant for early prevention of cognitive frailty and age-related dementia (6). Interestingly, the Mediterranean Diet (MeDi) and the Dietary Approaches to Stop Hypertension (DASH) diet contain high antioxidant components in its dietary patterns and have been practiced among the older adults to protect or slow the rate of cognitive decline (7).

Dietary inflammation has been linked to age-related neurodegenerative diseases such as cognitive decline, Alzheimer's disease, and vascular dementia (8). Consumption of antioxidant-rich micronutrients such as vitamins A, E, and C in food intake may protect against the development of neurodegeneration by eliminating free radical residues and thereby, reducing oxidative stress (7,9).

Older adults are often associated with inflammaging which is a low-grade, chronic, and sterile inflammatory condition that contributes to the onset of illness and cognitive decline (10,11). This is due to the imbalance between the pro-inflammatory response and the pro-inflammatory network persisting throughout the aging process. Inflammaging can also cause cell and tissue

deterioration in the body, leading to the development of age-related pathologies such as cancer and type 2 diabetes mellitus (11). Thus, there is an association between dietary patterns and inflammation among the older adults (10). However, related research is still limited and inconclusive. Hence, the aim of this research is to determine the relationship between pro-inflammation and anti-inflammation using Empirical Dietary Inflammatory Index (eDII) score and cognitive frailty status among older adults living in the community in Klang Valley.

MATERIALS AND METHODS

Study Design and Population

This study is a cross-sectional study, a part of screening phase in the Multi-Domain Intervention for Reversal of Cognitive Frailty: Towards Personalized Approaches (AGELESS Trial). This study included 158 older adults from Klang Valley (Kuala Lumpur and Selangor), who have completed data on their physical, cognitive and nutritional status assessments. Furthermore, this study was approved by the Research Ethics Committee, National University of Malaysia (UKM/PPI/111/8/JEP-2020-347).

Inclusion and Exclusion Criteria

All 158 participants were eligible to participate in this study as they met the inclusion criteria. The inclusion criteria for this study are Malaysian community-dwelling aged 60 years old and above, living in community and able to communicate either in Malay or English. The exclusion criteria includes are having dementia, non-ambulatory, loss of sight, hearing and bad communication, disorder/disease that may affect the intervention (Eg: Major Depressive Disorder (MDD)) and disorder/disease that can impede cooperation and evaluated by a study physician (Eg: Mentally ill patient). Before beginning this data collection, participants were provided with written consent. The type of sampling methods used in this research is purposive sampling, where a face-to-face interview was conducted lasting 20 to 40 minutes per session and the participant's feedback was recorded. This data collection involved five components such as sociodemographic, anthropometry, dietary, cognitive and frailty assessment.

Sociodemographic Assessment

A questionnaire adapted from AGELESS TRIAL was used to collect the sociodemographic profile such as name, address, phone number, gender, age, marital status, education level, work status, household income, living area, history of dementia, history of Traumatic Brain Injury (TBI), and smoking status.

Anthropometry

Participant's weight was recorded using the Bioelectrical Impedance Analysis (BIA) and height was recorded using a stature meter. Body Mass Index (BMI) is calculated as weight in kilograms divided by the square of height in meters. BMI was calculated using the Statistical Package for Social Science (SPSS) version 26.0 and classified as underweight (< 22kg/m^2), normal (22 - 27 kg/m^2), and overweight (> 27 kg/m^2) (12).

Nutritional Assessment

The Dietary History Questionnaire (DHQ) adapted by Shahar et al. (2000) was used to assess their one week dietary intake as it suits older adults with cognitive impairment (13). Participants were interviewed face-to-face using DHQ to determine the frequency of food intake, time and place of consumption, type of meal consumed, as well as examples of common foods, portion size, and cooking methods. The Nutritionist Pro (NutriPro) application was then used to analyze the food intake data. Dietary intake with over-reporting and under-reporting were excluded from the analysis.

A food checklist adapted from Kanauchi et al. (2019) was used and translated into Malay for the purpose of this study in order to assess the level of dietary inflammation (14). Furthermore, the translated food checklist was subjected to reliability and validity tests before being used in this study. Interpreters and health professionals both approved of the food checklist. The food checklist was then used in a pilot test, and was further analyzed using Cronbach's Alpha, yielding a value of 0.418, which is classified as acceptable (15).

