MALAYSIAN JOURNAL OF

NUTRITION

VOL. 26 NO. 2 AUGUST 2020

PP18053/02/2013 (033331)

ISSN 1394-035X

Official Publication of the
PERSATUAN PEMAKANAN MALAYSIA
NUTRITION SOCIETY OF MALAYSIA

Malaysian Journal of Nutrition is abstracted/indexed by Google Scholar, the WHO Western Pacific Region Index Medicus, Elsevier databases of the Scopus, EBiology and Ecare, ASEAN Citation Index (ACI), CABI Global Health database and Asian Digital Library (ADL)

MALAYSIAN JOURNAL OF NUTRITION

Peer-reviewed Journal of the Nutrition Society of Malaysia
(http//www.nutriweb.org.my)

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Malaysian Journal of Nutrition
Vol. 26 No. 2, 2020

Contents

Mal J Nutr 26(2): 141-155, 2020

Development of a tool to measure patients' satisfaction of hospital foodservice in a government hospital

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ABSTRACT

Introduction: Dissatisfaction towards the quality of foodservice can affect several important aspects such as nutritional intake and financial burden. The effect of dissatisfaction towards nutritional aspect can be observed via a decline in dietary intake. Therefore, reliable and valid questionnaires are important to measure patients' satisfaction with hospital foodservice. The main purpose of this study was to investigate the construct validity and reliability of a developed questionnaire in a local setting. **Methods:** A questionnaire adapted from previous studies and consisting of 27 statements from four dimensions, was administered to a total of 277 hospitalised patients in a government hospital. Factor analysis and reliability analysis were conducted using SPSS version 25. **Results:** Principal component of factor analysis revealed that the final questionnaire contained four main foodservice dimensions, namely food properties, staff and meal service reliability, customisation, and physical and social aspects. The reliability analysis revealed that the Cronbach's alpha value ranged from 0.55 to 0.84 for these foodservice dimensions. The analysis showed that the alpha value differed from one dimension to another such as food properties (α=0.84), staff and meal service reliability (α=0.67), customisation (α=0.69) and physical and social aspects (α=0.55). **Conclusion:** Twenty-seven questionnaire items were retained because their factor loadings were greater than 0.35. Therefore, the questionnaire on patients' satisfaction towards hospital foodservice was considered reliable and valid. The classification of the four dimensions provided detailed information of the satisfaction level, relationship and influence on the foodservice dimensions, which contributed to satisfaction towards hospital foodservice.

Keywords: Patients' satisfaction, hospital food, hospital foodservice, reliability, validity, factor analysis

INTRODUCTION

The importance of patients' satisfaction towards foodservice stems from its ability to influence the overall satisfaction on hospital care quality (Demir & Celik, 2002). The term satisfaction can be defined as the experience of a customer using a service and can evoke positive feelings (Namkung & Jang, 2007). In health care service, patients' satisfaction

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doi: https://doi.org/10.31246/mjn-2019-0047

can also be defined as an evaluation of a patient's experience of health care services via their cognitive and emotional reactions (Keegan & McGee, 2003). From the definition, satisfaction is always related with service. Thus, this indicates that a strong relationship exists between patients' satisfaction and health care service, especially foodservice (Wright, Comelly & Capra, 2006).

Modernisation of the healthcare industry has shown many improvements in almost every aspect of the component. In a hospital setting, the foodservice department often undergoes upgrading in almost every aspect to improve quality, as well as patients' satisfaction. The influence of patients' satisfaction towards foodservice affects the overall satisfaction towards hospital care quality (Ganasegeran *et al.,* 2015). Several studies have shown that the satisfaction towards hospital foodservice is influenced by different factors such as food quality, interpersonal dimension, and physical environment (Naithani *et al.*, 2009; Hartwell, Edwards & Symonds, 2006; Stanga *et al.*, 2008). The measurement of patients' satisfaction becomes an important tool to measure the quality given to patients. However, the measurement of satisfaction in a hospital setting is difficult to analyse because it involves the degree of feeling towards a service and is influenced by other factors.

There are various tools often used to measure patients' satisfaction with hospital food or foodservice. (Deluco & Cremer, 1990; Dube, Trudeau & Belanger, 1994; Capra *et al.*, 2005). The earliest tool used to evaluate the satisfaction towards a service is the Service Quality (SERVQUAL) model. This model rose from a study by Parasuraman, Zaithaml & Berry (1988) in which the tool stated that the dimensions of customer satisfaction towards a service were responsiveness, assurance, reliability, empathy and tangibility. However, because it was derived from a service/hospitality setting rather than a healthcare setting, SERVQUAL failed to produce clear dimensions for hospital service because the evaluation of hospital service by patients is different when compared with customers from other service industries (Babakus & Mangold, 1991; Johns & Howard, 1998).

Shortly after SERVQUAL was developed, Deluco & Cremer (1990) conducted a telephone interview with 223 randomly selected adults in Ohio to determine consumers' perceptions on the quality of hospital foods, food-related service, clinical service, and their importance. Four years later, Dube *et al.* (1994) developed a questionnaire to determine the overall satisfaction with meals and with foodservice, and satisfaction with 26 specific foodservice attributes. Food quality was the main predictor of the survey. Seven dimensions representing patients' perceptions of foodservice were identified: food quality, service timeliness, service reliability, food temperature, attitude of the staff who deliver the menus, attitude of the staff who serve the meals, and customisation (Dube *et al.,* 1994).

The Acute Care Hospital Foodservice Patient Satisfaction Questionnaire (ACHFPSQ) developed by Capra *et al.* (2005) was the first reliable and valid questionnaire to measure patients' satisfaction towards hospital foodservice (Capra *et al.*, 2005). The questionnaire was initially developed to measure patients' satisfaction with acute care hospital foodservice and contained 16 statements relating to four factors describing food quality, meal service quality, staff/service issues and physical environment (Capra *et al.,* 2005). Since then, the tool had been used widely to measure patients' satisfaction with

hospital foodservice because it was considered to be a comprehensive and complete tool.

Numerous satisfaction surveys had been performed in Malaysia. However, the results of these studies were too general without studying the actual causes that contribute to dissatisfaction towards foodservice. This study will identify the actual factors that are associated with dissatisfaction in hospital foodservice. The importance of this tool is that it can be useful for assessing the level of satisfaction towards hospital foodservice, as well as patients' perceptions towards hospital meals. Dietitians can use the results obtained as a reference to improve or modify any part of the foodservice components in order to enhance the quality of hospital meals and to create a positive perception among patients towards hospital meals, resulting in an increase in food consumption. This research will create awareness among hospital foodservice personnel on the actual foodservice dimensions that influence food intake. Thus, the specific dimensions identified can ensure that meals provided meet the requirement for patient recovery. In addition, the tool will hopefully enable these personnels to address issues pertaining to the high volume of food wastage. Data from this study can be used as baseline for further research regarding hospital foodservice systems.

The tool used in this study was based on international studies and the questions were modified to fit the local hospital setting. There is no published evidence that the tool used is valid and reliable for hospital setting in Malaysia. Hence, this study was conducted to determine the construct validity and reliability of the questionnaire using factor analysis and reliability analysis.

MATERIAL AND METHODS

Study design and data collection

This is a cross-sectional study that was conducted in a 620-bed urban government hospital in Malaysia. The duration for data collection for this study was three months. Prior to data collection, permission was obtained from the Ministry of Health (MOH) Malaysia and the Director of the hospital. Ethical approval was granted by the Medical Research Ethics Committee of the MOH Malaysia and the Medical Research Ethics Committee of the Faculty of Medicine and Health Sciences, Universiti Putra Malaysia. Data collection involved hospitalised patients who fulfilled the inclusion criteria. Patients were recruited based on the following inclusion criteria: consumed normal diet from hospital, stayed at least two days in the ward and able to give solid opinion. However, patients were excluded from the study if they consumed therapeutic diet, received enteral or parenteral nutrition, nil by mouth, and/or were unable to communicate well. The collected data were patients' specific characteristics (age, gender), and questionnaire on patients' satisfaction towards foodservice. A total of 562 respondents were interviewed. Out of that, 285 were unable to complete the questionnaire due to various reasons. As a result, only 277 respondents successfully completed the questionnaire. Approximately 116 patients were in second-class wards, while 161 were in third-class wards.

Measurements

In this study, the satisfaction of respondents towards hospital foodservice was measured using a questionnaire adapted from studies by Capra *et al.* (2005), Hartwell, Edwards

& Beavis (2007), Hwang & Desombre (2003), O'Hara *et al.* (1997), and Dube *et al.*, (1994). Initially, there were five dimensions and a total of 31 items applied and used to measure the satisfaction level among hospitalised patients.

Quality of food is an important dimension because this factor normally gives a major influence on patients' satisfaction during hospitalisation (Dube *et al.* 1994; Lau & Gregoire 1998; Wright *et al.*, 2006). In addition, according to previous literatures, the interaction or communication between staffs and patients also influences the satisfaction towards foodservice (Dubé *et al.*, 1994). The delay in food delivery and serving by service staffs can make patients less satisfied towards the quality of service (Stanga *et al.*, 2003). Some studies suggested that interpersonal or service aspects were the most significant in contributing towards patients' satisfaction (Deluco & Cremer, 1990; Hartwell *et al.*, 2007). Physical environment factors, such as smell, colour, lighting and ambient temperature, eating location and social variables can also affect patients' perceptions towards hospital foodservice (Capra *et al.*, 2005; Hartwell *et al.*, 2006). Finally, other important foodservice dimensions are timeliness and reliability. Dubé *et al.* (1994) stated that timeliness is related with the duration for eating and the time for staff to pick up the tray, whereas reliability is more related to punctuality of the foodservice and service hours.

Based on the literature discussed previously, five dimensions were selected as follows: 1. Food quality, 2. Timeliness and reliability, 3. Staff issue 4. Meal service quality and 5. Physical environment. There were fourteen questions in the food quality dimension. The questions were related with food texture, quality of fish and meat, temperature, food flavour and other food quality attributes. There were five questions in the staff issue dimension. The questions were related to courtesy and attitude of the staffs, punctuality of the staff who served the food and other related questions. There were seven questions in the dimension of timeliness and reliability. The questions were mostly related with the suitability of mealtimes and the time provided to finish the foods. The meal service dimension had three questions and most of them were related with the quality of cutlery and crockery, and options given to patients. The last dimension was the environmental presentation containing two questions in this dimension. The questions were related with the smell and noise of the ward.

Items labelled as FQ1, FQ2, FQ3, FQ4, FQ7, FQ9, FQ10, FQ11, FQ12, SI1, SI2, SI4, MS1, MS2, PE1 and PE2 were adapted from Capra *et al.* (2005), FQ5 and FQ6 were adapted from Hartwell *et al.* (2007), eight items labelled as FQ13, FQ14, TR5, TR6, TR7, SI3, S15 and MS3 were adapted from Hwang & Desombre (2003), while only four items labelled as TR1, TR2, TR3 and TR4 were adapted from Dube *et al.* (1994), and an item labelled as FQ8 was adapted from O'Hara *et al.* (1997).

The questions were modified to fit the hospital setting as presented in Table 1. To measure satisfaction towards these foodservice dimensions, a five-point Likert scale was used as previously done by Capra *et al.* (2005). The scale was coded as "strongly dissatisfied", "dissatisfied", "average", "satisfied" and "strongly satisfied". The lowest value was coded as "strongly dissatisfied," while the highest value was coded as "strongly satisfied". A score was given based on the answer - strongly dissatisfied was scored as 1, dissatisfied was scored as 2, average was scored as 3, satisfied was scored as 4 and strongly satisfied was scored as 5. The composite score, that is the sum of all dimension scores,

Table 1. The initial construct dimensions and items

Dimension	*Items*	*Label*
Food quality	The meal tastes nice	FQ1
	The fruit served is fresh	FQ2
	I like the way the vegetables are cooked	FQ2
	The meat quality (chicken, fish) served to me is the best	FQ4
	The texture of meals are good and suitable for my condition	FQ5
	Portion size of my meals are suitable and enough for me	FQ6
	The meals have excellent and distinct flavours	FQ7
	The drinks served are just at the right temperature	FQ8
	The hot foods are just at the right temperature	FQ9
	The cold foods are just at the right temperature	FQ10
	I can choose healthy foods in the hospital	FQ11
	The colour of meals is attractive	FQ12
	The smell of meal is nice and good	FQ13
Timeliness and reliability	The meal time for breakfast is suitable	TR1
	The meal time for lunch is suitable	TR2
	The meal time for tea is suitable	TR3
	The meal time for dinner is suitable	TR4
	The meals are served punctually according to schedule	TR5
	The meals are served exactly as ordered	TR6
	The time is enough to finish the meal	TR7
Staff issue	The staffs who deliver and take away my meal are friendly and polite	SI1
	The staffs who deliver and take away my meal are neat and clean	SI2
	The staffs (nurse or foodservice personnel) are willing to help patient with eating difficulties	SI3
	The staffs have explained to me about my diet	SI4
	The staffs only take my tray after I finish eating	SI5
Meal service quality	The crockery and cutlery in my tray is in good condition	MS1
	I like to be able to choose different sized meals	MS2
	Other meal should be provided when patient misses the regular meal service	MS3
Physical environment	The ward's smell stops me from enjoying my meal	PE1
	The ward's noise disturbs me from enjoying meal	PE2

was used as further calculation for the overall score. All the items were worded positively. The list of questions used in the study is presented in Table 1.

Data analysis

Determination of the validity of the scale

Principle component analysis (PCA) was used to determine the underlying dimensions of the questionnaire. Orthogonal transformation was used to convert the construct variables/ items into a set of variables which were most related to each other. This analysis was used to calculate the maximum total of variance in the data

Table 2. Distribution of patients' socio-demographic characteristics (*N*=277)

Socio-demographic variables	*n*	*%*	*Mean±SD*
Age (years)			34.96±12.32
≤20	34	12.3	
21-30	106	38.3	
31-40	49	17.7	
41-50	43	15.5	
≥51	45	16.2	
Gender			
Male	145	52.3	
Female	132	47.7	
Education level			
No education or primary	31	11.2	
Secondary	161	58.1	
Tertiary	85	30.7	
Occupational sector			
None	79	28.5	
Government	78	28.2	
Household income (RM)			2618.38±1683.40
≤2000	141	50.9	
2000 – 4000	97	35.0	
4001 – 6000	26	9.4	
≥6001	13	4.7	
Marital status			
Single	89	32.1	
Married	181	65.3	
Divorced	7	2.5	

set with the smallest value of mutually independent underlying statement or factor within each factor (Norman & Streiner, 2000; Pallant, 2005). The eigenvalue or total amount of variance explained by each factor that was used to separate the factors from each other was also determined. An eigenvalue of greater than 1 was used to separate the factors; a factor with a value of <1 was considered unfitting. Capra *et al.* (2005) however accepted a factor that was <1.

Several assumptions were examined before conducting the analysis. The sufficiency of sample size must meet the assumption. There are different suggestions regarding the suitability of a sample size for analysis. However, for this study, the sample size was calculated based on five cases or participants per variable (Allen & Bennett, 2008). Another assumption that needed to be considered was the strength of the relationship between items, which can be observed via a correlation matrix showing at least some correlation, at r=0.3 or above (Tabachnik & Fidell, 2007). Other than that, the factorability of the data can also be measured using the Bartlett's Test of Sphericity and Kaiser-Meyer-Olkin (KMO) to measure sampling adequacy. The Bartlett's Test of Sphericity should be statistically significant at p<0.05 and the KMO value ≥0.6 to be considered appropriate for the conduct of factor analysis in a study where orthogonal rotation is applied. This rotation is able to produce outcomes that are easier to

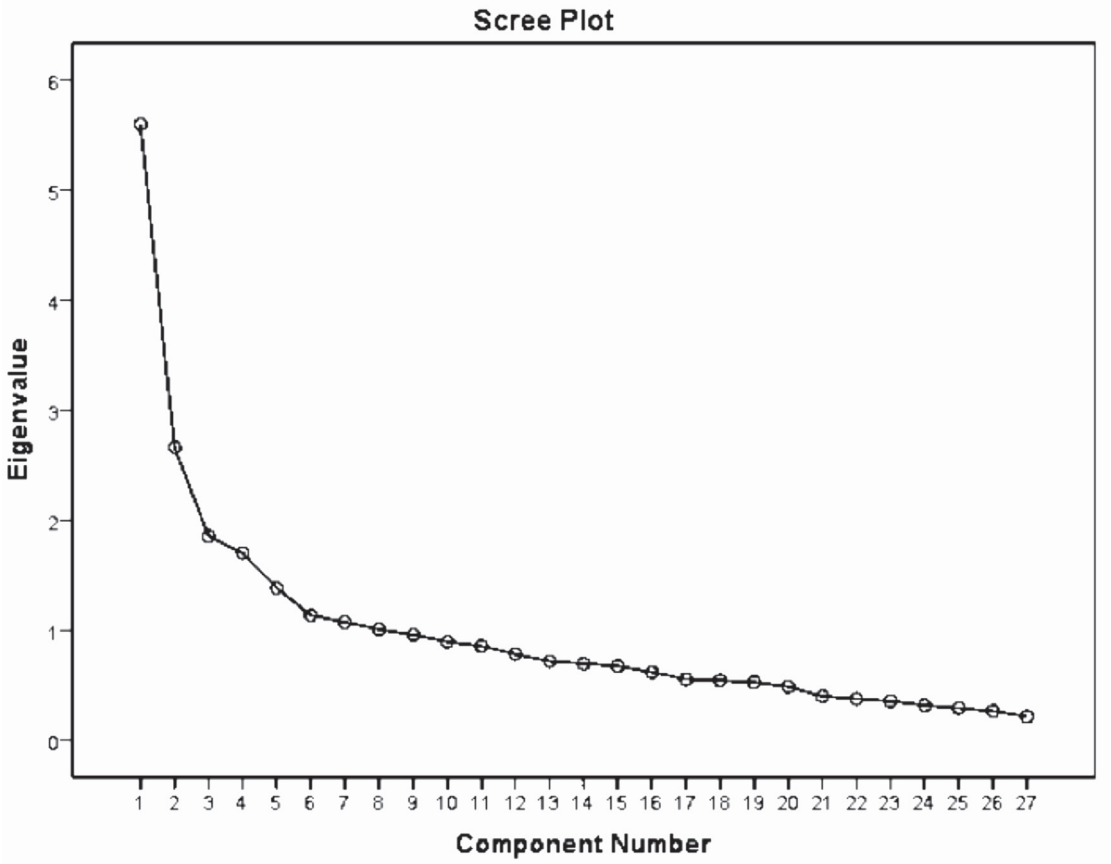

Figure 1. Scree plot

interpret and report, while the oblique rotation produces outcomes that are more difficult to interpret, describe and report (Tabachnik & Fidell, 2007). The Varimax method is the most common orthogonal rotation used because it is able to reduce the number of items, which have high loading on each factor.

