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Nutritional, Physical and Cognitive Status among Pre-Frail and Frail Malaysian Older Adults

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ABSTRACT

Introduction: Frailty is related to physical function, nutritional status, and cognition; however, these factors are rarely investigated comprehensively in a single study. Thus, this study aimed to examine the differences in nutritional, physical and cognitive function among frail, pre-frail and robust Malaysian elderly. **Methods:** A total of 473 participants were randomly selected from ten different areas in Klang Valley by multistage random sampling. Frailty was characterised using the Fried criteria. Anthropometric measurements, diet intake, body composition, and physical and cognitive function were assessed. Kruskal Wallis test was employed to examine the relationship between the independent variables and frailty. **Results**: Frail subjects had significant higher body mass index (26.8±4.4kg/m^2) compared to pre-frail (25.7±4.4 kg/m^2) and robust (24.9±3.9kg/m^2), (p<0.05). The same trend was found in waist circumference, an indicator for abdominal obesity. On the other hand, calf circumference, fat free mass, and basal metabolic rate (BMR) were lower in frail subjects (p<0.05 for all parameters). In fact, calf circumference in frail, pre-frail and robust groups were 34.6±3.6 cm, 34.5±3.6 cm and 35.6±5 cm, respectively (p<0.05). Frail subjects had the highest hours of overnight fasting and percent of energy intake and the poorest physical and cognitive performance compared to the other groups (p<0.05 for all parameters) **Conclusion:** Frail subjects are being categorised as obese with high fat intake but had muscle wasting and longer overnight fasting, together with known poor physical function and cognitive status. There is a need to strategically prevent frailty through a comprehensive diet, physical function and cognitive training.

Key words: Frailty, nutritional status, physical functions, cognitive function, elderly

INTRODUCTION

Frailty is an emerging geriatric syndrome with important implications for the care of the older population (Wou & Conroy, 2013). Pathologically, it is defined as a consequence of biological changes related to aging and the occurrence of one or more chronic conditions and one of its complications includes functional impairment (Pijpers *et al.*, 2012). Frailty

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can be categorised based on its different pathogenesis into physical, cognitive and psychological frailty. Physical frailty is manifested as a reduction in body strength and physiological functions that may lead to physical impairment, disability and death (Morley *et al.*, 2013); Ruan *et al.*, 2014). Frailty has been viewed in two main ways in the literature: as a syndrome e.g. frailty phenotype approach introduced by Fried and colleagues (Fried *et al.,* 2001) and as a state of pathological changes, i.e. frailty index approach (Mitnitski, Mogilner & Rockwood, 2001). In both approaches, physical functional impairment and nutritional status are among the main domains of frailty definition.

The association between frailty and functional impairment is expected because the deterioration in the pre-requisites of physical function such as muscle strength, endurance and power can lead to frailty in older adults. The main domains of this type of frailty are fatigue, decreased muscle strength, slowness, low physical activity weight loss (Fried *et al.*, 2001; Morley et al., 2013), level of dependency and low respiratory function (Mitnitski *et al.*, 2001).

Cognitive impairment is also one of the frailty domains in a few frailty assessment tools (Mitnitski *et al.*, 2001). Cognitive impairment has been identified as a distinct type of frailty, namely cognitive frailty (Panza *et al.*, 2006). The documented relationship between cognitive impairment and physical dysfunction is disability with increased risk of death. Physical and cognitive impairments are associated with poor prognosis in age related disorders (Panza *et a*l., 2006; Ruan *et al.*, 2014).

In relation to nutritional status, shrinking (unintentional weight loss) was among the phenotypes in the Fried criteria (Fried *et al.,* 2001), while improper body weight was among the deficits in the frailty index (Mitnitski *et al.*, 2001). Although a significant relationship between body weight and frailty has been reported in the literature, other parameters of nutritional status assessment such as diet intake or body composition (Manal, Suzana & Singh, 2015) have not been adequately studied. Normal body composition is an important factor to prevent frailty. Increased energy intake without an increase in physical activity can result in adiposity and sarcopenia leading to frailty. Only a handful of studies included nutritional parameters in describing frailty. An example is an early study by Engelheart, Lammes & Akner (2006) that investigated the relationship between frailty, number of meals, meal dispersion within the day and hours of overnight fasting. Meanwhile Beasley *et al.* (2010) reported that a diet higher in protein is associated with lower risk of frailty. In another study by Bartali *et al.(*2006), a diet lower in calories (less than 21kcal/kg/day) and lower in at least three micronutrients intake has been reported to be associated with a higher risk of frailty.