This food checklist is divided into two groups: (i) pro-inflammatory food and (ii) anti-inflammatory food, each with eight pro-inflammatory and eight anti-inflammatory components. Red meat, processed meat or internal organ meat, non-greasy fish, eggs, sugary sweet drinks and tomatoes, white rice and bread or noodles are all examples of pro-inflammatory foods. On the other hand, green leafy vegetables, dark yellow vegetables, fruit juices and oily fish, coffee and tea, wine and beer or other alcoholic beverages are all anti-inflammatory foods. The frequency of food intake was listed based on the average number of bowls or cups consumed per day and the amount consumed per week.

The frequency of pro-inflammatory and anti-inflammatory foods intake was then scaled using the eDII scoring. The pro-inflammatory component was scored as 0, 1, or 2 points, where as anti-inflammatory component was scored as 0, -1, or -2 points based on the frequency of food intake. The eDII score range was divided into three categories namely: (i) low (-9 to -2), (ii) medium (-1 to +1) and (iii) high (+2 to +10). The maximum score that can be obtained is 10 while the minimum score is -9. High scores indicated that the food has a high inflammatory potential and vice versa.

Cognitive Frailty Assessment

Since this study followed AGELESS trial, the classification of cognitive frailty status was determined by the presence

of mild cognitive impairment (MCI) and physical pre-frailty/ frailty (5). A Clinical Dementia Rating (CDR) questionnaire was used to assess the participant's cognitive status. It is based on six different cognitive and behavioral domain tests, including memory, orientation, judgment and problem solving, community affairs, home performance and hobbies, and self-care. The CDR is scaled from 0 to 3: no dementia (CDR = 0), questionable dementia (CDR = 0.5), mild cognitive impairment (MCI) (CDR = 1), moderate cognitive impairment (CDR = 2), and severe cognitive impairment (CDR = 3) (16). In this study, the participants were categorised as having MCI if they obtained a score of CDR 0.5.

Simultaneously, Fried's criteria was utilised to assess physical pre-frailty and frailty among older adults. It consisted of 5 categories namely weight loss, fatigue, poor muscle strength, low walking speed, and low physical activity (17). Weight loss was assessed based on the participant's subjective reports of unintentional weight loss of 5 kg or more over the previous year. Participant's fatigue was assessed through self-report using two questions from the Center for Epidemiologic Studies Depression Scale (CES-D). Hand grip tests were used to assess weakness, which was significantly lower than standard guidelines based on gender and BMI. Following that, 5 meter walking speed test was performed to evaluate walking speed. Finally, the Physical Activity Scale for Elderly (PASE) in Malay language was used to assess physical activity, with a low score indicating low physical activity (18). If the participants met one or two criteria of Fried's criteria, they were classified as physical pre-frailty while more than three criteria classified as physical frailty.

Therefore, the classification of cognitive frailty groups was divided into three categories; robust with absence of mild cognitive impairment and physical frailty, pre-cognitive frailty and cognitive frailty (2). However, in this paper, the pre-cognitive frailty and cognitive frailty status were categorised into the same group.

Statistical Analyses

Data was analyzed using Statistical Package for Social Sciences (SPSS) Version 26.0. The Kolmogorov-Smirnov test and skewness were used to determine the normality of the data. Descriptive statistics were used to analyze the nutrients intake. Parametric tests were used to analyze normal data and non-parametric tests were used for non-normal data distribution. Chi Square and Fisher's Exact Test were used for categorical data and Independent Sample T and Mann-Whitney U test for continuous data, comparison of sosiodemographic and anthropometric data with gender, the eDII category, pro-inflammatory and anti-inflammatory food groups with cognitive frailty status were made. The results were expressed as n (%), mean ± standard deviation or median (Interquartile Range). Additionally, Pearson's and Spearman's correlation tests were used to assess the correlation between pro-inflammatory, anti-inflammatory and eDII scores with anthropometric and nutrient profiles. These data were expressed as r values. Significance values were set at alpha <0.05 for all tests.