Determination of the reliability of the scale

Reliability analysis was conducted to examine the Cronbach's alpha of these new dimensions. According to the rule of thumb proposed by George & Mallery (2003), a value of α>0.8 indicates good internal consistency of the items in the scale. However, a Cronbach's alpha value ≥0.5 is considered to meet the minimum level of reliability (Hinton *et al.,* 2004). In this study, a Cronbach's alpha value of above 0.5 was accepted.

RESULTS

A total of 380 hospitalised patients participated in the study. However, only 277 patients (145 males and 132 females) were able to complete the study. Age ranged from 18 to 59 years old, with the mean age being 34.96±12.32 years old. The socio-demographic characteristics of the patients are presented in Table 2.

Initial principle component analysis was used to assess the suitability of the data. The examination of correlation matrix showed the presence of many coefficients of ≥0.3. The value of KMO

was 0.7, which was higher than the recommended value of 0.6. Bartlett's Test of Sphericity was also statistically significant (chi-square = 2235.71, $p<0.001$). At the initial stage, PCA revealed eight factors with eigenvalues >1 and the percentage of total variance explained were 20.74%, 9.86%, 6.89%, 6.31%, 5.13%, 4.21%, 3.98% and 3.75% respectively. The assessment of the scree plot showed that four factors should be retained as shown in Figure 1.

The rotation of four dimensions from the questionnaire showed that a few items were presented in two dimensions or were moved from the original dimension to another. Items with a factor loading of <0.30 were removed from the dimensions. The underlying dimensions were labelled as food properties, staff and meal service reliability, mealtime and physical-social issue, customisation, meal service and staff issue. The statements that appeared in each factor or dimension were considered fit based on the eigenvalue and the total of variance explained by the statement. A summary of the results is presented in Table 3.

In this study, there were 27 individual statements to be rated by patients. The individual score of the dimension was rated using five-point scales with 5 as the maximum point and 1 as the minimum point. The score of individual statements were evaluated. In the present study, the lowest scale used was 1 for highly dissatisfied, 2 for dissatisfied, 3 for moderate, 4 for satisfied and 5 as the highest scale for highly satisfied. If the mean score of an individual statement was <2.50, it was considered as dissatisfied. A mean score ≥2.50 but <3.50 was considered moderate and a score of ≥3.50 was considered satisfactory. The distribution of means for individual statements are presented in Table 4.

The dimension score was calculated using the summation of mean scores of individual statements. Four dimension scores represented four foodservice dimensions. As for the composite score, it was obtained by summation of the scores of four dimensions. Table 5 shows the distribution of dimension scores and their percentages. The findings indicated that there were three dimensions which were able to obtain above 70.00% in their composite score percentage. The dimension with the highest score was customisation (15.35±1.84) with scores ranging from 8 to 20. The second highest score was the dimension of physical-social issue (15.34±1.68) with scores ranging from 9 to 20. The third highest score was the dimension of meal service and staff issue (25.95±3.01) with scores ranging from 14 to 34. The food properties dimension (39.99±6.16) was only able to achieve 66.67% of the maximum possible score. The mean overall satisfaction towards hospital foodservice was 6.25±1.68 with a score of 62.50%. This indicated that the judgment of quality in foodservice dimensions were different from one another.

The results of the reliability analysis of the dimensions revealed that the Cronbach's alpha (α) value of the four dimensions after factor analysis were 0.84, 0.67, 0.69 and 0.55, respectively, which depicted good internal consistency of the scale for each dimension. In Table 3, the first statement under "staff and meal service reliability" (i.e. meals are served punctually according to schedule) was mentioned again in more details under the "mealtime" section. In addition, the first statement under the physical and social section (i.e. staffs who deliver and collect my meals are friendly and polite) was moved from the "staff issue" dimension to the physical and social dimension.

Table 3. The dimensions of foodservice satisfaction and factor loadings for each item

Items	*Factor loading*	*Eigenvalue*	*Variance explained by factor (%)*
Food properties		5.65	21.73
1. The meal tastes nice	0.58		
2. I like the way the vegetables are cooked	0.60		
3. The meat quality (chicken and fish) served to me is the best	0.50		
4. The texture of meal is good and suitable for my condition	0.36		
5. The portion size of the food is suitable and enough for me	0.42		
6. The meals have excellent and distinct flavours	0.58		
7. The drinks served are just at the right temperature	0.53		
8. The hot foods are just at the right temperature	0.73		
9. The cold foods are just at the right temperature	0.62		
10. I can choose healthy food in the hospital	0.57		
11. The colour of meals is attractive	0.58		
12. The smell of meals is nice and good	0.58		
Staff and meal service reliability		2.30	8.84
1. The meals are served punctually according to schedule	0.37		
2. The meals are served exactly as ordered	0.55		
3. The staffs who deliver and collect my meals are neat and clean	0.38		
4. The staffs (nurse or foodservice personnel) are willing to help patients with eating difficulties	0.56		
5. The staffs have explained to me about my diet	0.65		
6. The staffs only take my tray after I am done eating	0.55		
Mealtime		2.12	8.15
1. The mealtime for breakfast is suitable	0.77		
2. The mealtime for lunch is suitable	0.86		
3. The mealtime for tea is suitable	0.72		
Physical and social		1.41	5.43
1. The staffs who deliver and collect my meals are friendly and polite	0.56		
2. The ward's smell stops me from enjoying my meals	0.73		
3. The ward's noise disturbs me from enjoying my meals	0.78		

Table 4. Distribution of the scores of each foodservice individual statement

Foodservice dimension/ Statement	*Score*[†] *Mean±SD*
Food properties	
1. The meal tastes nice	3.23±0.77
2. I like the way vegetables are cooked	3.09±0.97
3. The meat quality (chicken and fish) served to me is the best	3.46±0.87
4. The texture of meals are good and suitable for my condition	3.53±0.75
5. Portion size of my meals are suitable and enough for me	3.95±0.64
6. The meals have excellent and distinct flavours	3.11±0.80
7. The drinks served are just at the right temperature	2.91±1.01
8. The hot foods are just at the right temperature	3.38±0.85
9. The cold foods are just at the right temperature	3.56±0.69
10. I can choose healthy food in the hospital	3.39±0.92
11. The colour of my meals are attractive	3.17±0.95
12. The smell of my meals are nice and good	3.21±0.87
Meal service and staff issue	
1. The mealtime for dinner is suitable	3.72±0.68
2. The meals served punctually according to schedule	3.61±0.78
3. The meals served exactly as ordered	3.56±0.84
4. The staffs who deliver and collect my meals are neat and clean	3.95±0.51
5. The staffs (nurse or foodservice personnel) is willing to help patient with eating difficulties	3.85±0.62
6. The staffs have explained to me about my diet	3.46±0.91
Customisation	
1. The fruit served is fresh	3.82±0.67
2. The mealtime for breakfast is suitable	3.84±0.63
3. The mealtime for lunch is suitable	3.89±0.60
4. The mealtime for tea is suitable	3.79±0.65
Physical and social	
1. The staffs who deliver and collect my meal are friendly and polite	3.62±0.80
2. The hospital or ward scent stops me from enjoying my meals	3.96±0.60
3. The noise at hospital or ward disturbs me from enjoying my meals	3.74±0.81
4. The duration given to finish the meal is enough	4.02±0.59

[†]Mean score was based on the scale of 1 to 5

DISCUSSION

This study found four underlying dimensions of patients' satisfaction towards hospital foodservice. An observation on the first dimension indicated that most of the statements were related to food quality attributes. Based on two studies that had been conducted previously by Capra *et al.* (2005) and Hwang & Desombre (2003), it was proposed that statements about food attributes (taste, temperature and aroma of food) could be classified as food properties. Based on that, the first dimension was labelled as food properties.

Table 5 Distribution of dimension scores rated by patients

Foodservice dimension	*Maximum possible score*	*Rated score Mean±SD*	*Percentage (%)*
Food properties	60.00	39.99±6.16	66.67
Meal service and staff issue	35.00	25.95±3.01	74.14
Customisation	20.00	15.35±1.84	76.75
Physical-social issue	20.00	15.34±1.68	76.70
Composite score	135.00	96.30±9.17	71.58

The second dimension was labelled as meal service and staff issue because the statements were mostly related to staff and meal service reliability. This finding contradicted with the finding by Dubé *et al.* (1994), which found that the dimensions of meal service reliability and staff issue were presented in two separate dimensions. However, a gap analysis found that the aspects of meal service and staff issue can be presented in one dimension (Hwang & Desombre, 2003), consistent with this study.

The third dimension was labelled mealtime because the statements of the dimension was regarding the suitability of mealtime. Normally, mealtime is related with timeliness and reliability aspects (Hwang & Desombre, 2003; Dube *et al.,* 1994). The attribute of mealtime suitability also affects patients' perceptions during hospitalisation (Dube *et al.,* 1994). Normally, meal times for hospitals in Malaysia are: breakfast at 7.00 a.m., lunch at 12.30 p.m., tea at 3.30 p.m. and dinner at 6.30 p.m. (Vijayakumaran, Eves & Lumbers, 2010). Previous literature reported that patients commonly stated that the gap between meal times were too short or too long (Naithani *et al.,* 2008). Inappropriate meal times tend to affect patients' perceptions (feeling unhappy with breakfast and dinner) on hospital foodservice (Vijayakumaran *et al.,* 2010). However, in a study by Lassen, Kruse & Bjerrum (2005), almost all patients were very satisfied with each meal time and only a minority of patients were dissatisfied. This indicted that the presence of meal time dimension is important in measuring satisfaction.

Physical-social issue dimension was labelled as the fourth dimension because the statements were mostly about meal time surroundings. According to Dickinson *et al.* (2005), there are three aspects which influence patients' perceptions towards hospital foodservice that needed to be considered. These aspects are physical environment, aesthetic, and social aspects. In comparison, the finding of the study was almost consistent with the finding by Hwang & Desombre (2003) that social contact and environment aspects can be presented in the same dimension. However, Capra *et al.* (2005) found that the statements regarding noise, scent and condition of items on the tray were only present in the physical environment dimension. On the other hand, Abd Manaf and Phang (2007) found five items grouped under physical dimension, namely cleanliness of the ward, environment of the ward, management of visitors to the wards, condition of the bathrooms and toilets and noise in ward.

Findings of this study revealed that the food properties dimension was the strongest dimension (β=0.392) contributing towards patients' satisfaction in hospital foodservice. The finding was consistent with previous studies, which concluded that food quality

attributes or food properties dimension play a major contribution as the main predictor of overall satisfaction (Lau & Gregoire, 1998, Wright *et al.*, 2006). This designated that the attributes of food quality become the most influential aspect in patients' judgment towards foodservice. The presence of individual factors in the dimension, which is mostly related to sensory judgment, could explain the current findings. Food quality attributes such as temperature, texture, flavour and appearance are found to be powerful determinants of satisfaction in hospital foods (Hartwell *et al.*, 2007). Another possible explanation for the high influence of food properties dimension is the patient's preconception towards hospital food before even tasting the food. Generally, patients have poor expectation on hospital foods, especially the texture and flavour (Hartwell *et al.*, 2006). This attitude was described as institutionalised stereotyping by previous studies (Cardello, Bell & Kramer, 1996; Hartwell *et al.*, 2006). This will negatively affect patients' attitudes where patients tend to exaggerate the magnitude of this dimension if they had experienced any improper food quality served. Thus, improvement in the quality of food properties dimension may be able to reduce the poor expectation among patients towards hospital food quality.

In this study, hospital food was able to provide 1869±213 kcal of energy. This energy value was able to fulfil the minimum requirement of patients. However, the actual energy intake consumed by patients was 1089±329 kcal. This value was slightly lower and in agreement with a study by Sahin *et al.* (2007). Other than that, the percentage of dietary intake indicated that about 72.6% were able to fulfil their individual requirements for energy intake. This could be due to patients skipping the served foods or eating less due to lesser appetite or other factors. The statistical analysis indicated that male patients tended to consume more hospital foods than female patients. The finding was consistent with Suzana, Kan & Wan (2002) and Sahin *et al.* (2007), where a higher percentage of male patients consumed hospital foods compared to female patients. On the contrary, the intake of non-hospital foods was higher in female patients compared to men. This could mean that men were less picky (higher acceptance level) towards foods compared to women. The difference in food intake could be a result of personal acceptance or preference towards hospital foods (Thibault *et al., 2011*; Johns, Hartwell & Morgan, 2010). As a consequence, patients chose other sources to fulfil their dietary intakes during hospitalisation. Food consumption during hospitalisation varies from one patient to another. It can be influenced by multiple factors such as cultural, treatment, underlying diseases, physical barrier and foodservice (Naithani *et al.,* 2008, Hartwell *et al.,* 2007).

Several studies had been conducted to determine the dimensions of patients' perceptions towards hospital service especially foodservice (Capra *et al.,* 2005; Hwang & Desombre, 2003; Dube *et al.,* 1994). However, the number of underlying dimensions of patients' satisfaction is different from one study to another. According to Hwang & Desombre (2003), there were three dimensions of patients' perceptions towards foodservice, while Capra *et al.* (2005) found five dimensions of patients' perceptions. Both studies used different methods of analysis, therefore the differences might be due to analysis techniques and duration of the study.

Furthermore, the questionnaire showed a good internal consistency or reliability within the recommended Cronbach's alpha value, ranging from 0.55 to 0.84 for individual dimensions.

The dimension of food properties showed the largest alpha value compared to other dimensions, suggesting that it is a major influence towards patients' satisfaction (Wright *et al.,* 2006; O'Hara *et al.,* 1997; Stanga *et al.,* 2003). Dimensions such as physical environment, which consisted of several statements, showed minimum alpha value. Thus, improvement of the reliability of this dimension is required in future studies. This is crucial because the role of technical aspects like physical environment is able to influence satisfaction (Hwang & Desombre, 2003).

CONCLUSION

The Patients' Satisfaction towards Hospital Foodservice Questionnaire is considered valid and reliable to be used among Malaysian inpatients, based on the statistical analysis. The classification of the four dimensions was able to provide detailed information on the satisfaction level, relationship and influence of these foodservice dimensions, which contributed to satisfaction towards hospital foodservice. This allows suitable strategies to be applied to improve satisfaction ratings. The rating can also be useful to detect changes of patients' satisfaction if a manager changes the foodservice system, foodservice contractor, as well as the diets. The dimension composite scoring indicated that most of the percentage scores were <80% based on the recommended value by MOH (MOH Malaysia, 2008). This questionnaire will assist hospitals in Malaysia to easily and efficiently obtain a general idea on their patients' health status. In addition, it will help the foodservice personnels to realise the importance of hospital foods in improving the health status of patients during hospitalisation. In addition, the data from this study can be used as baseline for further research regarding hospital foodservice systems.

It should be noted however that the study did have several limitations. First of all, due to logistic reasons, other hospitals could not be included and the study was limited to one hospital only. The major limitation was low response rate among hospitalised patients. One possible reason for low participation among patients was the condition of the patients, as most of those who refused were too ill or in pain. Others were discharged from the hospital before completing all sections of the questionnaire, while others refused to cooperate for fear that their negative comments will affect the treatment they receive from the hospital staffs. Few other patients declined participation saying they needed some privacy. Another limitation was that the trays of patients tended to get lost after tray collection or the foods were mixed with other foods due to improper handling. Thus, to overcome this limitation, the researcher tagged the tray of the respondents to avoid loss or mixture with other trays.

In conclusion, this set of questionnaire should be further analysed and improved to produce a more accurate and reliable tool across populations, time and foodservice systems.

Acknowledgement

We thank the Director General of MOH Malaysia, the Medical Research Ethics Committee of the Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, as well as the Director of Hospital Sungai Buloh. In addition, we thank all authors for their valuable contributions.

Authors' contributions

MB, principal investigator and main author, carried out the survey, prepared and revised the draft manuscript and provided critique; RJ, led the investigation and furnished her expertise in the conception and design of the study, drafting the manuscript, revising and providing critique; NAAM, contributed in the conception and design, data collection, data analysis and interpretation, and preparation of draft manuscript; HAS, participated in the conception and design of the investigation, reviewed the draft manuscript and provided

critique; MSAK, participated in the conception and design of the investigation, reviewed the draft manuscript and provided critique.

Conflict of interest

The authors declare no conflict of interest.

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Mal J Nutr 26(2): 157-164, 2020

Body mass index of adults, pre-elderly and elderly in Indonesia (Indonesian Family Life Survey 2014)

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ABSTRACT

Introduction: Nutritional status is an indicator of health status that can be determined using the Body Mass Index (BMI) (kg/m^2). This study aimed to determine factors affecting the nutritional status of adults, pre-elderly, and elderly. **Methods**: This cross-sectional study used secondary data from 13,655 respondents aged 36–66 years that were a part of the 2014 Indonesian Family Life Survey (IFLS). Food consumption patterns, physical activity, and socio-demographic data were used to assess nutritional status (BMI). **Results**: Consumption patterns of carbohydrates, protein, fat, vegetables, and fruits were significantly associated with mean BMI as an increase in consumption score led to an increase in mean BMI. Conversely, greater physical activity resulted in a decrease in mean BMI. Mean BMI among females was higher than that of males, irrespective of factors such as marital status, unemployment, presence of health insurance, or smoking. Sumatranese people had the highest mean BMI among the population, along with senior high school graduates and high-income earners. Both higher income and education levels led to higher mean BMI. **Conclusion**: Many factors were shown to affect nutritional status. The results imply that solving nutritional problems in order to improve quality of life will involve many factors, including socioeconomic variables, which are important for designing and evaluating health programmes.

Keywords: Nutritional status, adults, pre-elderly, elderly, factors

INTRODUCTION

Nutritional status is an indicator of health status that can be determined using the Body Mass Index (BMI). BMI is a metric currently used for defining anthropometric characteristics of weight and height in adults, pre-elderly, and elderly, and can be used to classify these populations into relevant groups. The Indonesian Ministry of Health (2013) has stratified BMI as thin (<18.0kg/m^2), normal (≥18.0 – <24.9kg/m^2), overweight (≥25.0 – <27.0kg/m^2), and obese (≥27.0kg/m^2). Numerous clinical consensus panels and public health organisations have recommended that persons with a BMI of ≥30kg/m^2 or those with risk factors of obesity and a BMI of ≥25kg/m^2 to achieve and maintain a lower weight. Additionally, a study by Hwang *et al.* (2009) found that BMI is a predictor of mortality in the elderly, with obesity (BMI >25kg/m^2) being a significant independent predictor for all-cause mortality and overweight (BMI >23kg/m^2) elevating the risk of mortality due to cancer, cardiovascular disease, and diabetes. Furthermore, the prevalence of all risk factors in adults, except for diabetes, decreases

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doi: https://doi.org/10.31246/mjn-2019-0045

with a greater reduction in BMI among overweight and obese individuals (Gregg *et al.,* 2006).