Although an association between frailty, nutritional status, and cognitive and physical function have been highlighted, all these aspects have rarely been studied comprehensively in a single study. Thus the aim of this cross-sectional study was to examine the differences in the nutritional, and physical and cognitive function in frail and pre-frail Malaysian older adults compared to the robust group.

METHODS

This study is the baseline data of a larger prospective community-based study investigating a neuro-protective model for healthy longevity among Malaysian elderly (LRGS TUA-LRGS-TUA: Long-term Research Grant Scheme - Towards Useful Aging, a 4-year longitudinal nationwide Malaysian study) as published earlier (Shahar *et al.*, 2015). It was conducted in 10 urban and rural districts in the Klang Valley, Malaysia. These districts were

selected as the study locations specifically because older adults formed 10% or more of the total population in these areas as indicated by data from the Malaysian Statistics Department. The study utilised a multistage random sampling method (stage one: selection of the states, stage two: random selection of the census circles, stage three: random selection of the living quarters, then random selection of the participant's names). This sampling method was conducted in order to recruit a representative sample of community-dwelling older individuals living in the aforementioned ten districts and comprising the three main ethnic groups (Malays, Chinese and Indians). The sample size was calculated using Cochran formula for prevalence studies. Prevalence of frailty was taken from a previous similar study conducted by Chen *et al.* (2010) to determine the prevalence and risk factors of frailty among elderly people in Taiwan.

Age 60 years and above was used to define older adults as Malaysia officially uses the '60 years and above' in deliberating ageing trends (Mohammad & Abbas, 2012). A few days prior to data collection commencement, the research team members scouted the selected areas to hand the invitation cards to selected participants. Written and verbal information was provided during this visit. Individuals with self- or caregiver-reported mental or terminal illnesses, current fractures of the extremities, neurological or neuromuscular disorders were excluded from the final analysis. The collected data included socio-demographic status, medical history, nutritional status, body composition, physical and functional status and cognitive function. Recruitment of the subjects took place from July 2012 to February 2013. Ethical approval for the study was obtained from Universiti Kebangsaan Malaysia Research Ethical Committee (Ref No.: UKM 1.5.3.5/244/ NN-149-2013).

Frailty assessment was done using Fried criteria(Fried *et al.,* 2001), which is well-known in clinical research and widely used in frailty assessment (Rockwood, Andrew & Mitnitski, 2007). It was developed in a very large prospective study conducted by Fried *et al. (*2001). This tool categorises the subjects into three categories: robust, pre-frail and frail. Researchers also standardised the method for assessing the five criteria. (1) Shrinking, defined as losing around 5kg in the last year unintentionally (i.e. not due to diet or exercise). (2) Self-report of exhaustion, defined by using two items of the CES-D Depression scale: (a) I felt that everything I did was an effort; and (b) I could not get going; (the question was how often in the last week did you feel like this (rare=0, some or little time (1-2 days)=1, moderate (3-4 days)= 2, most of the times= 3). Subjects who scored two and above were categorised as frail based on the exhaustion criteria. (3) For the low physical activity, the Fried *et al.* (2001) Minnesota Leisure Time Activity questionnaire is usually used. However, in this study, low physical activity was assessed using Physical Activity Scale for Elderly (PASE), and low physical activity identified by low scores (in the lowest tertile) of the PASE score (Yi, 2015). (4) Slowness was defined using the five-metre walking time using gait speed test that is more than the cut-off point mentioned in the original reference adjusted for gender and height. (5) The last criterion is weakness. It was defined using hand grip strength test less than the cut-off points mentioned in the original reference adjusted for gender and body mass index). This assessment tool was used in the study to get a categorical description of frailty; subjects were categorised into three groups according to their frailty status.