RESULTS

A total of 158 participants (66.7 ±5.2 years old) residing in Klang Valley were involved in this study. As shown in Table I, most participants were females (57.0%), Malays (88.6%), married (56.3%), attained secondary education level (51.3%), retired (49.4%), non-smoker (75.3%), living in urban areas (72.8%) and had household income of RM 1000 (RM 1425). Cognitive Frailty (CF) was detected among 48.1% of the participants, with prevalence in females (58.9%) was significantly higher than male (33.8%) (p<0.05). Table II shows the anthropometry profile according to gender where the majority of the participants were in the overweight BMI category (45.6%), with females (55.6%) having significantly higher BMI than male participants (23.4%)(p<0.05). According to Table III, the comparison of nutrient intake, recommended intake, and RNI percentage for both genders revealed that nutrient

Table I: Sociodemographic Profile According to Gender

Parameter	Mean ± SD / Median (IQR) / n (%)			
	Male (n=68)	Female (n=90)	Tatal (n=158)	*p* Value
Race[a]				.80
Malay	59 (86.8)	81 (90.0)	140 (88.6)	
Chinese	4 (5.9)	3 (3.3)	7 (4.4)	
Indian	5 (7.4)	6 (6.7)	11 (7.0)	
Age (year)[c]	67.1 ± 5.6	66.3 ± 5.0	66.7 ± 5.2	.51
Marital Status[a]				<.001**
Single/Widow/Widower	8 (11.8)	61 (67.8)	69 (43.7)	
Married	60 (88.2)	29 (32.2)	89 (56.3)	
Education Level[b]				.004**
No Education	1 (1.5)	7 (7.8)	8 (5.1)	
Primary	17 (25.0)	35 (38.9)	52 (32.9)	
Secondary	37 (54.4)	44 (48.9)	81 (51.3)	
Tertiary	13 (19.1)	4 (4.4)	17 (10.8)	
Working Status[a]				.045*
Unemployed	15 (22.1)	33 (36.7)	48 (30.4)	
Retired	34 (50.0)	44 (48.9)	78 (49.4)	
Working	19 (27.9)	13 (14.4)	32 (20.3)	
Household income (RM)[d]	1350 (1675)	1000 (800)	1000 (1425)	.005**
Living area[a]				.59
Urban	51 (75.0)	64 (71.1)	115 (72.8)	
Rural	17 (25)	26 (28.9)	43 (27.2)	
Family History of Dementia[a]	63 (92.6)	82 (91.1)	145 (91.8)	.73
No	5 (7.4)	8 (8.9)	13 (8.2)	
Yes				
Family History of Traumatic Brain Injury (TBI)[a]				.27
No	61 (89.7)	85 (94.4)	146 (92.4)	
Yes	7 (10.3)	5 (5.6)	12 (7.6)	
Smoking Status [b]				<.001**
Smoker	19 (27.9)	2 (2.2)	21 (13.3)	
Ex-Smoker	17 (25.0)	1 (1.1)	18 (11.4)	
Non-Smoker	32 (47.1)	87 (96.7)	119 (75.3)	
Cognitive Frailty Status[a]				
No	45 (66.2)	37 (41.1)	82 (51.9)	.002**
Yes	23 (33.8)	53 (58.9)	76 (48.1)	

a - Chi Squared Test
b - Fisher's Exact Test
c - Independent Sample T-Test
d - Mann-Whitney U Test
Note: *Significant at p<0.05, **Significant at p<0.01

Table II: Anthropometry Profile According to Gender [Stated as n (%) or meanSD]

Anthropometry Measurement	Mean±SD / n (%)			*p* Value
	Male (n=68)	Female (n=90)	Total (n=158)	
Height (cm)[a]	163.1±5.5	150.62±5.9	156.0±8.4	0.00*
Weight (kg)[a]	67.7±12.6	64.4±11.5	65.8±12.1	0.09
Body Mass Index (BMI), (kg/m²)[a]	25.4±4.3	28.4±4.9	25.9±4.0	0.00*
BMI Category [b]	17 (25.0)	7 (7.8)	24 (15.2)	.002*
Underweight (<22 kg/m²)	29 (42.6)	33 (36.7)	62 (39.2)	
Normal (22-27 kg/m²)	22 (32.4)	50 (55.6)	72 (45.6)	
Overweight (27 kg/m²)				

a. Chi Squared Test
b. Independent Sample T Test
***Note:** Significant at p<0.05

intake in older adults were below recommended intake, excluding vitamin A, C, and fat (RNI 2017) (19). Meanwhile, the average mean energy, protein, carbohydrate, riboflavin, and sodium intake (≥65 years old) were adequate. Nonetheless, the average mean intake of fat, vitamin A, C, iron, and sodium (men aged 60 - 65 years old) exceeded the RNI recommendation.