The prevalence of obesity in Indonesia continues to increase in both adult men and women (>18 years old). In the last 6 years, the prevalence of obesity among adult women has increased 19.0% (13.9% in 2007 to 32.9% in 2013) and 5.8% among adult men (13.9 % in 2007 and 19.7% in 2013) (MOH Indonesia, 2013). BMI is an accepted index of obesity in individuals and is also a risk factor for the development of or assessing the prevalence of health concerns, apart from being used for determining public health policies (Nuttal, 2015). Diet, physical activity, and nutritional status are recognised as major determinants of health that are required to monitor direct or indirect changes associated with public health projects (Castetbon *et al.*, 2009).

This study aimed to determine factors affecting the nutritional status of the adult, pre-elderly, and elderly populations in Indonesia using secondary data from the Indonesian Family Life Survey (IFLS) 2014. Specifically, this study sought to answer the following: 1. Socio-demographic profile of the Indonesian people in terms of age, gender, marital status, ethnicity, education, working status, income status, health insurance, smoking status; 2. Nutritional status; 3. Physical activity level; 4. Food consumption patterns; 5. Relationship between socio-demographic and nutritional status; 6. Relationship between physical activity and nutritional status; and 7. Relationship between food consumption patterns and nutritional status.

MATERIALS AND METHODS

A cross-sectional study design was determined to be the best method for analysing BMI and other factors among individuals for a certain time period. This study used secondary data collected during the IFLS, which is publicly accessible at the IFLS5 (2014) domain. Data for IFLS5 were collected between September 2014 and May 2015, and covered 13 selected provinces from IFLS or Sakerti (Indonesian Life Households Survey); specifically, four provinces in Sumatera (North Sumatera, West Sumatera, South Sumatera and Lampung), five provinces in Java (DKI Jakarta, West Java, Yogyakarta, East Java), and four other provinces, including a group of large islands (Bali, West Nusa Tenggara Barat, South Kalimantan, and South Sulawesi). Together, these provinces represented approximately 83.0% of the Indonesian population (Strauss *et al.*, 2009). The study population (N=13,655) comprised of adults (n=10829, 36–55 years), pre-elderly (n=1256, 55–59 years), and elderly (n=1570, 62–66 years). This research divided adults into two groups, young adults aged 36-45 years and late adults aged 46-55 years.

Data were collected from adults, pre-elderly and elderly in 2014, and were categorised based on gender. The independent variables for this study were socio-demographic characteristics, physical activity, and consumption patterns, while the dependent variable was nutritional status (BMI). Socio-demographic variables assessed included age, sex, marital status, ethnicity, education, employment status, income status, health insurance, and smoking status. Subjects were divided into three groups in terms of physical activity as: 1. Not performing regular physical activity (mild, moderate or heavy), 2. Performing physical activity (mild, moderate or heavy) for a period of <30 minutes per day, and 3. Performing regular physical activity (mild, moderate or heavy) for a period of ≥30 minutes per day. Consumption patterns were categorised

into five groups as: 1. Carbohydrate consumption, 2. Protein consumption, 3. Fat consumption, 4. Vegetable consumption, 5. Fruit consumption. Physical activity patterns based on a duration of <30 minutes or ≥30 minutes and dietary intake based on frequency (days per week) were determined using questionnaires (secondary data). Univariate and bivariate analyses were performed using the SPSS programme. Univariate analysis was performed as frequency distribution in mean and standard deviation, as well as size of frequency for categorical data, including age, sex, marital status, ethnicity, education, employment status, income status, health insurance, and smoking status. Bivariate analysis was performed using analysis of variance (ANOVA) and independent *t*-test, while Pearson correlation was used to determine the relationship between independent variables and BMI.

RESULTS

The respondents predominantly (47.1%) belonged to the age group of 36–45 years, while 32.2% were aged 46–55 years, 9.2% were aged 56–59 years, and 11.5% were aged 60–66 years (Table 1). The gender of respondents was evenly distributed as 51.1% were females and 48.9% were males. Most respondents were married (86.5%), were Javanese (62.8%), had graduated from senior high school (32.0%), were employed (82.0%), possessed health insurance (50.8%) and were non-smokers (59.7%). In terms of income, as shown in Table 1, only 4.7% of respondents were in percentile 2, which corresponds to an income of lesser than 1000,000 rupiahs per year, while many respondents were in percentiles 1, 4, and 5 (24.0% for all).

This study also aimed to obtain information on the consumption patterns, physical activity, and nutritional status of respondents. A consumption score was calculated for each type of nutrient, namely carbohydrate, protein, fat, vegetables, and fruits. These scores were then used to analyse consumption patterns. Table 2 shows that respondents often consumed carbohydrates (55.2%), proteins (52.3%), and fats (64.6%) in a week, but rarely consumed vegetables (52.9%) or fruits (51.5%). With respect to physical activity, most of the respondents reported engaging in physical activity for ≥30 minutes per day (69.8%), while the proportions of those who did not engage in any physical activity (16.4%) or those who did for <30 minutes (13.8%) were lower. Most of the respondents (53.3%) had good nutritional status, while the proportions of obese, overweight, and underweight respondents were 23.7%, 16.6%, and 6.4%, respectively.

Table 3 using bivariate analysis revealed a significant relationship between mean BMI and various socio-demographic characteristics, consumption patterns, and level of physical activity ($p<0.05$). The mean BMI in adults (24.3kg/m^2) was higher than that of both the pre-elderly (23.9kg/m^2) and the elderly (23.2kg/m^2). Gender of the respondents was also significantly related to mean BMI ($p<0.05$) as mean BMI in females (25.0kg/m^2) was higher than that of males (23.2kg/m^2). Marital status had a significant relationship with mean BMI ($p<0.05$), whereby married respondents had a higher BMI (24.2kg/m^2) than respondents who were not married (23.7kg/m^2). Sumatranese were found to have the highest mean BMI (24.4kg/m^2), implying that ethnicity may affect mean BMI ($p<0.05$).

The mean BMI of respondents was significantly related to their education level as a higher education was correlated with a higher mean BMI, and the highest mean BMI (24.7kg/m^2) was recorded among respondents who had graduated from senior high school. Mean

Table 1. Socio-demographic profile of respondents (*N*=13,655)

Variables	*n*	*%*
Age (years)		
36–45	6428	47.1
46–55	4401	32.2
56–59	1256	9.2
60–66	1570	11.5
Gender		
Female	6973	51.1
Male	6682	48.9
Marital status		
Married	11816	86.5
Not married	1839	13.5
Ethnicity		
Sumatera	1861	13.6
Jawa	8578	62.8
Other	3216	23.6
Level of education		
Not graduated in Primary School	4014	29.4
Graduated from Primary School	3413	25.0
Graduated from Junior High School	1862	13.6
Graduated from Senior High School	4366	32.0
Working status		
Unemployed	2457	18.0
Employed	11198	82.0
Health insurance		
Do not have	6721	49.2
Have	6934	50.8
Income status (per year)		
Percentile 1 (Rp 0)	3276	24.0
Percentile 2 (<Rp 1,000,000)	635	4.7
Percentile 3 (≥Rp 1,000,000 – <Rp 10,000,000)	3192	23.4
Percentile 4 (≥Rp 10,000,000 – <Rp 20,000,000)	3271	24.0
Percentile 5 (≥ Rp 20,000,000)	3281	24.0
Smoking status		
No smoking	8149	59.7
Smoking	5506	40.3

BMI increased with increasing income, whereby respondents with the highest income (>20 million rupiahs) had the highest mean BMI (24.7kg/m^2).

A significant negative relationship was observed between mean BMI with employment status and having medical insurance (p<0.05 for both). The mean BMI of unemployed respondents (24.9kg/m^2) was higher than that of employed respondents (23.9kg/m^2). Furthermore, respondents possessing health insurance had a higher mean BMI (24.3kg/m^2) than those without health insurance (23.9kg/m^2). The higher mean BMI of those who were unemployed may have been caused by the lack of physical activity in this population. Non-smokers had a greater BMI (24.9kg/m^2) than smokers (22.9kg/m^2). The mean BMI of respondents was significantly related to physical activity. Respondents who did not have any physical activity (24.3kg/m^2) or were engaged in <30 minutes per day of physical activity (24.4kg/m^2) had greater mean BMI than respondents

Table 2. Consumption patterns, physical activity and nutritional status of respondents (*N*=13,655)

Variables	*n*	*%*
Consumption of carbohydrates		
Seldom (<3 days/week)	6117	44.8
Often (≥3 days/week)	7538	55.2
Consumption of proteins		
Seldom (<2 days/week)	6507	47.7
Often (≥2 days/week)	7148	52.3
Consumption of fats		
Seldom (<1 days/week)	4838	35.4
Often (≥1 days/week)	8817	64.6
Consumption of vegetables		
Seldom (<3 days/week)	7220	52.9
Often (≥3 days/week)	6435	47.1
Consumption of fruits		
Seldom (<1 days/week)	7037	51.5
Often (≥1 days/week)	6618	48.5
Physical activity		
No physical activity	2245	16.4
Physical activity <30 min	1882	13.8
Physical activity ≥30 min	9528	69.8
Nutritional status		
Underweight (BMI <18.5kg/m^2)	875	6.4
Normal (BMI ≥18.5 - <24.9kg/m^2)	7280	53.3
Overweight (BMI ≥24.9 - <27.0kg/m^2)	2266	16.6
Obese (BMI ≥27.0kg/m^2)	3234	23.7

who were engaged in physical activity for ≥30 minutes per day (24.0kg/m^2). A significant positive relationship was seen between consumption patterns and mean BMI (p<0.05). Table 3 shows that respondents who frequently consumed carbohydrates, proteins, fats, vegetables, and fruits in a week had greater mean BMI than those who did not, implying that when various nutritional needs are met, the individual's nutritional status remains adequate.

DISCUSSION

In this study, BMI in adults was higher than that of both the pre-elderly and elderly. Meeuwsen, Horgan & Elia (2010) have stated that differences in age, BMI distribution, and possible loss of muscle may be compensated by an increase in other body components, and that it may be due to age-related decrease in the extracellular fluid relative to intracellular water (an indicator of body cell mass), especially in the elderly. Another explanation is survival bias. Obese persons are more likely to die earlier at a younger age, so those who survived into old age are selectively healthier. This commensurates with the recent observation of a population sub-group of obese people who were 'metabolically healthy' and therefore confounded due to prior disease-associated unintentional weight loss (Ng *et al.*, 2017).

Gender was significantly related to BMI, whereby females had a higher BMI than males. This difference can be attributed to body composition differences between males and females, as females generally have a higher percentage of body fat than males. Data from the study by Blaak (2001) also

Table 3. Relationship between socio-demographics, consumption patterns and physical activity with mean BMI of respondents (*N*=13,655)

Variables	*BMI (kg/m²) Mean (SD)*	*p-value*	*95% CI*
Age (years)			
36-45	24.3 (3.9)	<0.001***	-1.35 – -0.76
46-55	24.3 (3.9)	<0.001***	-1.35 – -0.74
56-59	23.9 (4.0)	<0.001***	-1.03 – -0.24
60-66	23.2 (3.9)		
Gender			
Female	25.0 (4.0)	<0.001***	1.73 – 1.99
Male	23.2 (3.6)		
Marital status			
Not Married	23.7 (3.9)	<0.001***	-0.71 – -0.32
Married	24.2 (3.9)		
Ethnicity			
Sumatera	24.4 (3.9)		
Jawa	24.2 (3.9)	0.049*	0.00 – 0.48
Lainnya	23.9 (3.9)	<0.001***	0.28 – 0.84
Education			
Not graduated in Primary School	23.6 (4.0)		
Graduated in Primary School	23.9 (3.9)	0.005**	-0.54 – -0.07
Graduated in Junior High School	24.3 (3.9)	<0.001***	-1.06 – -0.48
Graduated in Senior High School	24.7 (3.8)	<0.001***	-1.41 – -0.96
Working status			
Unemployed	24.9 (4.0)	<0.001***	0.79 – 1.15
Employed	23.9 (3.9)		
Income			
Percentile 1 (Rp 0)	24.6 (4.1)	<0.001***	-1.53 – -0.58
Percentile 2 (< Rp 1,000,000)	23.5 (4.0)		
Percentile 3 (≥ Rp 1,000,000- < Rp 10,000,000)	23.6 (3.9)	1.000	-0.58 – 0.37
Percentile 4 (≥ Rp 10,000,000- < Rp 20,000,000)	23.7 (3.8)	1.000	-0.63 – 0.32
Percentile 5 (≥ Rp 20,000,000)	24.7 (3.8)	<0.001***	-1.67 – -0.71
Health insurance			
Don't have	23.9 (3.9)	<0.001***	-0.41 – -1.46)
Have	24.3 (3.9)		
Smoking status			
No smoking	24.9 (3.9)	<0.001***	1.80 – 2.07
Smoking	22.9 (3.7)		
Physical activity			
No physical activity	24.3 (4.0)	0.01*	-0.54 – -0.05
Physical activity <30 min	24.4 (3.9)	<0.001***	-0.65 – -0.17
Physical activity ≥30 min	24.0 (3.9)		
Consumption of carbohydrates			
Seldom (<3 days/week)	24.0 (3.9)	0.002**	-0.34 – -0.08
Often (≥ 3 days/week)	24.2 (3.9)		
Consumption of protein			
Seldom (<2 days/week)	23.9 (3.9)	<0.001***	-0.58 – -0.31
Often (≥2 days/week)	24.4 (3.9)		
Consumption of Fat			
Seldom (<1 days/week)	23.9 (3.9)	<0.001***	-0.54 – -0.26
Often (≥1 days/week)	24.3 (3.9)		
Consumption of vegetables			
Seldom (<3 days/week)	24.0 (3.9)	0.049*	-0.27– -0.00
Often (≥ 3 days/week)	24.2 (3.9)		
Consumption of fruits			
Seldom (<1 days/week)	23.9 (3.9)	<0.001***	-0.68 – -0.41
Often (≥ 1 days/week)	24.4 (3.9)		

*p<0.05
**p<0.01
***p<0.001

showed that basal oxidation (adjusted for fat-free mass) is lower in females compared to males, thereby contributing to higher fat storage in women.

Marital status had a significant relationship with BMI, in which married respondents had a higher BMI than those who were not married. These results are in line with a study by Lipowicz, Gronkiewicz & Malina (2002) in Poland, which reported that married individuals had a higher BMI than those who were never married, in all age and educational groups analysed. Cobb *et al.* (2016) found that women gained more weight than men, and there was a stronger association between changes in the husband's BMI and that of the wife's, suggesting that marriage may lead to a wife's weight-related behaviours being influenced by their husbands, rather than vice-versa.

The result of BMI being related to education level is consistent with that reported by Zhoua *et al.* (2017), which stated that greater BMI was observed among those with elementary or higher education level compared to those who were less educated. Importantly, higher levels of education are associated with better socioeconomic status that is supported by greater incomes. Higher income therefore grants greater purchasing power to buy nutritious foods.

Non-smokers had a greater BMI than smokers. This is in agreement with results published by Jitnatrin *et al.* (2014) showing that BMI among male and female smokers were lower than male and female non-smokers, respectively. This may be due to the elevation in metabolic rate and/or reduced appetite caused by nicotine in smokers.

The benefits of optimum physical activity are apparent when BMI among respondents engaging in <30 minutes and ≥30 minutes per day of physical activity were compared as BMI decreased when duration of activity increased. Sun, Norman & While (2013) have reported that regular physical activity can lead to significant health improvements at all ages and that it can prolong the active years of independent living, apart from enhancing the quality of life for the elderly. Nelson *et al.* (2007) have recommended that the aim of physical activity for the elderly should be to increase the volume of aerobic physical activity to prevent unhealthy weight gain. There is evidence that an increase in physical activity is related to the prevention of weight gain, but a clear dose-response effect has yet to be established. The recommended goal includes moderate aerobic physical activity performed for 30–60 minutes per day. Interestingly, the fat-free mass accounts for 19.0% of weight gain due to decreasing physical activity while it represents 33.0% of weight loss in people who experience a decrease in weight (Hughes *et al.*, 2002). These observations imply that the duration of physical activity is related to body weight.

The strength of this study was that it represented the majority of the population in Indonesia which is spread across various provinces including urban and rural areas. The limitations of this study were its cross-sectional design and its use of bivariate, not multivariate analysis, to determine factors influencing BMI. Consequently, confounders could be adjusted for in this study. There were also limited information about portion of foods, variety of fruits and vegetables, duration of physical activity in this study.

CONCLUSION

Using BMI as an index, we showed that many factors affected nutritional status, such as age, gender, marital status, ethnicity, education, employment status, income status, health insurance,

smoking status, physical activity, and consumption patterns. These results strongly advocate the importance of nutrition improvement programmes that will help improve the quality of life among adults and elderly.

Authors' contributions

RADS, conceptualised and designed the study and reviewed the manuscript; ER, conducted the study, data collection, data analysis and drafting of the manuscript.

Conflict of interest

There is no conflict of interest

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Mal J Nutr 26(2): 165-172, 2020

Adiponectin, anthropometric measurements and insulin resistance in adolescence with obesity

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ABSTRACT

Introduction: Obesity in adolescents can cause metabolic syndrome. Insulin resistance increases the risk of metabolic syndrome, which then increases the risk of premature death. Studies about anthropometric measurements and adiponectin levels as early markers of insulin resistance in obese adolescents are still limited. **Methods:** A cross-sectional study was performed on 59 obese adolescents aged 13–16 years. Obesity was established on the basis of the Centers for Disease Control and Prevention (CDC) curve (2000). Insulin and blood glucose level measurements were carried out using an enzymatic kit. Adiponectin levels were assayed using enzyme-linked immunosorbent assay (ELISA). The relationships between variables were evaluated by correlation analysis using SPSS. **Results:** Statistical tests showed a positive correlation between waist circumference (r=0.421; p=0.001) and Homeostatic Model Assessment of Insulin Resistance (HOMA-IR) (r=0.396; p=0.002). Waist-to-hip ratio (WHR) and waist-to-height ratio (WHtR) had a weak positive correlation with insulin (r=0.343; p=0.008 and r=0.311; p=0.017) and HOMA-IR (r=0.306; p=0.018). There was a weak negative correlation between adiponectin and insulin in obese adolescents (r=-0.278; p=0.033). **Conclusion:** Anthropometric measurements (waist circumference, WHR and WHtR) and adiponectin can be used for early detection of insulin resistance and hyperinsulinemia in obese adolescents.

Keywords: Adiponectin, insulin, HOMA-IR, adolescents, obesity

INTRODUCTION

Obesity is a global problem. The number of obese individuals is increasing in Asia (Mazidi *et al.*, 2018). Obesity is associated with various complications, including metabolic syndrome, cardiovascular disease and type 2 diabetes mellitus (Asghar & Sheikh, 2017). These complications have varied effects, ranging from an increased risk of premature death to a reduction in quality of life (Hirko *et al.*, 2015; Morrison *et. al.*, 2015).

In obesity, an increase in the size of fat cells is associated with inflammatory conditions. Visceral fat plays an important

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doi: https://doi.org/10.31246/mjn-2019-0100

role in the production of adipocytokines and other pro-inflammatory cytokines to cause inflammation. Pro-inflammatory cytokines are associated with insulin insensitivity (Asghar & Sheikh, 2017). Insulin resistance plays a role in the pathogenesis of type 2 diabetes mellitus (Tangvarasittichai, 2015), metabolic syndrome (Banerji, Lam & Chaiken, 2017) and cardiovascular disease (Ormazabal *et al.*, 2018).