Nutritional status assessment was done using anthropometric measurements including weight, height, mid-upper arm circumference (MUAC), calf circumference

(CC), waist circumference and hip circumference. All measurements were taken twice using a standard method as reported in an earlier study (Lee & Nieman, 1993). A validated diet history questionnaire was used to determine the habitual food intake that included main and snack meals (Shahar, Earland, & Abdulrahman, 2000). Participants were also asked about duration of overnight fasting and meals dispersion (number of main and snack meals), food satisfaction, and eating with company. Body composition was measured using bio electrical impedance portable instruments (Korean brand, model Inbody S10®). Data about body fat percentage, lean body mass, skeletal muscle and basal metabolic rate were extracted from the machine output.

Comprehensive geriatric functional assessment included activity of daily living, instrumental activity of daily living and senior fitness test**.** Senior fitness test included assessments of 2-min step (endurance), hand grip and shoulder strength (upper body strength), chair stand (lower body strength), stretch and reach (lower body flexibility), back scratch (upper body flexibility), time up and go (balance and mobility), normal and rapid pace gait speed and peak flow (respiratory function). Activity of Daily Living (Shelkey & Wallace 1998) and Instrumental activity of Daily Living (Lawton & Brody 1969) were also administered. Cognitive function was assessed using Mini Mental Status Examination (MMSE), using the validated Malaysian version (Ibrahim *et al*., 2009).

Statistical analysis

All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) software, version 21.0. An alpha level of (0.05) was considered for all the statistical tests in the study. Two-sided *p* values of 0.05 and 80% power were considered to be statistically significant. Normality of the data was established. The prevalence of frailty was calculated by descriptive analysis, the association between frailty status and gender was determined by Chi square test. The differences in the median ranks between the three groups (frail, pre-frail and normal) were tested using Kruskal Wallis test as the data was not normally distributed.

RESULTS

More than 600 subjects were invited to join the study. A total of 473 participants (n= 210 (44.4%) men and n=263 (55.6%)

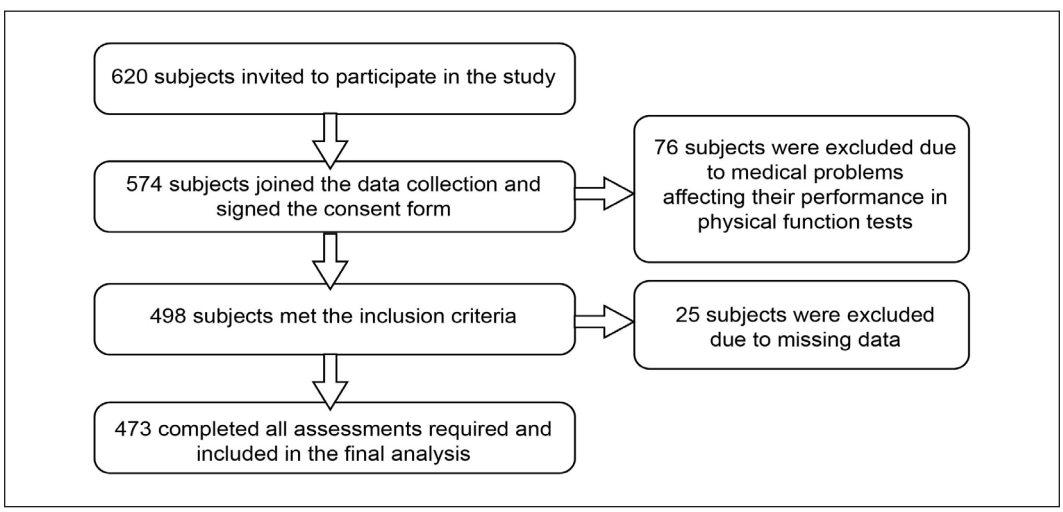

Figure 1. Subjects recruitment flow chart

women) were included in the final analysis (response rate 92%), as shown in Figure 1. The mean age of the participants was 68±5.9 years, with the range being 60 to 90 years old. The majority of the participants were Chinese (52%); married (75.3%); had primary education level (42.9%); and able to read and write (86.7%). Only 21% of participants lived alone, while the rest stayed with families. Men had a significantly higher mean of years of schooling, and higher economic status level indicated by monthly income compared to women (p<0.01). Women had a higher percentage of being single (3.8%) and widow (31.9%), compared to men (1% and 7.1%) respectively (p<0.01). Men had a significantly higher percentage of smoking and consuming alcohol behaviour compared to women (p<0.001). The most commonly reported comorbidity was hypertension (55.6%), followed by dyslipidaemia and diabetes mellitus (32.1%). Generally, 45% of the participants had normal weight, 35.5% were overweight, 16.3% were obese, whilst only 2.3% were underweight. Muscle wasting as assessed by calf circumference and mid-upper arm circumference was 3% and 2.3%, respectively.