In regards to association between anthropometry profile and empherical Dietary Inflammatory Index (eDII) (Table IV), there was a weak positive association between weight (r=0.03) and BMI (r=0.05), however the association was not significant. A significant weak correlation can be seen between energy (r=0.22) (p<0.01), protein (r=0.23)(p<0.01), carbohydrates (r=0.19)(p<0.05) and fat (r=0.19)(p<0.05) with pro-inflammatory score, indicated that a higher increase in energy and intake of macronutrients resulted in a higher inflammatory response. Subsequently, Table V shows a negative correlation between eDII score and nutrient intake for protein (r = -0.16) (p < 0.05), vitamin C (r = -0.16) (p<0.05) and niacin (r = -0.16) (p<0.05). Furthermore, eenergy, carbohydrates, fat, vitamin A, thiamine, riboflavin, calcium, iron and zinc also showed a negative correlation while sodium which was found to have a positive correlation with score of eDII, however, it was not significant.

Total eDII scores were found to be in the range of +3 to -6. The data for moderate eDII score category were combined with high eDII score category (Table VI). A higher percentage of CF was classified as consuming a diet with moderate to high inflammatory risk (53.9%) as compared to non CF older adults (53.7%), nevertheless the association was not significant. With respect to the pro- and anti-inflammatory food groups with cognitive status (Table VII), percentage of consumption in bread or noodle over 7 times per week and white rice over

Table IV: Pro-Inflammatory, Anti-Inflammatory and eDII Score with Anthropometry Profile (Stated as r value)

Parameter	Pro-Inflammatory Score		Anti-Inflammatory Score		eDII Score	
	r	p	r	p	r	p
Weight[a]	-0.10[r]	0.19	0.12[r]	0.14	0.03[r]	0.68
Height[a]	-0.05[r]	0.54	0.005[r]	0.96	-0.03[r]	0.74
BMI[a]	-0.07[r]	0.36	0.11[r]	0.16	0.05[r]	0.54

a. Pearson's Correlation
r. Correlation
Nota: *Significant at p<0.05

Table III: Nutrient Intake, Recommendation and RNI Percentage According to Gender

Nutrient	(Mean±SD) / n (%)								
	Male (n=68)			Female (n=90)			Total (n=158)		
	Intake	Recommendation	%RNI	Intake	Recommendation	%RNI	Intake	Recommendation	%RNI
Energy[a] **(kcal)**	1346±412	1780	75.6	1164±327	1550	75.1	1164 - 1346	1550 - 1780	75.1 - 75.6
Protein (g/day)	53.9±18.1	58	92.9	48.0±17.9	50.0	96.0	48.0 - 53.9	50 - 58	92.9 - 96.0
Carbohydrate[a] **(g/day)**									
60 - 65 years	179.8±54.5	222.5	80.8	162.2±48.2	193.8	83.7	162.2 - 179.8	193.8-222.5	80.8 - 83.7
>65 years	195.9±62.6	267	73.4	163.1±41.0	232.5	70.2	163.1 - 195.9	164.1 - 267	70.2 - 73.4
Fat [a] **(g/day)**									
60 - 65 years	41.50±15.1	39.6	104.8	35.7±12.9	34.4	103.8	35.7 - 41.50	36.6 - 39.6	103.8-104.8
>65 years	42.8±18.6	59.3	72.2	36.2±16.4	51.7	70.0	36.2 - 42.8	51.7 - 59.3	51.7 - 72.2
Vitamin A (µg/day)	862.0±421.9	600	143.7	779.3±473.3	600	129.9	779.3 - 862.0	600	129.9 - 143.7
Vitamin C (mg/day)[b]	114.2±81.0	70	163.1	89.8±56.6	70	128.3	70.0 - 114.2	70	128.3 -163.1
Thiamine (mg/day)[b]	0.72±0.31	1.2	60	0.63±0.21	1.1	57.3	0.63 - 0.72	1.1 - 1.2	57.3 - 60.0
Riboflavin(mg/day) [b]	1.1±0.48	1.3	84.6	1.0±0.48	1.1	90.9	1.0 - 1.1	1.1 - 1.3	84.6 - 90.9
Niacin (mg NE/day)[b]	8.7±3.8	16	54.4	7.3±3.8	14	52.1	7.3 - 8.7	14 - 16	52.1 - 54.4
Calcium (mg/day)[b]	342.0±155.0	1000	34.2	349.9±194.6	1200	29.2	342.0 - 349.0	1000 - 1200	29.2 - 34.2
Zinc (mg/day)[b]									
60 - 65 years	3.3±2.7	6.2	53.2	2.7±1.9	4.3	62.8	2.7 - 3.3	4.3 - 6.2	53.2 - 62.8
>65 years	3.3±1.8	6.3	52.4	2.9±1.6	4.4	65.9	2.9 - 3.3	4.4 - 6.3	52.4 - 65.9
Iron (mg/day)	10.2±4.0	9.0	113.3	9.1±3.6	8.0	113.8	9.1 - 10.2	8.0 - 9.0	113.3 - 113.8
Sodium (mg/day)[b]									
60 - 65 years	1277.5±918.9	1200	106.5	1026.0±567.3	1200	85.5	1026.0 - 1277.5	1200	85.5 - 106.5
>65 years	1226.9±601.6	1500	81.8	1099.2±472.8	1500	73.3	1099.2 - 1226.9	1500	73.3 - 81.8