Waist circumference is one of the indices used to assess a person's risk of metabolic syndrome (Prakaschandra & Naidoo, 2017). The associations of waist circumference, thigh circumference, waist-to-hip ratio (WHR) and waist-to-height ratio (WHtR) with insulin resistance have been studied previously. However, most studies were conducted in adult subjects of normal weight (Benites-Zapata *et al.*, 2019) or those with type 2 diabetes mellitus (Yoon *et al.*, 2016).

Adiponectin is an adipocytokine known to have anti-inflammatory, anti-atherogenic and insulin-sensitising effects (Achari & Jain, 2017; Orlando *et al.*, 2019). Adiponectin levels are known to decrease in obese adolescents (Orlando *et al.*, 2019). Adiponectin has been studied as a protective factor against complications of obesity, such as diabetes mellitus, metabolic syndrome, hypertension, dyslipidaemia and cardiovascular disease (Sharma, McClung & Abraham, 2016; Orlando *et al.*, 2019). The protective mechanism of adiponectin has been explained through various adiponectin signalling pathways (Ruan & Dong, 2016). However, clinical research on adiponectin as a marker of insulin resistance has mostly been conducted in adults and patients with type 2 diabetes mellitus (Aleidi *et al.*, 2015).

Studies on adiponectin and anthropometric measurements as initial markers for detecting insulin resistance in obese adolescents are still limited in developing countries. This study aims to analyse the association of anthropometric measurements and adiponectin levels with fasting glucose, insulin and Homeostatic Model Assessment of Insulin Resistance (HOMA-IR) levels in obese adolescents.

MATERIALS AND METHODS

Study design

This was a cross-sectional study conducted on obese adolescents. Respondents were considered obese if their Body Mass Index (BMI) was above the 95th percentile on the Centers for Disease Control and Prevention (CDC) 2000 BMI curve according to age and sex. The inclusion criteria were age 13–16 years, obese, and consent obtained from a parent/guardian to participate in the study. Respondents suffering from infections, inflammation, autoimmune diseases, cancer, chronic diseases and endocrine disorders, those who were smokers and who consumed alcohol were excluded from this study. This study was conducted after obtaining ethical approval from the ethics committee of the Dr Soetomo General Academic Hospital, Surabaya (No. 0411/KEPK/VII/2018).

Physical examinations

Respondents were examined for weight, height, waist circumference and thigh circumference. Weight was measured using a digital scale (Seca, Germany) accurate to 0.1kg. Height was measured with a portable stadiometer (Seca, Germany) accurate to 0.1cm. Body weight was measured with respondents standing straight and not wearing footwear or other accessories. Height was measured from the vertex of the head to the heel with respondents in standing position and not wearing footwear or a hat. BMI was calculated with the

formula of body weight (kilogrammes) divided by height squared (meter squared) and plotted onto the BMI curve according to age and sex (CDC, 2000). Waist circumference was measured using a tape measure accurate to 0.1cm at the midpoint between the lowest rib and the endpoint of the iliac crest upon expiration. Hip circumference was measured using a tape measure at the widest area of the hip at the point of the greatest gluteal protuberance. WHR was calculated as waist circumference (cm) divided by hip circumference (cm). WHtR was calculated as waist circumference (cm) divided by height (cm).

Biochemistry examinations

Blood measurements were performed, including adiponectin, fasting blood glucose levels, insulin and HOMA-IR. Blood collection was carried out in the morning after a 12-hour fast. Blood was drawn from the vena mediana cubiti. Blood was centrifuged, and the serum was removed and stored at –70°C until an adiponectin examination was performed. The adiponectin examination was carried out using enzyme-linked immunosorbent assay (ELISA) in accordance with manufacturer's instructions. The examination of insulin and fasting blood glucose levels was carried out with an enzymatic kit according to standard procedures. HOMA-IR was used to describe insulin resistance.

Statistical analysis

Adiponectin, fasting blood glucose, insulin and HOMA-IR levels were expressed as medians and percentiles due to skewed distributions. A normality test was performed on each variable using the Kolmogorov–Smirnov test. The associations between fasting blood glucose, insulin and HOMA-IR with anthropometric measurements and adiponectin levels were analysed by Pearson's and Spearman's rho correlation. Data analysis was performed using SPSS statistics software version 21.0.

RESULTS

In this study, there were 59 obese adolescents aged 13–16 years. A total of 32 (54.2%) adolescents were males and 27 (45.8%) were females. The median fasting insulin level and HOMA IR value were 16.09mU/ml and 2.85, respectively, in obese adolescents (Table 1).

A weak positive correlation was obtained between waist circumference (r=0.421; p=0.001) and HOMA-IR (r=0.396; p=0.002). WHtR also had a weak positive correlation with HOMA-IR (r=0.306; p=0.018) (Table 2). WHR and

Table 1. Characteristics of obese adolescents

Variable	*Median (25^{th}–75^{th})*
Body Mass Index (kg/m^2)	31.25 (29.20–33.70)
Waist circumference (cm)	97.20 (94.00–107.00)
Hip circumference (cm)	105.00 (99.00–110.00)
WHR	0.95 (0.91–0.99)
WHtR	0.62 (0.59–0.66)
Adiponectin (ng/ml)	6841.90 (5204.66–10044.31)
Fasting blood glucose (mg/dl)	79.00 (75.00–84.00)
Insulin (mU/ml)	16.09 (10.87–22.82)
HOMA-IR	2.85 (2.07–4.24)

25^{th}: percentile 25; 75^{th}: percentile 75
WHR: Waist-to-hip ratio; WHtR: Waist-to-height ratio; HOMA-IR: Homeostatic Model Assessment of Insulin Resistance

Table 2. Correlation between anthropometric measurements and insulin resistance

Variable	*Fasting blood glucose*		*Insulin*		*HOMA-IR*	
	r	*p*	*r*	*p*	*r*	*p*
Body Mass Index‡	0.168	-0.182	0.111	0.401	0.068	0.608
Waist circumference†	0.029	0.830	0.421	0.001*	0.396	0.002*
Hip circumference‡	-0.094	0.480	0.034	0.276	0.152	0.251
WHR‡	0.105	0.213	0.343	0.008*	0.159	0.230
WHtR†	0.108	0.416	0.311	0.017*	0.306	0.018*

†Spearman's rho correlation
‡Pearson's correlation
*significant at $p<0.05$
WHR: Waist-to-hip ratio; WHtR: Waist-to-height ratio

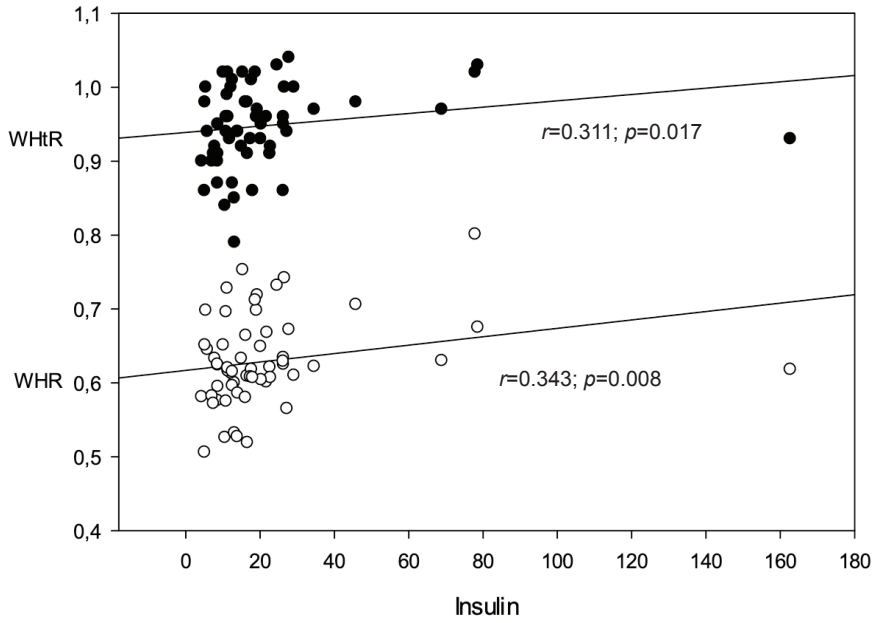

Figure 1. Correlation of insulin with WHR and WHtR

WHtR had a weak positive correlation with insulin (r=0.343; p=0.008; r=0.311; p=0.017) (Figure 1).

There was a weak negative correlation between adiponectin and insulin levels (r=–0.278; p=0.033). Statistical tests did not detect a relationship between adiponectin and HOMA-IR or fasting blood glucose levels (p>0.05) (Table 3). In this study, a negative correlation was found between adiponectin and insulin levels (Figure 2).

DISCUSSION

Pro-inflammatory cytokines are associated with various metabolic complications, such as insulin resistance (Asghar & Sheikh, 2017). As chronic, low-level inflammation occurs in obesity, it is therefore associated with insulin resistance (Lim *et al.*, 2015). There is an increase in fasting insulin levels and HOMA-IR in obese adolescents. HOMA-IR is an index of peripheral insulin sensitivity, which is used to predict

Table 3. Correlation between adiponectin and insulin resistance

Variable	*Adiponectin*	
	r	*p*
Fasting blood glucose‡	0.036	0.789
Insulin†	-0.278	0.033*
HOMA-IR‡	-0.205	0.119

†Spearman's rho correlation
‡Pearson's correlation
*significant at $p<0.05$

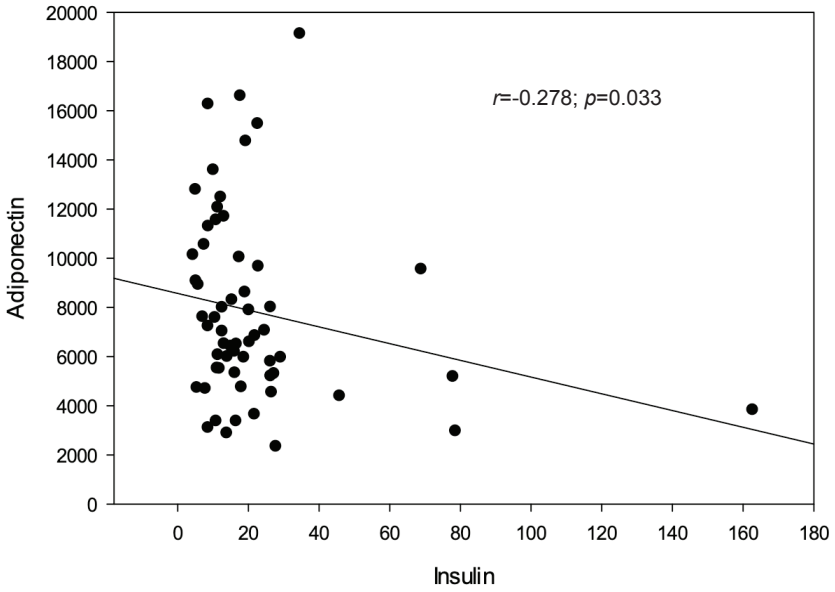

Figure 2. Correlation between adiponectin and insulin

insulin resistance. Increased HOMA-IR is accompanied by increased levels of blood glucose, low-density lipoprotein cholesterol, triglycerides, insulin and glycated haemoglobin (HbA1c), which are risk factors for metabolic syndrome (González-Jiménez *et al.*, 2016). BMI is associated with insulin secretion and insulin sensitivity in obesity (Wang *et al.*, 2016). An increase in HOMA-IR is proportional to an increase in the BMI of adolescents (González-Jiménez *et al.*, 2016), although this increase can also be found in healthy adolescents (Telford *et al.*, 2012). In this study, there was no relationship between BMI and fasting blood glucose levels, insulin or insulin resistance. The findings of this study differed from those of previous studies which showed BMI to be correlated with insulin resistance (Cheng *et al.*, 2017; González-Jiménez *et al.*, 2016; Lim *et al.*, 2015). However, the strength of correlation between BMI with insulin resistance shown by HOMA-IR was found to be weak in adolescents (Convit, Wedin & Diaz-Gimenez, 2012).

Body fat composition has a larger effect on insulin resistance than body fat percentage (Cheng *et al.*, 2017). In this study, waist circumference and WHtR were positively correlated with insulin and HOMA-IR. Previous studies have suggested that waist circumference is

correlated with increased insulin levels (Cempaka & Sidiartha, 2017) and HOMA-IR (da Silva *et al.*, 2018; Lim *et al.*, 2015). Waist circumference is more strongly correlated with HOMA-IR than with BMI (Convit *et al.*, 2012). In a similar study, adolescents stated that BMI, along with increased waist circumference and systolic blood pressure, were risk factors for insulin resistance (González-Jiménez *et al.*, 2016).

This study found that WHR has a positive correlation with insulin, similar to studies conducted in China. A study on respondents with normal weight showed that WHR was associated with hyperinsulinemia after tests of glucose tolerance and insulin resistance (Benites-Zapata *et al.*, 2019). Hyperinsulinemia in obesity occurs due to compensatory insulin secretion under conditions of insulin resistance (Wang *et al.*, 2016). WHR has also been shown to have a positive correlation with HOMA-IR (Lim *et al.*, 2015). However, in this study, there was no relationship between WHR and HOMA-IR. One possible explanation may be the similarities in pancreatic beta-cell function disorders between obese and non-obese respondents with impaired glucose tolerance (Takahara *et al.*, 2013).

Adiponectin is produced by fat tissue. The concentration of adiponectin in plasma is 2–30µg/ml (Sharma *et al.*, 2016). Although adiponectin is produced by fat tissue, but its level is decreased in obesity. Adiponectin is negatively correlated with metabolic syndrome (Ntzouvani *et al.*, 2016), prevents cardiovascular disease and improves insulin sensitisation (Stern, Rutkowski & Scherer, 2016). In this study, low levels of adiponectin were obtained. Adiponectin had no correlation with blood glucose and HOMA-IR levels, but had a negative correlation with fasting insulin levels.

The differences between our results and those of previous studies may have been due to several factors. The relationship between anthropometric measurements and insulin resistance can vary between study populations, influenced by ethnicity (Yoon *et al.*, 2016) and age (Chandler-Laney *et al.*, 2010). Similarly, adiponectin levels are also influenced by ethnicity and gender (Sharma *et al.*, 2016; Aleidi *et al.*, 2015). However, combinations of anthropometric measurements can be used to predict cardiometabolic risk in adolescents (Samouda *et al.*, 2015). In addition, adiponectin and anthropometric measurements are also useful for early detection of insulin resistance and hyperinsulinemia in obese adolescents.

This study has several limitations. Firstly, the sample size was limited and there were no non-obese subjects with normal BMI included as a comparison group in this study. Secondly, no serial measurements of adiponectin, blood glucose and insulin levels were performed in this study. This could have affected the accuracy of the results as blood glucose can be affected by dietary consumption and physical activity.

CONCLUSION

There was a positive correlation in waist circumference, WHR and WHtR with insulin, while a positive correlation was observed between waist circumference and WHtR with HOMA-IR. There was no correlation between adiponectin and blood glucose levels or HOMA-IR. Adiponectin had a negative correlation with fasting insulin levels. Adiponectin, waist circumference, WHR and WHtR can be used for early detection of insulin resistance and hyperinsulinemia in obese adolescents. This can be one step towards preventing metabolic syndrome in adulthood.

Acknowledgement

The authors thank Universitas Airlangga and Dr. Soetomo Academic General Hospital, Surabaya, Indonesia for supporting this research.

Authors' contributions

NAW, principal investor, conceptualised and designed the study, prepared the draft of the manuscript and reviewed the manuscript; RAP, led the data collection, data analysis and wrote the manuscript; MHH, reviewed the manuscript; RI, led the data collection and reviewed the manuscript; IDGU, reviewed the manuscript; RH, reviewed the manuscript.

Conflict of interest

The authors declare no conflict of interest in this study.

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Mal J Nutr 26(2): 173-187, 2020

Parental perception of child's body weight status and its association with socio-demographic factors among Malay children in primary schools in Kuala Terengganu, Malaysia

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ABSTRACT

Introduction: Obesity rate among school children has increased globally. Parental perception plays a significant role in the management of obesity among children. Previous studies indicated that parents who accurately perceived their child's body weight status (BWS) tended to encourage healthy behaviours as compared to parents who overlooked the problem. Therefore, this study aimed to determine the association between socio-demographic factors with parental perceptions of their child's BWS among school children in Terengganu, Malaysia. **Methods:** Using a cross-sectional study design, 389 school children aged 9 to 11 years old were recruited. Height and weight were measured using calibrated tools and inputted into the World Health Organization AnthroPlus software for body mass index *z*-score calculation. Parental perceptions of their child's BWS were explored using a self-administered questionnaire together with their socio-demographic background. **Results:** Of 389 subjects, 53.2% of school children were from rural and 46.8% were from urban schools. Overall, mean BMI-for-age *z*-score between school locations showed no significant difference, with higher means reported in urban (-0.2±1.6*SD*) than in rural (-0.4±1.6*SD*). Significant association was found between parents' perceptions and actual BWS ($p<0.001$). Logistic regression analysis showed that parents of overweight children and parents in rural schools were more likely to misperceive their child's BWS. **Conclusion:** This finding suggests that parents from rural areas and having overweight children were more likely to have misperceptions of their child's BWS. Therefore, knowledge-based intervention programmes among parents specifically in the rural areas are needed to increase the level of awareness to assist in obesity prevention.

Keywords: Parental perception, body weight, school children, Terengganu

INTRODUCTION

A child's lifestyle and body weight status (BWS) are strongly influenced by their surrounding environment including their family and home environment. Home and family environment can either be "obesogenic" or "leptogenic", depending on how they were designed (Rosenkranz

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doi: https://doi.org/10.31246/mjn-2019-0089

& Dzewaltowski, 2008). At this micro-level, parents play a critical role in shaping their child's activity pattern, dietary intake and overall attitude towards food (Sleddens *et al.*, 2014). In addition, parenting style practised by the parents may also predict the children's dietary and activity behaviours. Based on the Baumrind's parenting typologies which are Authoritarian, Authoritative, and Permissive, "Permissive" parenting style is associated with an obesogenic environment, whilst "authoritative" parents are linked with leptogenic environments (Johnson *et al.*, 2012). Thus, effective parenting styles are crucial to build a foundation of healthy practices and maintain healthy BWS among children.

Previous evidence has asserted parental roles in efforts to prevent and manage weight-related problems in children (Chen *et al.*, 2014). The level of support on positive and healthy activity behaviours in the family is determined by how the parents perceive their child's BWS and health. Parents who accurately perceive their child as having body weight problem tend to encourage their children to engage in positive healthy behaviours as compared to parents who overlook the problem (Tschamler *et al.*, 2010). In agreement, recent evidence by Katz found that parents have a high tendency to misperceive and overlook BWS of their child, which is referred to as 'oblivobesity' (Katz, 2015). Parents failed to recognise the weight problem faced by their children, hence, lifestyle changes related to weight control and management were less likely to occur. Nonetheless, previous literature had identified several factors associated with an increase in the misperception including child's BWS, education level, socioeconomic status, and socio-cultural influences (Duncan *et al.*, 2015; Eckstein *et al.*, 2006; Genovesi *et al.*, 2005; Hearst *et al.*, 2011; Jones *et al.*, 2011; Young-Hyman *et al.*, 2000).