Overall, frailty prevalence was 8.9%, with significantly higher prevalence among women (11.8%) compared to men (5.2%). Among the socio-demographic variables, females were associated with frailty [(OR=1.59 (95%, CI= 1.06-2.36), p<0.05)]. Frail subjects were found to be older than pre-frail and normal subjects (71±7, 68±9, 66±5, p<0.01) as assessed by the Kruskal Wallis test.

Nutritional status of participants based on frailty status

The results of the nutritional status profile based on frailty are as presented in Tables 1 to 3. The means of BMI and WC were significantly higher in frail participants compared to pre-frail and robust (p<0.05). On the other hand, calf circumference was significantly lower in frail and pre-frail participants compared to the robust group (p<0.05) (Table 1). Body composition and basal metabolic rate showed significant differences among the groups (p<0.05 for all parameters). Mean of percentage of body fat was higher in frail (42.5 ± 8.5%), followed by pre-frail (38.2 ± 7.9%) then robust(35.5±9.8 %)(p<0.01) group. On the other hand, lean body mass was lower in frail (33.4 ± 6.2%) followed by pre-frail(36.5± 7.5%)and robust group (38.4 ± 7.9%)(Table 2). With respect to diet intake, the percentage of calories from fat, number of total meals and hours of overnight fasting showed significant differences according to frailty status, (p<0.05). Mean percentage of calories from fat was significantly higher in frail participants (29.3%), followed by pre-frail (29.2%) and normal (25.9%) (p<0.05) (Table 3). Food sufficiency had a significant association with frailty status only in men with a significantly higher percentage of men reporting food insufficiency (all the time/ most of the time) (24%) being more likely to be frail compared to those with no such report (76%).

Physical and cognitive functional performance based on frailty status

As shown in Table 4, all the physical function parameters had significant relationships (p<0.05) with frailty status. Participants with frailty had a lower physical functional performance compared to pre-frail and robust groups in all of the physical function tests. With respect to ADL and IADL scores, participants with frailty scored significantly (p<0.05 for all parameters) but lower in comparison to those in the pre-frail and robust groups. In regard to cognitive function, MMSE scores were significantly higher in participants in robust (24.8 ± 4.0), followed by pre-frail (24.3 ± 4.6) and frail (22.5 ± 5.0) (p< 0.001 for all parameters) groups.

Table 1. Differences in anthropometric measurements according to frailty status and gender (mean±SD)

	Total (n=473)			*Men (n=210)*			*Women (n=263)*		
	Normal (n=139)	*Prefrail (n=292)*	*Frail (n=42)*	*Normal (n=73)*	*Prefrail (n= 126)*	*Frail (n=11)*	*Normal (n=66)*	*Prefrail (n=166)*	*Frail (n=31)*
Anthropometric									
BMI (kg/m2)	24.9±3.9	25.7±4.4	26.8±4.4*	24.1±3.6	25.6±3.8	27.1±3.7*	25.1±4.2	25.8±4.8	26.7±4.6
MUAC (cm)	29.0±4.2	29.2±3.4	29.8±3.1	29.5±4.8	29.4±2.9	30.6±3.3	28.5±3.4	29.1±3.8	29.4±2.9
WC (cm)	87.8±11.6	90.8±13.1	92.8±14.1**	89.9±11.3	94.9±12.6	97.3±13.2*	85.4±11.5	87.6±12.6	91.2±14.3
H C (cm)	99.1±9.5	99.5±9.5	100.9±10.1	98.2±8.2	98.6±8.3	100.1±7.9	100.0±10.8	99.9±10.3	101.3±10.8
CC (cm)	35.6±5.0	34.5±3.6	34.6±3.6*	36.8±6.0	35.2±3.4	35.4±3.8	34.4±3.3	34.1±3.6	34.3±3.5
Wc/Hc ratio	0.91±0.08	0.93±0.08	0.94±0.08	0.92±0.09	0.95±0.09	0.96±0.09*	0.91±0.07	0.91±0.08	0.93±0.08

* $p<0.05$ using Kruskal–Wallis test, ** $p<0.01$ using Kruskal–Wallis test.
BMI: body mass index; MUAC: mid upper arm circumference; WC: waist circumference; HC: hip circumference; CC: calf circumference.