a. Independent Sample T-Test
b. Mann-Whitney U Test

Table V: Pro-Inflammatory, Anti-Inflammatory and eDII Score with Nutrient Intake (Stated as r value)

Parameter	Pro-Inflammatory Score		Anti-Inflammatory Score		eDII Score	
	r	p	r	p	r	p
Energy[a]	0.22[r]	.006**	-0.31[r]	.000**	-0.12[r]	.14
Protein[a]	0.23[r]	.004**	-0.37[r]	.000**	-0.16[r]	.04*
Carbohydrates	0.19[r]	.019*	-0.25[r]	.002**	-0.09[r]	.25
Fat[a]	0.19[r]	.018*	-0.25[r]	.001**	-0.10[r]	.24
Vitamin A[b]	0.28[r]	.000**	-0.27[r]	.001**	-0.06[r]	.46
Vitamin C[b]	0.04[r]	.62	-0.20[r]	.012**	-0.16[r]	0.05*
Thiamine[b]	0.20[r]	.013*	-0.23[r]	.004**	-0.09[r]	0.25
Riboflavin[b]	0.19[r]	.017*	-0.19[r]	.019*	-0.05[r]	.51
Niacin[b]	0.10[r]	.20	-0.28[r]	.000**	-0.16[r]	.04*
Sodium[b]	0.20[r]	.013*	–0.10[r]	.22	0.04[r]	0.66
Calcium[b]	0.09[r]	.28	-0.09[r]	.25	-0.04[r]	.65
Iron[b]	0.20[r]	.011*	-0.22[r]	.005**	-0.07[r]	.39
Zinc[b]	0.31[r]	.000**	-0.27[r]	.000**	-0.03[r]	.71

a. Pearson's Correlation
b. Spearman's Correlation
r. Correlation
Note: *Significant at p<0.05; **Significant at p<0.01

Table VI: Mean and Standard Deviation for Pro-Inflammatory, Anti-Inflammatory, eDII Score and eDII Category with CF Status

Parameter	Mean±SD / n (%)			*p* Value
	Cognitive Frailty (n=76)	Non-Cognitive Frailty (n=82)	Total (n=158)	
Pro-Inflammatory [a]	2.07 ± 1.10	2.06 ± 1.14	2.06 ± 1.12	0.98
Anti-Inflammatory [a]	-3.33 ± 1.60	-3.33 ± 1.40	-3.33 ± 1.50	0.99
Total eDII Score[a]	-1.26 ± 1.81	-1.27 ± 1.78	-1.27 ± 1.79	0.99
eDII Category[b]				0.97
Low (-9, -2)	35 (46.1)	38 (46.3)	73 (46.2)	
Moderate to High (-1,10)	41 (53.9)	44 (53.7)	85 (53.8)	

a - Independent Sample T Test
b - Chi Squared Test
Note: *Significant at p<0.05

3 bowls per week was higher among CF compared to non-CF older adults (52.6% and 22.4%, 24.1% and 8.5% respectively). However, only white rice from the pro-inflammatory food group showed a significant association. CF older adults are more likely to consume a pro-inflammatory diet (mean 2.07±1.10) as compared to non-CF (mean 2.06±1.14), particularly significantly higher intake from the white rice food group (≥ 3 bowls/day) (22.4%) as compared to the non CF (8.5%)(p <0.05).