A recent review by Tompkins, Seablom & Brock (2015) on parents' perceptions of their children's BWS reported that about 13.3% to 100% of parents with overweight children underestimated their child's weight, instead perceiving their child to have a normal weight. Despite the international evidence on parental misperception of BWS, the studies conducted in Malaysia are still limited. Majority of local studies exploring parental perception on child's BWS were conducted in the central Peninsular area including Kuala Lumpur and Selangor (Kok & Yit, 2019; Muhammad *et al.*, 2008; Serene Tung, Shamarina & Mohd Nasir, 2011), whilst studies in the East Coast area especially in Terengganu are still in its infancy. Therefore, the aim of this study was to determine the association between children's age, gender, school locality, family income and family size with parental perception of their child's BWS among 9 to 11 years old school children in Terengganu.

MATERIALS AND METHODS

Study design and sampling

A cross-sectional study was conducted from February 2016 to September 2016 involving parents of primary school children aged 9 to 11 years from government schools located within the Kuala Terengganu district. All subjects involved in this study were Malays. Six primary schools in Kuala Terengganu were randomly selected from rural and urban locations based on a list obtained from the Terengganu State Department of Education (JPNT). Schools within the district were classified as rural and urban by JPNT based on certain criteria including population density, total population and facilities.

Study protocol

This cross-sectional study was conducted after obtaining ethical approval from the Universiti Sultan Zainal Abidin Human Research Committee (UHREC) and permission from JPNT. This study involved self-reported questionnaires and anthropometric measurements. Parental consent for subjects' participation was obtained prior to anthropometric measurements.

Anthropometric measurements

Body weight and height were measured using calibrated scales (Tanita BC 587 Innerscan Body Composition Monitor and Seca 217 Portable Stadiometer) to the nearest 0.1 kg and 0.1 cm, respectively. Data on height, weight, gender, and age of each subject were inputted into the World Health Organization (WHO) AnthroPlus software (WHO, 2009) to calculate the body mass index (BMI)-for-age *z*-score (BAZ). Age of each subject was calculated to the precise day by subtracting the date of birth from the date of measurement, while BMI was calculated by dividing body weight in kilograms (kg) with height in metre squared (m^2). During data collection, all subjects were apparently healthy and all measurements were taken in light sports attire without shoes during the mornings or early afternoons. BMI categories were defined using age- and sex- specific cut-off points relative to the 2007 WHO classifications (WHO, 2007). The interpretation of the cut-offs classifies overweight as having a z-score >+1 standard deviation (*SD*) (equivalent to BMI 25 kg/m^2 at 19 years), obesity as having a *z*-score >+2*SD* (equivalent to BMI 30 kg/m^2 at 19 years) and underweight as having a *z*-score <-2*SD*. Overweight and obese categories based on researchers' measurements were combined to compare with parent's reported perception of their child's BMI categories. To simplify parental assessment in perceiving their child's body weight status, only three BMI categories (underweight, just about the right weight, or excessive weight) were used, as adapted from the National Health and Nutrition Examination Survey III (Maynard *et al.,* 2003).

Self-administered questionnaire

The self-administered questionnaire was distributed to each subject with detailed explanation on each question. It was completed by the parent at home and was then collected one week later. The questionnaire had three sections and took approximately three to five minutes to complete. Section 1 gathered information on demographic characteristics including child's age, gender, family member, parental education level, parental age, and household monthly income. The three questions in Section 2 assessed the parents' perceptions of their child's BWS. The first question assessed parents' perceptions of their child's weight using the question, "I feel my child is..." (response options: underweight, about the right weight, or overweight). This was followed by the question "Did your child's doctor ever tell you that your child is gaining weight too fast or is overweight?" (response options: yes or no). Then, it was followed by the question "Did your child's doctor ever tell you that your child is lack of weight?" (response options: yes or no). The five questions in Section 3 assessed parental attitude about the health effects of overweight, their child's body weight status and their degree of influence on their child's food choices. Five-point Likert scale response choices were provided for these questions (response options: strongly agree, agree, neutral, disagree, or strongly disagree). The questionnaire on parents' perceptions of their child's BWS and parental attitude on health was adapted from a previously validated

questionnaire (Eckstein *et al.,* 2006) and was translated into *Bahasa Malaysia* with back-to-back translation by an independent translator. A pilot study was conducted and the questionnaire showed an internal consistency of 0.735, thus indicated an overall good reliability.

Data analysis

A new binary variable (yes/no) was created to identify the agreement between parental perceptions and the actual BWS of their children. The agreement was 'no' when parents incorrectly classified their child's BWS. The agreement was 'yes' if parents correctly classified their child's BWS with the actual BWS as measured by the researchers. All statistical analyses including creating the new binary variable were conducted using IBM SPSS Statistics for Windows, Version 22.0 software (IBM Corporation, Armonk, New York, USA). Statistical significance was accepted at $p<0.05$. Independent sample *t*-test was used to examine the variation in continuous variables between two groups, whilst association between categorical variables were assessed using chi-square test. Simple logistic regression was performed to determine the associated factors of parental misperception. Then, all significant variables ($p<0.25$) were included in the multiple logistic regression analysis. The final parsimonious model of associated factors of misperception using multiple logistic regressions was checked for fitness using the Hosmer-Lemeshow goodness-of-fit test.

RESULTS

Anthropometric characteristics and socio-demographic factors

Of the 389 subjects who completed the questionnaires, 53.2% (n=207) were from rural and 46.8% (n=182) were from urban schools (Table 1). Overall, mean BAZ between school locations showed no significant difference between rural and urban subjects. Mean BAZ was higher in urban (-0.2±1.6*SD*) than in rural (-0.4±1.6*SD*) (p=0.404). In total, the prevalence of underweight, normal and overweight were 11.8%, 59.4% and 28.8% respectively. Socio-demographic factors of subjects between school locations are also shown in Table 1. Sixty two percent of mothers and 59.8% of fathers had an education level up to secondary school. Interestingly, there was a significant association between school location and father's education level (χ^2=8.21, p=0.016). There were 39.9% of working mothers, where the proportion was higher among urban mothers (43.5%) as compared to rural mothers (36.8%) (χ^2=1.80, p=0.208). As for family size, 45.8% of the subjects had five to six family members. Based on the 10th Malaysian Plan 2011-2015 classification, 44.0% parents were classified in the low-income group (<RM2300/month), 19.0% in the middle-income group (RM2300-5599/month) and 37.0% in the high-income group (>RM5600). However, no difference was found in parental income group between rural and urban parents. A total of 38.6% of rural parents were classified in the high-income group as compared to 35.2% urban parents, whilst 41.2% of urban parents were classified in the low-income group than their rural counterparts (46.4%).

Parental perceptions on their child's BWS

Table 2 presents the parental perceptions of their child's BWS in comparison with the child's actual BWS. There was a significant difference between parent's perception and the actual body weight of their child ($p<0.001$). Nearly half of the parents (45.5%) misperceived their overweight child as being normal or underweight. Nonetheless, 21.7% of

Table 1. Anthropometric characteristics and socio-demographic factors by school location

Characteristics	*Urban (n=182)*	*Rural (n=207)*	*Overall (n=389)*	*p-value*† *(χ^2)*
Anthropometric characteristics, *Mean±SD*				
Weight (kg)	35.4±11.0	32.8±10.7	34.0±10.9	
Height (cm)	138.6±7.9	134.4±8.4	136.4±8.4	
BMI *z*-scores	-0.2±1.6	-0.4±1.6	-0.3±1.6	0.404‡
BMI categories (actual), *n* (%)				
Underweight	24 (13.2)	22 (10.6)	46 (11.8)	0.700
Normal	105 (57.7)	126 (60.9)	231 (59.4)	(0.71)
Overweight	53 (29.1)	59 (28.5)	112 (28.8)	
Mother's education level, *n* (%)				
Primary education	9 (5.2)	15 (7.7)	24 (6.5)	0.312
Secondary education	105 (60.3)	126 (64.3)	231 (62.4)	(2.33)
Tertiary education	60 (34.5)	55 (28.1)	115 (31.1)	
Father's education level, *n* (%)				
Primary education	11 (6.7)	24 (12.6)	35 (9.8)	0.016
Secondary education	93 (56.4)	120 (62.8)	213 (59.8)	(8.21)
Tertiary education	61 (37.0)	47 (24.6)	108 (30.3)	
Mother's current working status, *n* (%)				
Working	77 (43.5)	75 (36.8)	152 (39.9)	0.208
Not working	100 (56.5)	129 (63.2)	229 (60.1)	(1.80)
Family size (member), *n* (%)				
1 to 4	23 (12.6)	30 (14.5)	53 (13.6)	0.770
5 to 6	82 (45.1)	96 (46.4)	178 (45.8)	(0.52)
≥7	77 (42.3)	81 (39.1)	158 (40.6)	
Household income§ (RM), *n* (%)				
Low (<2300)	75 (41.2)	96 (46.4)	171 (44.0)	0.095
Moderate (2300-5599)	43 (23.6)	31 (15.0)	74 (19.0)	(4.72)
High (>5600)	64 (35.2)	80 (38.6)	144 (37.0)	

†*p*-values for difference between school locations (Pearson's chi-square test)
‡*p*–value for the difference between school locations; (independent sample *t*-test)
§Household income level based on the 10th Malaysian Plan 2011-2015 classification

parents misperceived their thin child as having a normal weight.

The proportion of subjects with correct and incorrect parental perception of BWS compared to the actual BMI in age, gender, school location, family income and family size are presented in Table 3. Overall, of the 389 subjects, 25.7% of the parents incorrectly perceived their child's BWS regardless of their actual BMI category. Pearson's correlation coefficient was used to determine the relationship between the accuracy of parental perception with socio-demographic variables. While rural area showed a significantly higher percentage of misperception compared to urban (p=0.027), there was no significant association found between parental perceptions and other variables *i.e.* age, gender, family income and family member.

Table 2. Parental perceptions of their child's body weight status (BWS) in comparison with actual child's BWS

Parents' perception of their child's BWS (n)	*Child's actual BWS (N=389)*			*p-value*†
	Thin (n=46)	*Normal (n=231)*	*Overweight (n=112)*	
Underweight (*n*=72)	36 (78.3)	35 (15.2)	1 (0.9)	<0.001
Normal (*n*=254)	10 (21.7)	193 (83.5)	51 (45.5)	
Overweight (*n*=63)	0 (0.0)	3 (1.3)	60 (53.6)	

Data presented as frequency (%)
†*p*-values for difference between parents' perception of their child's BWS and child's actual BWS (Pearson's chi-square)

Table 3. Accuracy of parental perceptions by gender, school location, family income and size

Characteristics	*Parental perceptions*		*p-value*†
	Correct n (%)	*Incorrect n (%)*	
Overall subjects	289 (74.3)	100 (25.7)	-
Age (years)			
9	66 (22.8)	20 (20.0)	0.119
10	48 (16.6)	26 (26.0)	
11	175 (60.6)	54 (54.0)	
Gender			
Male	106 (77.9)	30 (22.1)	0.274
Female	183 (72.3)	70 (27.7)	
School location			
Urban	145 (79.7)	37 (20.3)	0.027
Rural	144 (69.6)	63 (30.4)	
Family income (RM)			
<2300	128 (74.9)	43 (25.1)	0.843
2300-5599	53 (71.6)	21 (28.4)	
>5600	108 (75.0)	36 (25.0)	
Family size (member)			
1 to 4	40 (75.5)	13 (24.5)	0.750
5 to 6	129 (72.5)	49 (27.5)	
≥7	120 (75.9)	38 (24.1)	

†*p*-values for difference between correct and incorrect parental perceptions (Pearson's chi-square test)

Physician's opinion on child's BWS and parental attitude towards the health effects of obesity

The history of physician's opinion on child's BWS versus actual BWS is presented in Table 4. Almost twenty percent (19.6%) of parents with overweight children were told by their physician about their child's weight problem (p<0.001). Meanwhile, 26.1%

Table 4. History of physician's opinion on child's body weight status, parental attitude towards the health effects of obesity vs. actual BMI categories

Characteristics	*Actual body weight status*			*p-value*
	Thin	*Normal*	*Overweight*	
History of physician's opinion on child's body weight status，n (%)				
Did your physician ever tell you that your child is overweight?				
Yes	0 (0.0)	2 (0.9)	22 (19.6)	<0.001
Never	46 (100.0)	229 (99.1)	90 (80.4)	
Did your physician ever tell you that your child is underweight?				
Yes	12 (26.1)	15 (6.5)	4 (3.6)	<0.001
Never	34 (73.9)	216 (93.5)	108 (96.4)	
Percentage (%) agree or strongly agree vs. actual body weight status				
I am worried about my child's weight right now	54.3	16.5	56.3	<0.001†
Overweight children are likely to become overweight adults	65.2	56.3	58.9	0.844†
Overweight children are more likely to develop diabetes (high blood sugar) than children who are not overweight	84.8	71.0	67.9	0.349†
Overweight children are more likely to have problems in their social relationships with other children who are not overweight	71.7	50.6	56.3	0.252†
Eating habits of parents influence the eating habits of their children	65.2	64.5	60.7	0.795†

Pearson's chi-square test

†*p*-values for differences between parental attitude towards health effects of obesity *vs*. actual body weight status (Pearson's chi-square test)

(Physician refers to any medical doctor which the parents and the children meet during check-up at any clinic or hospital)

of parents with an underweight child reported being told by their physician that their child was underweight as compared to parents with normal (6.5%) and overweight (3.6%) children.

More than half of the parents of overweight (56.3%) and underweight (54.3%) children were worried about their child's BWS ($p<0.001$) (Table 4). Majority of parents (65.2%) agreed that overweight children were more likely to become obese during adulthood, develop diabetes and have problems with their social relationships compared to children with normal body weights. Parents of children in all BMI groups held similar opinions about the influence of parents' eating habits on the eating habits of their children.

Table 5. Associated factors of parents' misperception on their child's body weight status by simple and multiple logistic regression model

Risk factor	*Regression coefficient (β)*	*Crude OR*[†] *(95% CI)*	*Wald statistic*	*p-value*	*Regression coefficient (β)*	*Adjusted OR*[‡] *(95% CI)*	*Wald statistic*	*p-value*
Gender								
Male	0	1						
Female	0.301	1.35 (0.83, 2.21)	1.45	0.228				
Age (years)								
9	0	1						
10	0.581	1.79 (0.90, 3.57)	2.71	0.100				
11	0.018	1.02 (0.57, 1.83)	0.04	0.952				
School location								
Urban	0	1			0	1		
Rural	0.539	1.79 (1.08, 2.74)	5.12	0.023	0.632	1.88 (1.15, 3.09)	6.26	0.012
Actual BMI category								
Underweight	0	1			0	1		
Normal	- 0.344	0.71 (0.32, 1.55)	0.74	0.388	-0.388	0.68 (0.31, 1.49)	0.93	0.336
Overweight	1.138	3.12 (1.41, 6.90)	7.91	0.005	1.109	3.03 (1.36, 6.75)	7.35	0.007
Family size (member)								
1 to 4	0	1						
5 to 6	0.156	1.17 (0.58, 2.37)	0.19	0.665				
≥7	-0.026	0.97 (0.47, 2.01)	0.01	0.974				
Family history of obesity								
No	0	1						
Yes	0.208	1.23 (0.59, 2.59)	0.301	0.538				
Household income[§] (RM)								
<2300	0							
2300-5599	0.112	1.12 (0.58, 2.14)	0.113	0.74				
>5600	-0.203	0.82 (0.31, 2.14)	0.171	0.68				

[†]Binary logistic regression

[‡]Forward LR multiple logistic regression model was applied; multicollinearity and interaction term were checked and not found; Hosmer-Lemeshow test, (p=0.915), classification table (overall correctly classified percentage=76.2%) and area under the ROC curve (69.3%) were applied to check for model fit

[§]Household income level based on the 10th Malaysia Plan 2011-2015 classification

Factors related with parental misperceptions

Logistic regression analysis was used to identify the predictors for the misclassification of parent's perceived BWS as compared to actual measurements. Crude and Adjusted Odds Ratio (OR) from simple and multiple logistic regression are presented in Table 5, respectively. Out of seven variables which were age, gender, school location, actual BMI categories, family income, family history of obesity and family size, two variables were found to be statistically significant predictors for parents' misperceptions. The analysis revealed that the greatest predictor of parental misperceptions was the child's actual BWS, followed by school location. Parents of overweight children (*OR*=3.03) and rural school children (*OR*=1.88) were more likely to misperceive their child's BWS, after controlling for gender, age, family size, family history of obesity and household income. The Hosmer-Lemeshow Test (χ^2=0.968, degrees of freedom=4; *p*=0.915) indicated that numbers of misclassification were not significantly different from those predicted by the model and the overall model fit was good. There was no significant association between the misclassification of parent's perceived BWS and other factors (gender, age, family size, family history of obesity and household income).

DISCUSSION

To our knowledge, this is the first study that attempted to identify parental misperception of BWS among school children in Kuala Terengganu, Malaysia and to explore the factors associated with such misperception. The current findings confirmed the observation from previous studies that a substantial percentage of parents inaccurately categorise their child's BWS. Almost twenty-six percent (25.7%) of parents in this study misperceived their child's BWS. This finding is comparable from that of Muhamad *et al.* (2008) who reported a higher percentage of misperception (38.2%) among 204 parents of 9 to 12 years old children in Kuala Lumpur. The study also suggested that knowledge on nutrition and obesity among parents was not associated with the ability to recognise the development of overweight and obesity problems among their children. Similarly, another local study by Serene Tung *et al.* (2011) also found a total of 50.8% parents who had an incorrect perception of their child's BWS. However, the researchers pooled the findings on misperception, which included the over-estimators (12.8%), under-estimators (19.6%) and non-estimators (18.4%). Only 49.2% of the parents correctly perceived their children's weight (correct estimators). Nonetheless, the available evidence seems to suggest that the accuracy of parental perceptions of their child's BWS has not changed from previous studies (Gerards *et al.*, 2014; Tompkins *et al.*, 2015).