Table 2. Differences in the body composition measurements according to frailty status and gender presented in (mean ± SD)

	Total			*Men*			*Women*		
	Robust (n=139)	*Prefrail (n=292)*	*Frail (n=42)*	*Robust (n=73)*	*Prefrail (n= 126)*	*Frail (n=11)*	*Robust (n=66)*	*Prefrail (n=166)*	*Frail (n=31)*
FM (kg)	22.8±8.2	24.5±8.9	26.9±9.1*	21.1±7.9	23.8±8.9	26.5±9.9	24.4±8.3	25.0±8.9	26.9±8.9
SLM (kg)	38.4±7.9	36.5±7.5	33.4±5.9**	44.5±6.5	43.0±5.7	41.2±5.7	32.4±3.6	31.7±4.4	30.7±3.1
FFM (kg)	40.5±8.4	38.4±7.9	35.2±6.2**	46.8±6.9	45.3±6.1	43.3±6.1	34.2±3.8	33.5±4.6	32.4±3.2
SMM (kg)	21.8±5.0	20.5±4.7	18.5±3.7**	25.6±4.1	24.6±3.6	23.5±3.5	17.9±2.3	17.5±2.7	16.9±1.9
SMI (kg/m2)	8.4±1.3	8.2±1.3	7.9±1.0	9.2±1.1	9.1±1.1	8.9±0.8	7.6±0.8	7.6±1.1	7.5±0.8
PBF	35.5±9.8	38.2±9.6	42.5±8.5**	30.4±8.5	33.5±8.4	36.9±9.8*	40.6±8.3	41.6±8.9	44.3±7.4
BMR (kcal)/day	1245±180	1200±170	1130±130**	1380±150	1350±130	1300±130	1110±80	1090±100	1070±70

* $p<0.05$ using Kruskal–Wallis test, ** $p<0.01$ using Kruskal–Wallis test.
FM: fat mass; SLM: soft lean mass; FFM: fat free mass; SMM: skeletal muscle mass; SMI: skeletal muscle index; PBF: percentage of body fat; BMR: basal metabolic rate.

Table 3. Dietary intake according to frailty status and gender (mean ± SD)