DISCUSSION

In this study, almost half of the participants were categorised as cognitive frailty (48.1%) which 9.5% of them were cognitively frail while 38.6% were cognitively pre-frail. This was supported by local research that conducted in LRGS-Towards Useful Ageing (TUA) cohort study (2). However, this figure was higher than other studies, ie. Singapore Longitudinal Ageing Study (SLAS-1 and SLAS-2) (7.1%) (20), and a cross sectional study in Thailand (28.72%) (21). Discrepancy could be due to the fact that our samples were mostly from urban areas with low socioeconomic status.

Table VII: Pro-Inflammatory and Anti-Inflammatory Food Group with CF Status

Parameter		n (%)			
		Cognitive Frailty (n=76)	Non-Cognitive Frailty (n=82)	Total (n=158)	*P* Value
Pro-Inflammatory Food					
Red meat, processed meat, organ meat	< 2 times/week	62 (81.6)	63 (76.8)	125 (79.1)	.69[b]
	2-6 times/week	14 (18.4)	18 (22.0)	32 (20.3)	
	≥ 7 times/week	0 (0)	1 (1.2)	1 (0.6)	
Other fish, eggs, SSB, tomatoes	< 5 times/week	29 (38.2)	25 (30.5)	54 (34.2)	.60[a]
	5-6 times/week	8 (10.5)	10 (12.2)	10 (12.2)	
	≥ 7 times/week	39 (51.3)	47 (57.3)	86 (54.4)	
White Rice	< 3 bowls/day	59 (37.3)	75 (91.5)	134 (84.8)	.016*[a]
	≥ 3 bowls/day	17 (22.4)	7 (8.5)	24 (15.2)	
Bread/Noodles	< 7 times/week	36 (47.4)	44 (53.7)	80 (50.6)	.43[a]
	≥ 7 times/week	40 (52.6)	38 (24.1)	78 (49.4)	
Anti-Inflammatory Foods					
Leafy green vegetables	< 7 times/week	23 (30.3)	26 (31.7)	49 (31)	.91[a]
	7-13 times/week	36 (47.4)	36 (43.9)	72 (45.6)	
	≥14 times/week	17 (22.4)	20 (24.4)	37 (23.4)	
Dark yellow vegetables	< 5 times/week	62 (81.6)	68 (82.9)	130 (82.3)	.50[a]
	5-6 times/week	7 (9.2)	10 (12.2)	17 (10.8)	
	≥ 7 times/week	7 (9.2)	4 (4.9)	11 (7)	
Fruit juice, oily fish	< 2 times/week	16 (21.1)	15 (18.3)	31 (19,6)	.90[a]
	2-4 times/week	36 (47.4)	41 (50)	77 (48.7)	
	≥5 times/week	24 (31.6)	26 (31.7)	50 (31.6)	
Coffee, tea	< 1 cup/day	24 (31.6)	19 (23.2)	43 (27.2)	.23[a]
	1 cup/day	27 (35.5)	40 (48.8)	67 (42.4)	
	≥ 2 cups/day	25 (32.9)	23 (28.0)	48 (30.4)	
Wine	< 2 glass/week @>21 glass/week	76 (100)	82 (100)	158 (100)	-
	2-6 glass/week	0 (0)	0 (0)	0 (0)	
	7-20 glass/week	0 (0)	0 (0)	0 (0)	
Beer or other alcohol beverages	< 5 bottle/week @>bottle/week	76 (100)	82 (100)	158 (100)	-
	5-6 bottle/week	0 (0)	0 (0)	0 (0)	
	7-13 bottle/week	0 (0)	0 (0)	0 (0)	