This study found notable proportions of misperceptions among parents on their child's BWS. Only 53% of the parent's perceptions of overweight children had an agreement with the actual BWS. In line with a previous finding (Karunanayake *et al.*, 2016), this study reported that almost half of the parents of overweight children (46.4%) failed to accurately categorise their child's BWS. Parry *et al.* (2008) suggested that misperception among parents regarding their child's BWS increases as population gets fatter. This is based on the presumption that "what is common is alright", thus making heavier weight become more culturally acceptable (Parry *et al.*, 2008). The tendency of these parents to minimise issues related

to overweight might also be intensified especially when majority of the family members are obese, or when excess body weight is something common in their living community (Francescatto *et al.*, 2014). This is further supported by the increasing prevalence of childhood obesity among low- and middle-income Asian countries, which have become home to nearly half of the world's obese children (WHO, 2016). In Malaysia, the National Health and Morbidity Survey (NHMS) in the year 2015 (IPH, 2015) reported that 11.9% children aged <18 years were obese, which almost doubled from 6.1% in 2011 (IPH, 2011). Another potential explanation for the misperception may be due to the gradual changes in a child's body weight including both muscle and fat that occur over time, which are often unnoticeable, thus ignored by parents. Eventually, due to the gradual shift of weight, parents failed to recognise when their children have become overweight or obese (Hansen *et al.*, 2014). Nonetheless, parental misperception regarding their child's BWS is hypothesised to be associated with the "theory of idealisation", in which parents idealise their child to be of a normal size (Hager *et al.*, 2012). This may be due to cultural influence which often regards high body weight as a sign of successful parenting, especially during early childhood (Southwell & Fox, 2011).

Previous studies have linked discrepancy between parental perception and actual BWS of children with several associated factors. Gender of the child possibly influences the parent's classification of BWS (Karunanayake *et al.*, 2016). In contrast with earlier findings (De La O *et al.*, 2009; Maynard *et al.*, 2003), this study reported no significant gender difference in percentage of misperception among parents. Maynard *et al.* (2003) reported that mothers of overweight daughters were three times more likely to misclassify their child's BWS as compared to mothers of overweight sons. This indicated that parents may have a different set of thresholds regarding overweight status between gender. Besides, since females are known to have a higher recognition of body image and body weight concerns compared to males, it may also trigger parents to pay more attention to girls' body image than that of boys'. Not only that, a previous finding found that the age of the children could also influence parents' perceptions (Duncan *et al.*, 2015). However, in the present study, there was no relationship found between the child's age and parent's perception. In contrast, a study by Júlíusson *et al.* (2011) reported that parents were more likely to underestimate their younger overweight children (2-5 years old), whilst in older children, parents tended to overestimate their underweight teenagers (12-19 years old). They suggested that parents who underestimated their young children were reluctant to label their toddler as overweight due to misconception that weight gains during this stage reflected healthy growth in children. Conversely, parents who misclassified their underweight teenagers as being normal may have distortion in healthy body image. Nevertheless, there are several socio-economic factors such as parental education level and family income that may influence parental perceptions of their child's BWS (Hansen *et al.*, 2014). In agreement with previous studies, this study found no relationship between socio-economic status and parental perceptions of their child's BWS. Nonetheless, a previous study by Hearst *et al.* (2011) reported 8.92 times higher odds of misperception in overweight children by non-college-graduated parents as compared to four times higher odds among college-graduated parents. This rather contradictory result may be

owing to the difference in the studied population.

Although a high percentage of parents with overweight children underestimated their child's body weight status, only 56.3% of these parents were found to be worried about their child's body weight and agreed with the health and psychosocial effects of obesity. A possible explanation for this finding may be related to the "optimistic bias" of personal risk (Weinstein, 1989). These parents simply deny the fact that their child is overweight or obese and use this bias as a coping strategy when confronted with the health risks of obesity (Myers & Vargas, 2000). In other words, parents who operate under this situation distort their views from the possible consequences of overweight on their children. However, despite the high prevalence of overweight reported in this study, only one out of five parents of overweight children reported being told by a clinician about their child's body weight problem. This intriguing finding may be due to a lack in routine healthcare follow-up or misreporting among parents. There are possibilities that clinicians did not inform parents about their children's body weight status as a health risk. Based on the 1999 to 2002 analysis of the National Health and Nutritional Survey (NHANES) by the Centre for Disease Control and Prevention (CDC), it was reported that only 36.7% of overweight children aged 2 to 19 years were told by their clinicians that they were overweight. Since early detection of obesity and its related consequences are crucial, clinicians are expected to convey the information to parents to ensure a better understanding on the definition of childhood obesity and to increase their awareness of their child's body weight status (Rietmeijer-Mentink *et al.*, 2013).

Previous studies have found large variabilities in the predictors influencing parental perception of their child's BWS (Gerards *et al.*, 2014; Karunanayake *et al.*, 2016). The current study found that the strongest predictor related to the inaccuracy of parental perception of their child's BWS was having an overweight child. Secondly, the most interesting finding from the logistic regression analysis was that parents from rural areas were twice more likely to misclassify their child's BWS as compared to their urban counterparts. These findings are important for Terengganu stakeholders particularly in the Kuala Terengganu district as this district has a higher prevalence of childhood obesity in the rural (14.1%) compared to the urban area (12.7%) (Nurzaime *et al.*, 2017). Despite Kuala Terengganu being the capital district of Terengganu, there are underprivileged and underdeveloped areas which are associated with lower socioeconomic status (SES). Previous studies have reported an association between low SES particularly parental education level with a higher percentage of misperception of child's weight among parents, indicating that families with lower education level and economic background probably have decreased level of awareness about healthy body weight (Hearst *et al.*, 2011). The present study also found that parents with overweight children (those with BAZ>1SD) were three times more likely to have inaccurate perceptions of their child's BWS. Additionally, a previous study by Huang *et al.* (2009) found that parents with at-risk-of-overweight (AROW) and overweight children were 67% less likely to recognise their own child's BWS as compared with their normal and underweight counterparts (OR=0.33, 95% CI: 0.23, 0.46). The findings reported in this study suggested the association between parental misperception of their child's body weight and low health literacy leading to distorted perception of healthy weight. Therefore, this warrants an active role

of healthcare providers in informing all parents of overweight children on the risks of obesity-related health problems and its co-morbidities, and offer family-based body weight control interventions.

The high percentage of parental misperception from the present study provided evidence to support the conceptual premise that parental recognition of their child's BWS is the precursor and a critical component of successful weight management practices in children. Furthermore, parental perception on their child's BWS may determine the level of support on health, activity and behaviour of the family. The ability of parents to correctly identify their child's body weight problem often indicate their concern and intention to positively modify their family lifestyle and behaviours compared to parents who overlook the problem. However, contradicting to popular belief, Robinson and Sutin (2016) found that the ability of parents to identify weight problem of their children did not act as a protective factor against obesity. Instead, it led to further weight gain across childhood. The stigma and label that were attached to the children not only increased the risk of lower self-esteem and unhealthy weight-control behaviours; it may also change the way parents treat their children. Children who are viewed as overweight by their parents tend to gain more weight across childhood, irrespective of their initial BMI. These parents are more likely to encourage unhealthy eating, serve larger meals and may believe that their child's body weight itself prevents the child from doing exercises, which eventually leads to further weight gains (Robinson & Sutin, 2016). Therefore, a study proposed that instead of commenting on their child's body weight, parents should provide a home environment that nurtures healthy eating and active behaviours in the family (Neumark-sztainer *et al.*, 2011). In addition, healthcare providers can play an important role by discussing and advising the parents about their child's BWS, thus suggesting management strategies to control the associated problems.

Strengths and limitations

This study was the first attempt to assess the perceptions of parents from Terengganu on BWS of their children, which offered some insights on the factors that influence their perceptions. The most meaningful finding from this study was that both parents with overweight children and those from rural areas had difficulties understanding their children's BWS. Therefore, the information presented herein will serve as an accurate baseline quantitative data that can be used in planning future research. BWS based on height and weight measured by trained personnel has reduced the potential of bias compared with studies that used self-reported data.

The present study did not cover other related factors especially parental BWS and parenting styles, which may also be associated with parent's perception of their child's BWS. Furthermore, the study design was cross-sectional and therefore could only describe the association between parental perception of child's BWS and child's actual BWS, and also parental concern about their child's body weight and health, but obviously could not explain the causality effect. This study also did not include pubertal assessment using Tanner staging, thus may have overlooked the influence of a child's pubertal and maturity stage on parental perception of his/ her BWS.

CONCLUSION

This study highlighted that majority of parents failed to accurately determine

their child's BWS. Parental misperception on their child's BWS particularly on those with weight problems potentially impedes the intervention and prevention against obesity. Parental acknowledgement of body weight problem among their children is crucial as the initial step of promoting positive behaviours among the family members. Moreover, parental identification reflects the level of parental understanding with regards to BWS and health. Apparently, parents from rural area and those having overweight children were more likely to have a misperception of their child's BWS. Therefore, novel strategies that are culturally-tailored to this population are required to improve parental identification of their child's BWS. Additionally, health-care providers also play an important role in identifying children with body weight problems and assisting parents with suitable family-based obesity prevention strategies. This research has thrown up many questions that require further research to understand on how parental perception of their child's BWS may affect further weight gain and future health outcomes among these children.

Acknowledgement

The authors would like to acknowledge the Malaysian Ministry of Education and Terengganu State Education Department for the permission granted to conduct this study. Enormous appreciation extended to the participating school children and their caregivers, all teachers and school administrators, enumerators and to all members of the Health of Adolescents in Terengganu study (HATs). Funding for this research was provided by the Malaysian Ministry of Higher Education's Fundamental Research Grant Scheme (FRGS/2/2013/SKK/UNISZA/01/1).

Authors' contribution

NZ, made substantial contributions to the acquisition of data, analysis and interpretation of data, and also participated in manuscript writing, drafting and revising it critically for important intellectual content; AA, principal investigator, grant owner, made major contributions to the conception and design, methodology, acquisition of data, analysis and interpretation of data, drafting, writing and revising of the manuscript; MRS, made substantial contributions to methodology, acquisition analysis and interpretation of data, and also participated in the drafting of the manuscript and revising it critically for important intellectual content; AA, made substantial contributions to the idea, conception and design, methodology, acquisition of data, statistical analysis and interpretation of data, and also participated in drafting of the manuscript and revising it critically for important intellectual content.

Conflict of interest

All authors declare no potential conflict of interest with respect to the research, authorship, and/or publication of this article.

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Mal J Nutr 26(2): 189-201, 2020

School-based nutrition education to improve children and their mothers' knowledge on food and nutrition in rural areas of the Philippines

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ABSTRACT

Introduction: Nutrition education among school children and their mothers is an opportunity to promote lifelong healthy eating behaviours to improve their nutrition and well-being. The present study determined the effectiveness of nutrition education modules in improving children and their mothers' knowledge on food and nutrition. Likewise, changes in attitude and behaviour among children were also determined. **Methods:** Five nutrition education modules were developed with key messages on healthy plate, fruits and vegetables, protein sources, nutrient-dense sources of energy, and water and healthy beverages. Grades 2 and 3 students received 60 hours of nutrition education with a duration of 25 minutes per session. Students were divided into two groups: (1) nutrition education alone (n=83) and (2) nutrition education with feeding (n=83). Simultaneously, a total of nine one-hour nutrition education sessions were conducted among mothers, following the same five modules taught to the students. Mothers were also grouped according to their child's group. **Results:** Student participants in both groups exhibited improvements in mean scores on knowledge, attitude, and behaviour (KAB) from baseline to end line. Based on results of mothers' classes, mean post-test scores of participants were significantly higher than mean pre-test scores in both groups. Group 1 had a higher increase in score from 67.2±32.8 at pre-test to 71.8±33.7 in post-test. **Conclusion:** The developed nutrition education modules were effective in teaching children proper nutrition. Incorporation of these modules into the K to 12 curriculum will emphasise importance of proper nutrition in early childhood. Moreover, mothers' classes can be an effective way to bridge the gap between school and community nutrition interventions.

Keywords: School-based nutrition education, nutrition knowledge scores, mothers' nutrition classes

INTRODUCTION

Stunting and underweight among Filipino school children of 6-10 years old are still public health problems of high severity with prevalences of 31.1% and 31.2%, respectively, as reported in the 2015 Updating National Nutrition Survey of the Department of Science and Technology-Food and Nutrition Research Institute (DOST-FNRI) (FNRI-DOST, 2015). Overweight and obesity are also growing problems for this age group with a prevalence of 8.6%.

Nutrition plays a vital role in ensuring

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doi: https://doi.org/10.31246/mjn-2020-0004

full potential physiological and cognitive growths among children. Eating habits, which also develops early in life, can also affect health and nutritional status of children. Thus, teaching nutrition at an early age can be an opportunity to promote lifelong healthy eating habits and other behaviours to improve nutrition and well-being of school children.

Schools are the most effective and efficient venue to reach out to young children, school staffs, families and community members via nutrition education. In addition, children and adolescents spend the most time in schools (Aldinger & Jones, 1998; Perez-Rodrigo *et al.*, 2001). Several studies examined the effects of school-based nutrition and health education in improving nutrition and health-related knowledge, attitude and behaviour (KAB) of children related to healthy eating, diet, physical activity, and increased consumption of fruits and vegetables (Wall *et al.*, 2012; Watts, 2012; Evans *et al.*, 2016). Other studies looked into the duration, length and frequency of nutrition education interventions in relation to increasing fruits and vegetables consumption, increasing physical activity, promoting healthy eating and reducing overweight and obesity among school children (Morgan *et al.*, 2010; Prelip *et al.*, 2012; Rosario *et al.*, 2012; Moss *et al.*, 2013). Based on a systematic review across 7218 studies about the effectiveness of school-based interventions among children and adolescents aged 6–18 years old, most school-based interventions (82.0%) have the potential to improve dietary and physical activity behaviours and to prevent unhealthy body weights in low- and middle-income countries. To reach full potential, process evaluations that document programme implementation should be conducted (Verstraeten *et al.*, 2012). Another systematic review which identified effective behavioural models and behavioural change strategies showed a similar outcome and suggested that interventions should also be focused on developing children's and parents' perceived competence at making dietary and physical changes (Nixon, 2012). Evidence suggests that school-based nutrition education is effective in improving nutrition knowledge and attitudes of school children. Nutrition education in the classroom is intended to convey nutrition information and change unhealthy attitudes to motivate students in establishing healthy eating practices and to teach positive skills.

In the Philippines, schools recently transitioned to a new curriculum with a 13-year basic education called the K to 12 Programme. The K to 12 Programme covers Kindergarten and 12 years of basic education (six years of primary education, four years of Junior High School, and two years of Senior High School [SHS]). In this curriculum, nutrition is taught in the first quarter of each school year among Grades 1-4 students as part of their Health subject. For Grade 1, nutrition topics focus on healthful and less healthful foods, consequences of eating less and good eating habits. Nutrition topics for Grade 2 include healthy foods and the body, and guides in eating a balanced diet such as the food pyramid and healthy plate. For Grade 3, good nutrition and health, and Nutritional Guidelines for Filipinos (NGF) are topics included in the curriculum guide. Reading food labels and food safety principles are topics discussed in Grade 4 (Department of Education, 2016). Given that the curriculum is particularly new, learning materials can still be enhanced so that students acquire in-depth knowledge, skills, and attitudes, particularly on nutrition. Developing a good nutrition

education module is important to create an effective nutrition education (Anwar *et al.*, 2018).

Most of the local nutrition interventions by the government are focused only on children as programme participants. However, in reality, mothers and caregivers play an important role in achieving proper nutrition for children. Extending nutrition interventions to mothers will have a positive impact on health and nutrition. Improved nutrition knowledge of mothers can be applied in their households, thus preventing malnutrition among children (Sukandar *et al.*, 2015).

In August 2017, the DOST-FNRI undertook a comprehensive one-year school-based programme on food and nutrition, which includes feeding underweight school children and nutrition education among targeted school children and their mothers. The programme, Forging Public-Industry-Society alliance: A Program United for Healthier Kids (PISO for Healthy Kids), consisted of four components, namely, Project 1 – Translation of *Pinggang Pinoy* for Children into Adequate Meals, Project 2 – Translation of *Pinggang Pinoy* for Children into Adequate Meals - Recipe Development, Project 3 – Nutrition Education, and Project 4 – Evaluation Research.

Project 3 of the programme - Nutrition Education aimed to develop nutrition education modules for use by Grades 2 and 3 teachers of four selected public elementary schools, and to conduct nutrition education campaigns among Grades 2 and 3 students of selected public schools and their mothers or caregivers. Therefore, the present study determined the effectiveness of these developed nutrition education modules in improving children and their mothers' knowledge on food and nutrition. Likewise, changes in behaviours among children were also determined.

MATERIALS AND METHODS

Development of nutrition education modules

Workshop

A workshop was conducted among teams of DOST-FNRI nutritionist-dietitians and teachers from Daang Hari Elementary School, Bicutan, Taguig City, Philippines to develop comprehensive nutrition education modules that are in line with the K to 12 curriculum. Five nutrition education modules were developed based on the pre-determined key messages of the researchers.

Pre-testing of nutrition education modules

These nutrition education modules were pre-tested to determine their attractiveness, comprehensibility, acceptability, and self-involvement of the modules for Grades 2 and 3 students, and to assess if the materials given to the teachers were sufficient for the conduct of nutrition education classes. Pre-testing activities were done in elementary schools of both urban and rural areas. These elementary schools had similar characteristics with the study schools, but were not study participants.

The study employed random pre-testing. Pre-tested lessons were representative of five modules. Out of the 29 lessons in each module, nine lessons were randomly selected for pre-testing. These pre-testing lessons were also representative of the different learning activities included in the modules like word search, true or false, and matching type. Nutrition education lessons that were to be pre-tested were given to the teachers in advance for familiarisation. Collaterals for the lessons like worksheets, posters, flash cards, big books, and puzzles were also given in advance to the teachers. Teachers demonstrated the lessons in the modules and conducted individual or group activities for the evaluation of

the lessons. After the demonstration, the researchers conducted key informant interviews using a validated questionnaire developed by the researchers following the metrics of attractiveness, comprehensibility, acceptability and self-involvement.

Study design and participants

The study used a quasi-experimental design. The study participants were from the PISO for Healthy Kids programme who received nutrition education. A total of 1,788 Grades 2 and 3 students from four schools in Laguna, Philippines were included in the nutrition education sessions from August 2017 to March 2018. Among these students, 166 were considered eligible study participants based on criteria for age (7-9 years old) and nutritional status (underweight). The criteria for age were based on the age grouping of the Philippine Dietary Reference Intakes (PDRI). The eligible participants were the ones assessed based on changes in their KAB. Students were distributed into two groups: (1) nutrition education alone (n=83) and (2) nutrition education with feeding (n=83). Simultaneously, nutrition education sessions were conducted among mothers of these selected students, following the same five modules taught to the students. The groupings of the mothers were based on their child's grouping.

The intervention

Implementation of nutrition education component

A training entitled "Teaching Nutrition for Healthier Kids" was conducted to capacitate the teachers for the ensuing conduct of nutrition education in selected schools in Bay and Calauan, Laguna, Philippines. A total of 51 Grades 2 and 3 teachers from Calauan and Bay Central Elementary Schools attended the training on July 24-25, 2017. A nutritionist emphasised important nutrition concepts in every module to ensure that the teachers understood the content of the modules. After discussions on the technical content of the modules, a teaching demonstration of the nine sessions in each module was done. The teacher-participants were grouped and asked to demonstrate the nine topics in each module. The facilitators and nutritionists gave comments and suggestions for further improvement in discussing the nutrition concepts. A follow-up meeting was conducted among Grades 2 and 3 teachers after completing each module. This was done to get feedback from the teachers on the use of these modules.