	Total			*Men*			*Women*		
Parameter	*Robust (n=139)*	*Prefrail (n=292)*	*Frail (n=42)*	*Robust (n=73)*	*Prefrail (n=126)*	*Frail (n=11)*	*Robust (n=66)*	*Prefrail (n=166)*	*Frail (n=31)*
Calories(kcal/ day)	1680±670	1630±480	1530±480	1750±480	1790±550	1780±690	1600±800	1500±370	1440±350
CHO (g/day)	222±72	214±67	192±53	246±76	237±74	201±53	195.7±56	196.7±55.6	188.7±53.9
CHO (% Kcal)	51±12.1	51.6±9.5	51.1±9.3	52±13	52±10	48±11	49.9±11.8	51.3±8.9	52.1±8.7
Protein (gm/day)	75.3±75.1	72.7±92.2	64.9±17.0	71±25	71±23	70±17	79.5±106	73.6±119	63.0±17
Protein % Kcal	20.3±12.1%	18.2±8.4	18.1±6.8	21±14	18±10	19±8	19.2±8.7	17.9±7.1	19.3±6.3
Fat (g/day)	54.1±29.4	54.6±21.6	55.8±36.9	53±19	58±25	77±27	55.4±37.7	51.7±17.8	47.9±15.9
Fat % Kcal	25.9±11.3	29.2±9.1	29.3±11.1*	25±11	28±10	31±18	27.4±11.7	30.1±8.6	28.6±8.7
Numbers of meals	4.0±0.8	3.7±0.9	3.6±0.8*	4.1±0.8	3.9±0.9	3.8±0.6	1.1±0.8	0.95±0.9	0.87±0.2
Hours of overnight fasting (hours)	11.8±1.3	12.0±1.4	12.4±1.7*	11.8±1.5	11.8±1.4	12.0±0.9	11.7±1.2	12.2±1.5	12.5±1.9*
Thiamin mg\day	1.5±2.9	2.2±4.6	0.79±0.31	1.5±3.4	2.2±4.8	0.8±0.25	1.55±2.4	2.3±4.4	0.78±0.33
Riboflavin mg\day	1.3±0.52	1.3±0.49	1.1±0.40	1.3±0.45	1.4±0.47	1.2±0.43	1.3±0.6	1.3±0.5	1.1±0.4
Niacin mg\day	10.1±3.7	10.0±3.9	8.9±2.9	10.6±3.9	10.2±3.7	9.5±2.9	9.5±3.5	9.9±4.1	8.7±3.0
Folate µg\day	124±76	119±78	101±75	63.1±7.7	73.4±6.9	70.1±22.2	125±89	118±82	102±78
Vitamin C mg\day	138±90	134±85	128±94	122±69	137±82	119±62	158±107	131±87	131±105
Vitamin A µgRE\day	1322 ±1170	1182±769	1025±556	1279±1246	1313±890	879±395	1373±1081	1086±652	1076±600
Vitamin D µg\day	0.43±0.89	0.38±1.2	0.24±0.4	0.41±0.52	029.±0.91	0.09±0.13	0.49±1.2	0.45±1.5	0.29±0.49
Vitamin E mg\day	5.4±2.9	5,5±4.2	5.2±2.1	5.0±2.6	5.7±3.2	5.3±1.1	5.8±3.1	5.3±4.8	5.2±2.4
Calcium mg\day	496±216	527±263	466±198	465±192	239±22	199±63	534±238	522±281	460±200
Iron mg\day	13.8±5.3	13.8±5.4	12.1±4.9	13.7±4.3	14.5±5.2	12.6±4.1	14.1±6.4	13.4±5.7	11.9±5.3
Zinc mg\day	3.4±1.8	3.7±1.9	3.4±1.5	3.4±1.9	3.9±1.9	3.7±1.4	3.4±1.6	3.6±2.0	3.3±1.6
Selenium µg\day	23.6±17.8	27.6±20.7	24.4±16.1	18.9±2.3	24.8±2.4	20.9±6.6	22.5±16.5	25.6±16.9	22.7±14.1
Sodium mg\day	1370±700	1400±850	1167±730	1521±803	1550±868	1169±620	1200±580	1295±824	1166±772
Fiber gm\day	5.1±2.9	4.7±2.7	4.3±3.9	5.1±2.9	4.8±2.8	4.1±0.97	5.0±3.1	4.7±2.7	4.5±4.6

*p<0.05 using Kruskal–Wallis test, **p<0.01 using Kruskal–Wallis test.

DISCUSSION

In this study we examined the nutritional status of frail, pre-frail and robust older adults through a comprehensive nutritional status assessment, anthropometric measurements, body composition, diet and biochemical data.

This study observed that frailty is associated with higher BMI and obesity and lower limb muscle wasting as indicated by calf circumference. The relationship between weight and frailty can be explained in two different ways. Weight loss is one of the components of frailty (Fried *et al*., 2001). Therefore, it can be expected that older adults with frailty will be underweight due to progressive weight loss. Similarly, obesity in older adults is associated with lower muscle strength, weakness, low physical activity and higher level of independency, which are also some of the components accounted for in frailty status (Sheehan *et al*., 2013). As a result, older adults with obesity can be classified as frail due to the afore -mentioned characteristics.

It has been reported that under-nourished older adults had lower muscle mass and poor physical function with three times higher risk to be frail compared to older adults with good nourishment (Chevalier *et al*., 2008). However, our present study failed to demonstrate the association between frailty and under-nutrition, probably due to a smaller percentage of under-nutrition among the sample (2 to 3%). The relationship between BMI and frailty is not linear but rather a U-shaped curve as established in a previous study (Hubbard *et al*., 2010). Calf circumference was found to be lowest in older adults with frailty compared to those in the pre-frail and robust groups. This suggests that calf circumference is a better muscle mass indicator compared to the others. Older adults with frailty had a significantly lower muscle mass and a higher fat mass compared to their normal counterpart (Chevalier *et al*., 2008).