a - Chi Squared Test
b - Fisher's Exact Test
Note: *Significant at p<0.05

The analysis for this study also focused on identifying the subject's daily nutrient intake as well as meeting the recommended nutrient intake for both genders based on the Recommended Nutrient Intake (RNI) 2017. It was discovered that nutrient intake of thiamine, niacin, calcium and zinc in older adults was lower than the recommended intake for both genders and these were in line with previous studies (22,23). Niacin, thiamine, and riboflavin is a potential biomarker for detecting the presence of CF in older adults. These vitamin B were essential co-enzymes in catabolic energy production, fatty acids and amino acids that contribute to citric acid cycle (24). Their insufficiencies cause individuals to develop neurological deficits leading to dementia (25,26). Lower intake of thiamine, riboflavin and niacin indicated a more severe CF in older adults (2).

Calcium intake among older adults was report to have low intake (≤300 mg/day) for both genders. They found that countries in South, East and Southeast Asia also had low calcium intake (< 400 mg/day), with more countries accumulating in Asia Pacific especially in older adults (27). The factors contributing to this were possibly due to lack of appetite, lack of money, and lack of knowledge (28). All of the aforementioned factors are the reason for the older adult's to have decreased intake of nutritious foods.

Nevertheless, an average mean intake of energy, protein, carbohydrate, riboflavin, and sodium intake (≥65 years old) met the requirement set by RNI. Moreover, the average mean intake of fat, vitamin A, C, iron, and sodium (men aged 60 - 65 years old) exceeded the RNI recommendation. Fat intake is one of the risk factors for decline in cognitive function among older adults (29). Other than that, food high in fat, refined carbohydrates and lack of physical activity with unhealthy lifestyle were a well-known factor in increasing metabolic syndrome among older adults (30).

Our findings also showed that the intake of vitamin A and iron among older adults are high, which contradicts previous research that claimed the intake of vitamin A and iron for older adults with CF was low (31). We presumed that these nutrients were high due to large consumption of fish and eggs food group as evidenced in eDII food checklist. According to Monteiro et al. (2010), the higher the BMI value, the lower the iron intake and this might be due to the inflammatory status present in obese subjects and have an association between iron intake and other disorders that could cause cognitive decline, such as Parkinson's disease (32). Interestingly, research done by Shi et al. (2019) stated that the high intake of iron has an association with lower cognitive. There is no established amount of high iron intake that could lead to cognitive decline as a limited number of studies on iron intake related to cognitive function in Asia. However, this longitudinal study among Chinese older population discovered that approximately more than 30% of iron intake more probably to have poor cognitive abilities (33).

According to our findings, high intake of vitamin C may be due to high intake of frequency and portion size of fruits rich in vitamin C content, such as guava, orange and papaya. However, the high vitamin C intake is most likely due to overestimation or over-reporting of food intake (34). Furthermore, it was found that taking slightly higher doses of vitamin C does not harm the individual's body because the bioavailability absorption of vitamin C is low and the excess will be excreted from the body through urine (35).

In this study, female participants showed a significantly higher presence of CF and BMI than male participants. This is consistent with other research where increasing age female older people linked with obesity, reduced grip strength, gait speed and depression (36,37). Increase of weight and BMI showed weak positive correlation with empherical Dietary Inflammatory Index (eDII) score, but the association was not significant. On the other hand, a significant weak correlation can be seen between energy and macronutrients (protein, carbohydrates and fat) intake with pro-inflammatory scores, indicating that a higher energy and intake of macronutrients resulted in higher inflammatory response. High calorie and macronutrients intake caused excessive accumulation of fats and circulating fatty acids in the body, triggering pro-inflammatory responses and leading to low grade chronic inflammation, insulin resistance and eventually cognitive decline among older adults (38,39).

However, there is a negative correlation in comparison between nutrients and eDII with significant values for protein, vitamin C and niacin. Hypothesis can be made that the higher the intake of vitamin C and niacin will lower the eDII score. According to McCall et al. (2019), vitamin C has strong antioxidants and cannot be synthesized by the human body due to the lack of an enzyme known as gluconolactone oxidase (40). Thus, lack of vitamin C plays a role in the dysfunction of neurodegenerative and relates to cognitive impairment, depression and confusion (41). Previous research stated that the intake of vitamin C has a close association with cognitive impairment (41).