Copies of the nutrition education modules were given to the teachers, which served as their guide in teaching students. The teachers followed the modules provided by the project and used the collaterals for each module. The teachers taught the modules in their individual creative ways by adding more photos and drawings, and supplementing the modules with audio-visual presentations and videos.

The students were exposed to nutrition education topics through a 25-minute session totalling to 144 sessions (about 60 hours). There was a dedicated time slot for the 25-minute nutrition education session, and was conducted during school days (Monday to Friday). The nutrition sessions were not incorporated in the Health and Science subject because in the existing curriculum, nutrition concepts are only discussed in the first quarter of each school year. The four schools conducted different number of hours of nutrition education sessions, ranging from 57.50 hours to 60.42 because of varying school activities and class suspensions due to typhoons and holidays (Table 1). Two nutritionist-researchers were assigned to ensure that the nutrition education sessions were conducted during school

Table 1. Number of hours of nutrition education conducted per school, grade level and section

Name of school	*Grade level and section*	*No. of hours of nutrition education*	*Reasons for not completing the 60 hours nutrition education*
Sto. Tomas Elementary School, Calauan, Laguna	Gr. 2-Emerald*	60.42	-
	Gr. 2-Pearl	60.42	-
	Gr. 2-Ruby	60.42	-
	Gr. 2-Amethyst	60.42	-
	Gr. 3-Rizal*	57.92	Additional school activities
	Gr. 3-Lapu-lapu	57.50	Additional school activities
	Gr. 3-Bonifacio	57.50	Additional school activities
	Gr. 3-Del Pilar	57.92	Additional school activities
	Gr. 3-Mabini	56.67	Additional school activities
	Gr. 3-Silang	57.50	Additional school activities
Dayap Eelementary School Annex, Calauan, Laguna	Gr. 2- Marangal*	58.33	Additional school activities
	Gr. 2-Matapat	58.33	Additional school activities
	Gr. 2-Matiyaga	57.92	Additional school activities
	Gr. 2-Magalang	57.92	Additional school activities
	Gr. 2-Masikap	57.92	Additional school activities
	Gr. 3-Matulungin	58.33	Additional school activities
Bay Central Elementary School, Bay, Laguan	Gr. 2-Luna*	58.33	Early school vacation
	Gr. 2-Amorsolo	58.33	Early school vacation
	Gr. 2-Tolentino	57.50	Early school vacation
	Gr. 2-Joya	57.50	Early school vacation
	Gr. 2-Francisco	57.92	Early school vacation
Kabaritan Elementary School, Bay, Laguna	Gr. 2-Polite	57.50	Early school vacation

days and to observe how the teachers conducted the lessons for improvement of its conduct in succeeding months.

Implementation of mothers' classes

The mothers' classes were done either once or twice a month alongside the nutrition education classes for students. DOST-FNRI nutritionist-researchers conducted a total of nine one-hour lectures among mothers using the same topics in the nutrition education modules taught to the students. The mothers' classes were designed to ensure that the topics covered were targeted to the mothers by presenting nutrition concepts through interactive ways and various formats like giving practical examples, asking mothers to share their experiences in meal planning and preparation, and conducting games and contest among the group. The mothers' classes were conducted so that key learning concepts taught to their children would also be learnt by the mothers. This way, reinforcement of key nutrition messages was addressed. Also, feedbacks on how their children were faring in terms of knowledge gained through nutrition education were also determined.

The nine sessions of mothers' classes covered all topics in the modules. One session of mothers' class comprised of 14 to 15 topics in the module taught to the students. This meant that one module was equivalent to 2 sessions of mothers' class. One session of mothers' class ran for an hour, inclusive of pre- and post-tests.

Each session included a pre-test before the start of the session to measure the baseline knowledge, followed by the nutrition lecture and a post-test after the session. Each session tackled different topics based on the five modules as detailed below:

- Module 1: Go, Grow and Glow + Water/Beverage in every plate (*Pinggang Pinoy*)
  - Session 1
    - Three food groups (Topics/ Sessions 1-8)
    - Healthy kids need water (Topics/Sessions 9-11)
  - Session 2
    - *Pinggang Pinoy* (Healthy Plate) for children, 6-9 years old (Topics/Sessions 12-19 including review of concepts)
- Module 2: Eat fruits and vegetables of varied colours (the colourful plate)
  - Session 3
    - Eat fruits and vegetables of every colour (Topics/Sessions 1-16)
    - Food choices from the fruit group and vegetable group (Topics/Sessions 17-19)
  - Session 4
    - Planting seeds for healthier eating (Topics/Sessions 20-26)
    - Why are fruits and vegetables important in a child's diet (Topics/Sessions 27-29)
- Module 3: Consume various kinds of protein sources
  - Session 5
    - The different protein sources (Topics/Sessions 1-14)
  - Session 6
    - The functions of protein for the body (Topics/Sessions 15-21)
    - Healthy proteins for healthy eating (Topics/Sessions 22-29)
- Module 4: Consume more nutrient-dense sources of energy
  - Session 7
    - Food sources of energy (cheap and concentrated sources of energy) (Topics/Sessions 1-6)
    - What are nutrient-dense foods (Topics/Sessions 7-15)
  - Session 8
    - Nutrient-dense or energy-dense foods (Topics/Sessions 16-23)
      - The taste palette
      - How sweet or salty are you
    - Why are nutrient-dense foods important in a child's diet (Topics/Session 24-29)
      - Smart snacking
- Module 5: Drink recommended glasses of water and complement it with nutritious beverages
  - Session 9:
    - The water cycle (Topics/ Sessions 1-6)
    - Forms and sources of water (Topics/Sessions 7-16)
    - Drink enough healthy fluids (Topics/Sessions17-22)
      - Better beverages choices
    - Kid-friendly beverages
    - Why are water and other nutritious beverages important in a child's diets

Data collection

The study used validated questionnaires developed specifically for the study. KAB of children and mothers/caregivers were collected at baseline and end line. The

study also used the modified version of the Child and Diet Evaluation Tool (CADET) questionnaire developed by the Nutrition Epidemiology Group, Division of Epidemiology and Biostatistics of the University of Leeds for behaviour change indicators among student participants.

For mothers' classes, a 10-item validated questionnaire was used to measure increase in knowledge on the nutrition concepts taught. The 10-item questionnaire used in the mothers' classes for pre- and post-tests were not the same as what was used for the children in terms of knowledge. All the pre- and post-test questions for the mothers' classes were derived from the modules or lectures. Questionnaire used for the children were developed based on the modules taught to the students.

Data analysis

Data collected were encoded, processed and analysed using the Statistical Package for Social Sciences (SPSS) for Windows versions 16 and 20. Paired *t*-test was used to compare means between groups and between periods for each group. A p-value<0.05 was considered significant for the tests performed.

The changes in the mean scores on KAB among children were compared within and between groups by period of data collection. The changes in mean pre-test and post-test scores of mothers were also compared between groups. For the mean score on behaviour among children and mothers, the 4-option choices (i.e. always; often; seldom; and never) were recoded into 3-option choices (i.e. 'always' and 'often' combined; seldom; never).

The mean scores for CADET attitude were determined. The 5-option choices (i.e., strongly agree; agree; neutral; strongly disagree; and disagree) were recoded into 3-option choices ('strongly agree' and 'agree' combined; neutral; 'strongly disagree' and 'disagree' combined).

Ethical considerations

Prior to programme implementation, the research protocols were approved and cleared on May 31, 2017 by the FNRI Institutional Ethics Review Committee (IERC) with the code FIERC-2017-007.

The teachers and others/caregivers of the students were orientated on the objectives and details of the study. Participants were assured of the confidentiality of information collected in connection with the study. Mothers/caregivers signed the consent forms for participation in the study during the orientation. Students' assents to participate in the study were also sought with the assistance of the teachers, who explained and guided them in filling-up the Assent Forms.

RESULTS

A total of five nutrition education modules were developed with key messages as follows: 1. Go, Grow and Glow + Water/beverage in every plate (*Pinggang Pinoy*); 2. Eat fruits and vegetables of varied colours (the colourful plate); 3. Consume various kinds of protein sources; 4. Consume more nutrient-dense sources of energy; and 5. Drink recommended glasses of water and complement it with nutritious beverages. The modules were revised accordingly based on the comments and suggestions from the teachers (Table 2).

The results showed that student participants in both groups exhibited an improvement in mean scores on knowledge from baseline to end line, but the improvement was only significant in Group 2 (55.7±7.3 to 58.6±4.7, p=0.01). In terms of attitude, increments in the scores were observed at end line for children in both groups. In terms of

Table 2. Title of the modules and highlights of pre-testing of each module

Title of modules	*Highlights of pre-testing of each module*
Module 1: Go, Grow and Glow + Water/Beverage in every plate (*Pinggang Pinoy*)	• More visuals, actual food items, bigger photos; module is attractive, additional materials in teaching like video clips on GO, GROW, GLOW foods; activities like jumbled words and word search should be group activity instead of individual activity • Teachers need to emphasise and explain unfamiliar words to students • Teachers may introduce games to be more familiar with concepts • Negative sentence should be rephrased in a more positive note
Module 2: Eat fruits and vegetables of varied colours (the colourful plate)	• More colourful visuals and pictures for visualisation • Video presentation as supplement to the module • Identification of vegetables can be done through actual or plastic food items • Add in the presentation part, photos of healthy foods and less healthy foods • For the evaluation part of the module, change the instruction like study the picture, encircle the healthy foods and cross out unhealthy foods, multiple choice
Module 3: Consume various kinds of protein sources	• Video clips during motivation part related to the lesson • Photos should be available in local setting • More pictures, video presentation and group activities • Too technical terms • For evaluation part of the module, change enumeration to multiple choice or word or picture matching type and colouring the food item instead asking the children to draw sources of protein • The evaluation can be colour the sources of red meat, instead of letting them draw • Generalisation of the session should be emphasised through group reading-text visuals for generalisation
Consume more nutrient-dense sources of energy	• Video presentation for discussion part of the session • Include games to show teamwork among students • Big book should have bigger words • Add more photos for visualisation of the lesson • Add props like pictures during storytelling activity • The application part of the module can be a group activity to show teamwork
Drink recommended glasses of water and complement it with nutritious beverages	• Video clip should not be used for generalisation • Add photos with explanation • Session is more appropriate to Grade 3 • Change the motivation part, it does not jive with the objectives

Table 3. Mean scores on KAB of children at baseline and end line*

Period	*Scores (Mean±SD)*	
	Group 1	*Group 2*
Knowledge		
Baseline	13.7±4.3	13.6±4.5
End line	16.6±4.1	17.5±5.3
p-value (base-end)	<0.001*	<0.001*
Attitude		
Baseline	63.3±7.7	63.4±7.6
End line	64.8±7.7	65.8±8.4
p-value (base-end)	0.110	0.050
Behaviour		
Baseline	56.4±5.1	55.7±7.3
End line	56.8±5.7	58.6±4.7
p-value (base-end)	0.648	0.001

Source: Project 4: Evaluation Research under the Programme PISO for Healthier Kids
*$p<0.05$ represents statistical significance (paired *t*-test)

changes in behaviour, there was an increase in mean scores of both groups from baseline to end line, but with significant difference only in Group 2 (Table 3).

As presented in Table 4, the post-test scores of participants in both groups were significantly higher than their pre-test scores. Group 1 had a higher increase in score from 67.2±32.8 at pre-test to 71.8±33.7 in post-test. However, only five sessions among those in Group 1 had significant increases from pre-test to post-test scores. Contrariwise, all but one session among those in Group 2 had scores which increased significantly from pre-test to post-test. Moreover, participants obtained the highest scores in sessions 1, 4 and 8 in both groups. These topics were generally about the three food groups and water, importance of eating fruits and vegetables, and nutrient-dense foods, respectively.

Table 4. Pre- and post-tests scores (*mean±SD*) of participants of mothers' classes

Session	*Group 1*			*Group 2*		
	Pre-test	*Post-test*	*p*	*Pre-test*	*Post-test*	*p*
Session 1	13.4±0.9	14.6±0.6	0.001*	13.6±0.9	14.1±0.6	0.002*
Session 2	12.9±0.7	13.4±1.2	0.168	12.9±0.9	13.5±0.6	<0.001*
Session 3	12.8±0.9	13.3±1.4	0.180	12.9±1.4	13.8±1.6	0.001*
Session 4	13.4±1.2	14.1±0.8	0.015*	13.3±1.6	14.3±0.8	<0.001*
Session 5	12.6±0.8	12.7±1.4	0.866	12.5±1.2	13.4±1.1	<0.001*
Session 6	12.6±1.8	13.3±1.7	0.108	12.1±2.1	13.7±1.5	<0.001*
Session 7	11.5±1.9	13.5±1.5	0.004*	12.0±1.2	13.6±1.5	<0.001*
Session 8	13.0±1.2	14.0±1.0	<0.001*	13.4±1.1	14.0±1.0	0.011*
Session 9	12.9±1.5	13.7±1.6	0.033*	13.2±1.6	13.7±1.1	0.065
Total	67.2±32.8	71.8±33.7	<0.001*	49.1±36.3	52.2±32.8	<0.001*

*$p<0.05$ represents statistical significance (paired *t*-test)

DISCUSSION

Nutrition education is for teachers and students. Teachers play an important role in helping students develop good eating habits. As teachers learn more about food and nutrition, they can better convey nutrition information to their students.

Prior to the conduct of the nutrition education campaign, teachers were trained to capacitate them in teaching nutrition. In the study done by Stage *et al.* (2016), providing teachers with professional developments like training and integrative resources and activities may result in improved self-efficacy in teaching nutrition, but the amount of training needed to improve this should be considered. Perceived self-efficacy is the people's beliefs about their capabilities to produce effects (Bandura, 1994). A study by Ross & Bruce (2007) attributed that professional developments likely led to increased knowledge and confidence in teachers. Therefore, Falhman *et al.* (2011) found that as self-efficacy was related to teacher's effectiveness in teaching nutrition, thus providing them with continual training should be pursued.

In the present study, the nutrition education sessions were taught as a separate subject and had a dedicated time slot in each school depending on the approved schedule by the school principal. A total of 144 sessions were conducted during school days totalling to 60 hours, which was more than the recommended number of 40-50 hours needed to exhibit behavioural changes based on previous studies (Connell, Turner & Mason, 1985; Contento, 1995; Perera *et al.*, 2015). The nutrition sessions were not incorporated in the Health subject because nutrition concepts were only discussed in the first quarter of the school year as specified in the K to 12 curriculum. Our study is in contrast with the study of Perera *et al.* (2015), which suggested that nutrition education can be implemented by integrating it in the Math, Science, and/or English subjects.

The results showed that children in all study groups exhibited significant improvements in their mean scores on KAB from baseline to end line. This is consistent with the study conducted by Connell *et al.* (1985) that few hours of classroom instructions were needed to produce knowledge effects, while more hours of classroom education to produce attitude and practice effects. To establish stable effects for knowledge, attitude and practice, about 40-50 classroom hours are needed. Another study confirmed that they needed 15 classroom hours to have an effect on knowledge, and 50 hours per year to bring about changes in attitudes and behaviours (Contento *et al.*, 1995).

A total of nine sessions or nine hours of nutrition education among mothers were conducted following the same five modules taught to the students. Nutrition education is beneficial in increasing mothers' nutritional knowledge and improving their children's nutritional status. Empirical evidence suggests that the greater the knowledge of mothers on health and nutrition, the better is the overall quality of their children's diet (Blaylock, Variyam & Lin, 1999). A recent study conducted by Mbogori & Murimi (2019) strengthens the importance of nutrition education with results stating that maternal nutrition knowledge improved after a nutrition education intervention. Another study also found that nutritional status of children with and without supplementary feeding improved significantly when their mothers received nutrition education twice a week for three months (Roy *et al.*, 2005). Although these studies showed significant results among children under five years old only, continuous conduct of

nutrition education targeted at mothers would still have a positive impact to their nutritional knowledge and the nutritional status of their children as they age.

The above mentioned studies were all conducted in low- to middle-income countries which have high prevalences of malnutrition. Moreover, programmes which aim to address malnutrition problems usually target these countries. The Catholic Relief Services, in partnership with the World Bank, implemented a four-year programme called the "Community-Driven Nutrition Improvement Programme" or CDNIP focusing on mothers and their children to improve nutrition in targeted communities of Timor-Leste. The programme worked with the communities to educate young mothers and pregnant women on the importance of nutrition and healthy lifestyles. Through this programme, families are increasing the variety of fruits and vegetables they eat with meals, more regularly including sources of protein, and mothers learn about the importance of eating different types of foods which will help their children grow (World Bank, 2017).

CONCLUSION

The nutrition education modules developed by the project can greatly help teachers in teaching proper nutrition and good food habits to school children. For the mothers' classes, the nutrition education campaign was effective in improving the nutrition knowledge of mothers. In addition, the study showed improvements in KAB of students using the developed nutrition education modules.

However, some limitations were still encountered. Firstly, there was a lack of trainings conducted among the teachers due to time constraint, but the researchers were able to conduct feedback meetings after completion of each module. Some classes were not able to reach a total of 60 hours for the sessions because of varying school activities and class suspensions due to typhoons and holidays.

The study recommends that nutrition is included in the K to 12 curriculum as a separate subject from Music, Arts, PE, and Health (MAPEH) subjects, instead of limiting to one quarter of the school year. In addition, nutrition education modules developed can be used to teach children on proper nutrition. Incorporation of these modules in the curriculum can be a way to introduce proper nutrition in early life of children.

Moreover, the study underscores the mother-child pairing for nutrition education to be sustained and that lessons taught to students must be the same with those taught to mothers for follow-through of learnings in the home. Other than teaching children, setting up mothers' classes can be an effective way to bridge the gap between school and community nutrition interventions.

Acknowledgement

The authors would like to acknowledge the support of Ms. Divorah V. Aguila, DOST-FNRI Planning Officer IV and Project Coordinator of PISO for Healthy Kids for facilitating the smooth conduct of the project; Creative Publications Unit (CPU) staff for assisting in the conduct of pre-testing of five nutrition education modules; and Ms. Julieta B. Dorado, DOST-FNRI Supervising Science Research Specialist and Project 4 Component Leader for allowing us to use some results from the evaluation component. The authors also acknowledge the participation and help of the teachers and children involved in the study.

Authors' contributions

IGG, principal investigator, conceptualised and designed the study, led the data collection in Bay and Calauan, Laguna, prepared the draft and final manuscript, reviewed the final manuscript before submission to Malaysian Journal of Nutrition; revise the manuscript based on the comments of two reviewers; MSG, conceptualised and designed the study; assisted in drafting of the manuscript, reviewed the final manuscript before submission

to Malaysian Journal of Nutrition; AMPM, data analysis and interpretation, assisted in drafting of the manuscript, proofread the manuscript and assisted in the revision of manuscript based on the comments of two reviewers.