Earlier, frailty was associated with thinness, weakness, and under-nourishment (Fried *et al.,* 2001), however, recently, there is strong evidence that excessive adiposity contributes to frailty by reducing the ability of older adults to perform physical activities and increasing metabolic instability (Starr et al., 2014). Hubbard *et al.* (2010) also reported that obesity is associated with frailty among women.

In our study, frail participants had a higher intake of fat, lesser number of meals per day and longer hours of overnight fasting. Although, the total calories and protein intake were the lowest in frail participants compared to pre-frail and robust, these differences were not significant. Previous studies have reported that low intake of calories (Bartali *et al*., 2006) and protein (Beasley et al., 2010) are associated with frailty. It appears that frail individuals are consuming a low quality diet with high fat that contributes to obesity. Studies exploring the relationship between fat intake and frailty are sparse. However, there are many studies reporting the association or correlation between fat intake and adverse health outcomes, such as a higher fat intake increases the risk of dementia and cognitive impairments (Morris *et al*., 2004).

Higher meal numbers have been reported in robust participants compared to pre-frail and frail. More meal numbers per day is associated with better health outcomes in older adults as the increase in the number of meals enhances nutrients absorption, and improves the appetite in case of anorexia of aging. These factors lead to better nutritional status in older adults (Engelheart *et al*., 2006). In our study, older adults with frailty reported longer overnight fasting time compared to those in the normal group. Similar findings were found in a previous study (Engelheart *et al*., 2006). Food insufficiency

was found to be associated with frailty in our study. This is consistent with another recent community study that found older adults with frailty tend to report less food sufficiency compared to robust adults, using the same scale as our study (Smit *et al*. 2013).

As expected, the lower the physical function, the higher the risk of frailty, as observed in our study. These results are expected because frailty definition includes functional status impairment. Frailty assessment consists of two or more of physical function criteria or impairments that include weakness and slowness (Fried *et al.*, 2001; Mitnitski *et al*., 2001). Physiologically, deterioration in all the pre-requisites of physical function such as muscle strength, endurance and power can lead to frailty in older adults. Moreover, all of the intervention studies targeted frailty as the main outcome using the physical function status as a primary outcome (Manal *et al*., 2015).

Disability as indicated by a lower ADL and IADL scores are also associated with frailty as observed in this study. Frailty is a risk factor for disability (Gobbens & Van Assen 2014; De La Rica-Escuín *et al*., 2014), and the level of disability is usually assessed using ADL and IADL. Hence, some frailty assessment tools include ADL and IADL for frailty status assessment (Mitnitski *et al*., 2001; Searle, Mitnitski, Gahbauer, Gill, & Rockwood, 2008. Also, performance of ADL and IADL is partly dependent on physical function.

As observed in another study conducted by Macuco *et al.* (2012), this present study also found that frail individuals had a poorer cognitive function as assessed using MMSE score. In some assessment tools of frailty, the cognitive function is considered as one of the frailty domains indicating poorer cognitive status among the frail, and thus included in the assessment (Mitnitski *et al*., 2001; Ruan *et al*., 2014; Searle ***et al.,*** 2008). Using other methods of frailty assessment which did not include cognitive function, a significant association or relationship was reported between frailty and cognitive function (Ruan *et al*., 2014). Auyeung *et al.* (2011) reported a significant association between cognitive function and frailty in baseline data analysis. And further, frailty was found to be a predictor for cognitive impairment at a 4-year follow-up period.

The main limitation in our study is related to the frailty assessment tools. For Fried's criteria, the cut-off points of hand grip and gait speed used were from the original study published by Fried *et al.* (2001) conducted on a western population. This might over or under-estimate the prevalence of frailty and pre-frailty in our Asian population. Even though, we selected the participants randomly, the sample did not represent all the races in the Malaysian community. The majority who participated in this study belonged to the Chinese ethnic group while the Malays are the major race in the Malaysian community. This study is part of a larger longitudinal study where the total sample is representative of the population. In other selected areas of the larger study, the majority of participants were Malays.

CONCLUSION

Frailty was more pronounced in women who were obese with lower limb muscle wasting, on high fat diet but a lower number of meals and longer overnight fasting, and who had poor physical function and cognition. This indicates that interventions for frailty will benefit from a holistic and multi-component approach that includes nutrition, and physical and cognitive function in order to reverse, impede or prevent frailty in older adults.

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Conflict of interest

The authors report no conflict of interest in this work.

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