Subsequently, the lack of niacin intake by 1 mg will have an increase the risk of getting cognitive frailty by 6% and can cause diseases such as pellagra (19). Pellagra can occur as a result of a niacin deficiency and can affect the neurology, manifesting as dementia overtime (19). Further research also revealed that, niacin has a therapeutic effect on depression and that is often accompanied by cognitive frailty (42). Therefore, the research conducted by Malek Rivan et al. (2019) concluded that niacin is likely to be a potential biomarker of cognitive frailty among older adults (2).

In addition, higher DII scores were associated with lower cognitive function such as working memory, processing speed, attention and verbal semantic fluency among community-dwelling older people (43). Those who consumed a pro-inflammatory diet indicated by higher eDII mean score and categorized by moderate to high eDII score, had increased risk for cognitive frailty than the robust group, nevertheless the association was not significant. Several studies also indicated that significant associations between higher Dietary Inflammatory Index (DII) scores with lower cognitive functions among older adults (39,44).

With respect to the food group, this current study found that higher frequency intake of the pro-inflammatory food group of white rice increased the risk of cognitive frailty among older adults. Interestingly, consumption of white rice in Southeast Asia countries including Malaysia, is seen to be significantly higher than other countries (45). Besides that, white rice is one of the main staple foods commonly eaten twice daily by Malaysian adults (45). This result is supported by studies on dietary patterns in Korea that showed the intake of "white rice pattern" was positively associated with increased risk of cognitive impairment among the Korean older adult population (46). Consumption of refined carbohydrates, such as white rice that have a high pro-inflammatory potential, could increase the level of inflammation

and is associated with an increased risk of mild or moderate cognitive impairment among older adults (47). Consequently, it could increase the risk of dementia and Alzheimer's disease (47). The portion size of white rice that linked to the inflammation is inconsistent however, recent finding indicated that consumption of white rice more than 14 times per week was correlated with the risk of mild cognitive impairment (48).

According to Ricker & Haas (2017), consumption of food from refined carbohydrate sources with high glycemic levels is one of the main nutritional factors that influence inflammation (49). The frequency of high carbohydrate intake can result in chronic hyperglycemia, which in turn increases the production of free radicals and causes a pro-inflammatory status in the body. Refined carbohydrates contained lower fiber and nutrients. On the contrary, whole grains are rich sources of antioxidants and bioactive and have been scientifically proven to have positive benefits including decreasing inflammation markers. In fact, glucose is the main energy source utilized by the brain, and therefore most preferably whole and enriched grains should be the main carbohydrate sources that are important and beneficial for the brain functioning (50).

Other pro- and anti-food groups do not show any significant association with cognitive status among elderly. However, further studies are needed to study between dietary food groups and inflammation with cognitive frailty status among older adults.

There are some limitations in the study and one of them is the small sample size, which found that the percentage of non-CF participants was higher than the percentage of CF participants. This is due to Malaysia having only 2.2 percent prevalence of older adults with CF. As a result, our findings are more focused on non-CF participants, and several studies contradicted our findings.

Following that, some nutrient data evaluated using the Nutritionist Pro (NutriPro) application can be said to be overestimated or underestimated due to nutritional information in the application's database being incomplete. For example, even though previous studies have shown that palm oil contains a high vitamin E content, the vitamin E content does not show any value. In addition, the nutrient intake between vitamin A, C, thiamine, riboflavin and niacin must be taken as recommended because it plays a significant role in reducing the chances of developing cognitive frailty (2, 24). Among other constraints, data collection in urban areas was greater than in non-urban areas. As a result, most participants living in cities consumed more anti-inflammatory foods than pro-inflammatory foods.

CONCLUSION

In conclusion, this study highlighted that cognitive frailty (CF) in older adults are more likely to consume a pro-inflammatory diet particularly from the rice food group. CF was detected among 48.1% of the participants, with females significantly higher than male. In terms of nutritional intake, both genders consumed higher fat, vitamins A, C, iron, and sodium, while thiamin, niacin, calcium, and zinc intake are low. Larger intakes of energy and macronutrients led to a greater inflammatory response, but higher intakes of vitamin C and niacin were associated with lesser inflammatory response. Food groups, rather than nutrients, may suggest promising overall outcomes of cognitive frailty among older adults. For future research, there is a need to further assess the risk of consuming a pro-inflammatory diet among older adults using larger sample size and appropriate biomarkers.

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