Conflict of interest

The authors declare no conflict of interest in this study. PISO for Healthy Kids project was supported by Nestle Inc. Philippines. The funding organisation did not exert influence on the study methodology and interpretation of the findings.

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Mal J Nutr 26(2): 203-213, 2020

Food consumption behaviours and associated personal and socio-economic factors in elderly adults, Northeastern Thailand

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ABSTRACT

Introduction: This research was a cross-sectional study. The objective was to study food consumption behaviours and associated factors in elderly adults in the Northeastern Region. **Methods:** The study included 1,336 older adults (age >60 years) from five provinces, i.e. Udornthani, Nakornratchasima, Mahasarakam, Nakhonpanom and Amnatcharoen. Random multi-stage sampling was used, and data were collected through interview. The statistics used for content analysis was percentage, mean, standard deviation (*SD*) and multiple logistic regression analysis. **Results:** The food consumption behaviours of the study population was fair or poor (60.0%), followed by good (40.0%). Multiple logistic regression revealed that there were some personal factors that were significantly associated with food consumption behaviours. These factors included sex, education level, living condition, health condition, knowledge, attitude and preference of food. Regarding the effect of socio-economic factors towards food consumption behaviours, it was found that those effects included food sources and food factors. **Conclusion:** Local health authorities should pay attention to the factors mentioned above in order to designate policies or methods to oversee future food consumption behaviours in the elderly.

Keywords: Food consumption behaviours, factors, elderly, Thailand

INTRODUCTION

Thailand faced a tremendous change in its population structure since 2005 when it entered the Aged Society. Ten percent of the Thai population is over 60 years old and this number is likely to grow. In 2017, 17% of the Thai population was aged. It has been predicted that Thailand will be a Complete Aged Society in 2021, which means that the aged population will increase by 20% and Thailand will become a Super Aged Society in 2035. It is estimated that the aged population will be 30% of all Thai population then. The progression towards an aged society in Thailand is a result of decreased birth rate and increased longevity among people, in addition to decreased death rate. These factors are consequences of advanced medical technology within the field of public health in Thailand (Sangthong, 2017).

As people age, the risk of ill health increases, especially with regards to non-communicable diseases. The reason is that the elderly's body deteriorates physically, mentally and socially (Jones & Boelaert, 2015). Non-communicable diseases are connected to food consumption behaviours (Rauber

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doi: https://doi.org/10.31246/mjn-2019-0095

et al., 2018). When older adults have appropriate dietary intakes, their health will be better, thus more able to slow down symptoms of non-communicable diseases. On the other hand, if older adults do not have appropriate and healthy foods, they may succumb to malnutrition (under- and over-nutrition). According to a survey by the National Statistics Office, under 50% of the elderly who were >60 years old reported themselves to be in good health (Aekplakorn & Satheannoppakao, 2012). The fifth physical examination, conducted in 2014 by the Office for the Survey of Thai Population Health under the Institute of Public Health Survey, found that the elderly were at risk of heart and blood system diseases, i.e. hypertension at 53.2%, diabetes at 18.1%, overweight (BMI≥25 kg/m^2) at 35.4%, obesity at 49.4% and metabolic syndrome at 46.8%. Regarding chronic diseases, it was found that a quarter of the elderly (about 2.2 million people) had knee arthrosis, followed by gout (5.4%), and heart attack (4.6%). It is common to find that anaemia comes with age. Around 48% of the elderly who are >80 years old has anaemia (Aekplakorn & Satheannoppakao, 2012). As a result, nutrition in the elderly should be looked at very closely and carefully because it could affect an elderly person's health in the future. In addition, appropriate food consumption behaviours could prevent diseases and increase longevity.

From a recent survey on the nutritional state of Thai elderly, it was found that at least half of the respondents did not have three meals a day. Only 29.1% of elderly aged >70 years old and 11.4% of elderly aged over 80 years old consumed enough portions of fruits and vegetables daily (Aekplakorn, 2014). Moreover, the elderly tended to eat lesser protein, calcium, vitamin A, and fibre, especially in the Northeastern region of Thailand (Aekplakorn & Satheannoppakao, 2012). Physical changes associated with ageing, such as problems related to the digestion system, chewing, swallowing and also food preferences are important causal factors of malnutrition in the elderly (Ahmed & Haboubi, 2010). In addition, society has been changing rapidly, and the gain in popularity of social media has increased foreign culture accessibility including Western foods. In fact, food behaviours of Thai people has changed from the past and consumption of fast foods has been on the rise (Warathornpiboon, 2014; Pruksa & Sripoona, 2017). Many factors have been associated with the food consumption behaviours of Thai people, such as a lack of knowledge, false beliefs, incorrect information, abandonment from children, and social status of the elderly (Kitreerawutiwong & Mekrungrongwong, 2016).

Based on the findings described above, it is necessary to improve food consumption behaviours among the elderly, and to increase their awareness of the link between their diet and health. Such an approach could also decrease the risks of under- and over-nutrition, especially among the elderly in the Northeastern region of Thailand. Malnutrition among the elderly in this region is a particularly significant problem, because nutrient intakes in these elderly are below average (Aekplakorn & Satheannoppakao, 2012), and this region is home to the largest number of elderly in the country (Foundation of Thai Gerontology Research and Development Institute, 2017). Therefore, the aim of this study was to determine food consumption behaviours and associated factors among elderly adults living in the Northeastern region of Thailand. The data obtained from this study will be used to solve the food consumption behaviour problems, improve the nutritional status of the elderly, plan activities to promote health

of the elderly, and improve their food consumption behaviours so that they can have better health in the future.

MATERIALS AND METHODS

Sample selection and subjects

Multistage cluster sampling was applied to obtain a sample which was representative of the Northeastern Thai elderly population, based on the overall Thai population from the Department of Provincial Administration. For the first stage, five provinces were randomly sampled by proportion to size from each of the five Northeastern provincial clusters. In the second stage, 2-8 districts were randomly selected by proportion to size from each province. In the third stage, two villages were randomly selected by proportion to size from urban and rural areas in each province. In the final stage, elderly adults were randomly selected by proportion to size from each village.

Subjects were 1,336 elderly people. This was computed using the formula for a single proportion with an expected prevalence of 0.06-0.45 with an error of 5% at 95% confidence interval (CI). In order for subjects to be able to participate in this study, a set of inclusion criteria was followed. The participants were required to be reliable and willing to take part in this study. Before the start of the study, the objectives were carefully explained to the subjects. Informed consent was then obtained from all subjects.

Questionnaire and data collection

Information about food consumption behaviours and related factors were collected using an interviewer-administered questionnaire, which was developed by the author (Cronbach's α = 0.83). The questionnaire consisted of six parts: demographic and socioeconomic factors, food sources, food factors, food culture, knowledge towards food consumption, attitude and preference towards food consumption, and food consumption behaviours. The questionnaire covered the sources of foods that the elderly usually consume. Food factors meant easy or convenient accessibility of food sources, as well as quality, taste, nutritive value, and safety of food sources, in addition to appropriate and stable prices of foods. Food preference referred to how much the elderly liked or disliked different types of foods. Binary-choice questions were used for food culture and its total score equaled to 16. A ten-item test was used for knowledge. A score was given for each correctly answered question. A 3-rating scale questionnaire was used for attitude and food preferences, family relations, and food factors. The total scores for these questions equaled to 24, 27, 9, and 24, respectively. The questionnaire on food consumption behaviours covered meals and five food groups, foods that the elderly should consume, foods that the elderly should avoid, cooking, purchasing, and changes in food behaviours. A 4-rating scale for response was used for food consumption behaviours. The total score equaled to 148. Those were then classified into three levels (poor, fair, and good) according to Best (1977), except for knowledge, which was classified according to Bloom (1971). For food consumption behaviours, a good level was used as a cut-off point for categorical data (i.e. total score >112). Data were collected by trained research assistants with a manual for data collection. These were individuals who had knowledge on food and nutrition or health, namely nutritionists, community dietitians, nurses, and public health officers. Elderly participants were asked about their food consumption patterns and to recall how often they consumed foods or meals during the past month. Collection of some information was

randomly repeated by food and nutrition experts, in order to ensure that high-quality data were obtained within a week.

Ethical considerations

The research protocol was approved by the Ethics Committee of Loei Rajabhat University. All participants gave their written consent, and voluntarily cooperated and partook in the research. Before signing the consent form, participants had been told about the objectives of the research, the research methodology and also the benefits of the research. They could choose whether to join the research or not, or withdraw from the research without giving any reasons. Their information were kept confidential. The researcher did not harm the participants, and the researcher did not benefit from them at all.

Data analysis

Data were analysed using descriptive statistics (percentage, mean, standard deviation (*SD)* for food consumption behaviours and related factors. Multiple logistic regression was carried out for categorical data to determine the factors associated with food consumption behaviours of elderly in Northeastern Thailand.

RESULTS

Table 1 shows that 40.0% of respondents had "good" food consumption behaviour and 60.0% had "fair or poor" food consumption behaviour. The mean±*SD* score for food consumption behavior score was 103.84±15.59.

Table 2 shows the characteristics of the elderly and the distribution of factors. The mean±*SD* for age of the subjects was 68.01±6.86 years (58.6% females and 41.4% males). The majority of them were married (61.83%), had a primary education or lesser (62.1%), lived with their family (95.4%), and took care of themselves (93.1%). Half of them had an income of <3,000 Thai Baht (98 USD) per month. Around 68% declared that their incomes were sufficient and enough for savings. Three quarter (74.7%) of the households had 3-4 family members. Over half (53.8%) of the family members were responsible for caring for the elderly, and 91.6% had a good relationship with the elderly. The proportion of the elderly that had a good level of knowledge about food and nutrition amounted to 54.1%. Almost two thirds (62.7%) had a "good" attitude towards food consumption, and 41.7% had a "good" preference towards food consumption. The proportion of elderly who had a good level of culture around food consumption was 78.7%. It was found that 93.0% of the elderly had access to health information. Moreover, 49.4% of respondents consumed foods that were obtained from the village market, 20.2% consumed foods taken from their own garden, and 13.9% ate foods purchased from the market in town. In addition, 79.6% of respondents scored a good level for food factors.

Binary logistic regression showed that personal factors related to food

Table 1. Distribution of food consumption behaviours among the elderly residing in Northeastern Thailand (*N*=1,336)

Food consumption behaviours	*n*	*%*	*Mean±SD*
Good	534	40.0	
Fair or poor	802	60.0	
Food consumption behaviour score			103.84±15.59

Table 2. Distribution of factors and binary logistic regression of factors influencing food consumption behaviours (*N*=1,336)

Factors	*n (%)*	*Behaviour*		*Good behaviour Crude OR (95% CI)*	*p-value*
		Good %	*Fair or poor %*		
Personal Factors					
Sex					
Male	553 (41.4)	66.2	33.8		
Female	783 (58.6)	55.7	44.3	1.56 (1.24-1.95)	<0.001***
Age (years)					
60-69	914 (68.4)	60.8	39.2		
70-79	312 (23.4)	58.0	42.0	1.12 (0.87-1.46)	0.38
≥80	110 (8.2)	59.1	40.9	1.08 (0.72-1.61)	0.72
Status					
Single	46 (3.4)	60.9	39.1		
Married	826 (61.8)	61.1	39.0	0.99 (0.54-1.82)	0.97
Widowed	411 (30.8)	57.9	42.1	1.13 (0.61-2.11)	0.70
Divorce/separated	53 (4.0)	58.5	41.5	1.10 (0.49-2.47)	0.81
Education level					
≤ Primary school	138 (10.3)	78.3	21.7		
Secondary school	830 (62.1)	62.3	37.7	2.18 (1.42-3.34)	<0.001***
Diploma	210 (15.7)	51.9	48.1	3.34 (2.05-5.42)	<0.001***
College and above	158 (11.8)	43.0	57.0	4.76 (2.85-7.96)	<0.001***
Living situation					
Alone	62 (4.6)	74.2	25.8		
Living with family	1274 (95.4)	59.3	40.7	1.97 (1.10-3.52)	0.02*
Health condition					
Disease	629 (47.1)	62.0	38.0		
No disease	707 (52.9)	58.3	41.7	1.17 (0.94-1.46)	0.17
Dependent on others					
Yes	92 (6.9)	55.4	44.6		
No	1244 (93.1)	60.4	39.6	0.82 (0.53-1.25)	0.35
Knowledge about food consumption behaviours					
Fair or poor	613 (45.9)	71.1	28.9		
Good	723 (54.1)	50.6	49.4	2.4 (1.91-3.02)	<0.001***
Attitude towards food consumption behaviours					
Fair or poor	499 (37.4)	73.8	26.3		
Good	837 (62.7)	51.9	48.2	2.61 (2.05-3.32)	<0.001***
Food preference					
Fair or poor	779 (58.3)	73.3	26.7		
Good	557 (41.7)	41.5	58.5	3.87 (3.07-4.88)	<0.001***
Socio-economic factors					
Income (Thai Baht)					
≤3000	681 (51.0)	62.3	37.7		
3001-6000	224 (16.8)	62.1	38.0	1.01 (0.74-1.38)	0.96
6001-9000	169 (12.7)	68.1	32.0	0.77 (0.54-1.11)	0.16
>9000	262 (19.6)	47.3	52.7	1.84 (1.38-2.45)	<0.001***

Table 2. Distribution of factors and binary logistic regression of factors influencing food consumption behaviours (*N*=1,336) [Cont'd]

Factors	*n (%)*	*Behaviour*		*Good behaviour Crude OR (95% CI)*	*p-value*
		Good %	*Fair or poor %*		
Sufficient income					
Inadequate	419 (31.4)	65.2	34.8	1	
Adequate	917 (68.6)	57.7	42.3	1.37 (1.08-1.74)	0.01*
Number of family members					
1	57 (4.3)	73.7	26.3	1	
2	151 (11.3)	55.6	44.4	2.23 (1.14-4.37)	0.02*
3	624 (46.7)	60.6	39.4	1.82 (0.99-3.36)	0.05
4	374 (28.0)	57.0	43.1	2.11 (1.13-3.95)	0.02*
≥5	130 (9.7)	65.4	34.6	1.48 (0.74-2.96)	0.27
Family caretaking					
Family members care for the elderly	719 (53.8)	62.7	37.3	1	
Taking care of family	617 (46.2)	56.9	43.1	1.28 (1.02-1.59)	0.03*
Family relationship					
poor	23 (1.7)	65.2	34.8	1	
fair	89 (6.7)	70.8	29.2	0.77 (0.29-2.05)	0.61
good	1224 (91.6)	59.2	40.9	1.29 (0.54-3.08)	0.56
Food culture					
Poor	10 (0.8)	70.0	30.0	1	
Fair	274 (20.5)	70.4	29.6	0.98 (0.25-3.88)	0.98
Good	1052 (78.7)	57.2	42.8	1.74 (0.45-6.78)	0.42
Food sources					
Own garden	270 (20.2)	67.8	32.2	1	
Natural source	120 (9.0)	71.7	28.3	0.83 (0.52-1.33)	0.44
Village market	660 (49.4)	55.6	44.4	1.68 (1.25-2.26)	0.001**
Town market	186 (13.9)	48.4	51.6	2.24 (1.53-3.30)	<0.001***
Mobile grocery truck	88 (6.6)	80.7	19.3	0.50 (0.28-0.91)	0.02*
Department store	12 (0.9)	41.7	58.3	2.94 (0.91-9.54)	0.07
Food factors					
Poor	115 (8.6)	71.3	28.7	1	
Fair	158 (11.8)	74.7	25.3	0.84 (0.49-1.45)	0.53
Good	1063 (79.6)	56.6	43.4	1.90 (1.25-2.90)	0.003**
Health information					
Yes	1242 (93.0)	59.8	40.2	1	
No	94 (7.0)	62.8	37.2	0.88 (0.57-1.36)	0.58

*p<0.05
**p<0.01
***p<0.001

consumption behaviours of the elderly were sex, education level, living situation, health condition, knowledge, attitude and preference of foods. Regarding socio-economic factors related to food consumption behaviours of elderly, these were income, sufficiency of income, number of family members, family caretakers, food sources and food factors, as shown in Table 2.

Table 3. Multiple logistic regression of factors associated with food consumption behaviours of the elderly residing in northeastern Thailand (*N*=1,336)

Factors	*Good behaviour*		
	Adjusted OR	*95% CI*	*p-value*
Personal factors			
Sex			
Male	1		
Female	1.59	1.23-2.05	<0.001***
Education level			
Primary school	1		
Secondary school	1.51	0.94-2.43	0.09
Diploma	2.34	1.34-4.09	0.003**
College and above	2.20	1.22-3.98	0.009**
Living situation			
Alone	1		
Living with family	2.21	1.14-4.28	0.02*
Health condition			
Disease	1		
No disease	1.40	1.08-1.81	0.01*
Knowledge about food consumption behaviours			
Fair or poor	1		
Good	2.00	1.51-2.64	<0.001***
Attitude towards food consumption behaviours			
Fair or poor	1		
Good	1.82	1.37-2.43	<0.001***
Food preference			
Fair or poor	1		
Good	3.28	2.55-4.22	<0.001***
Socio-economic factors			
Family caretaking			
Family member care for the elderly	1		
Elderly person taking care of his/her family	1.59	1.22-2.09	0.001**
Food sources			
Own garden	1		
Wild source	1.11	0.66-1.87	0.69
Village market	1.67	1.19-2.34	0.003**
Town market	1.70	1.08-2.66	0.02*
Mobile grocery truck	0.69	0.36-1.31	0.25
Department store	1.10	0.30-4.07	0.88
Food factors			
Poor	1		
Fair	1.04	0.57-1.90	0.90
Good	2.37	1.47-3.81	<0.001***

*p<0.05
**p<0.01
***p<0.001

These variables were analysed together by using multiple logistic regression analysis, while controlling for other variables. It was found that personal factors related to food consumption behaviours of the elderly in the Northeastern region included sex (p<0.001), education level (p<0.01), living situation (p=0.02), health condition (p=0.01), knowledge (p<0.001), attitude (p<0.001) and preference of foods (p<0.001). Socio-economic factors related to food consumption behaviours of the elderly in the Northeastern region were family caretakers (p=0.001), food sources (p<0.05) and food factors (p<0.001), as shown in Table 3.

DISCUSSION

Food consumption behaviours of majority of the elderly in the Northeastern region were in the fair or poor levels, which were in accordance with a previous research about the elderly in Burirum (ManLuan *et al.*, 2019). From this research, it was found that food preferences of the elderly had a statistical significance with their food consumption behaviours. The reason might have stemmed from the development of their food preferences during childhood. The elderly tended to like foods that they had liked when they were young. Their food consumption behaviours, which was in an unsatisfactory level, was also about putting seasoning powder in their foods. It was believed that the reason they did this was because they believed that it would make their foods more delicious (Pruksa & Sookprasert, 2018; Pruksa & Sripoona, 2017).

The results from this research demonstrated that sex and education level were associated with food consumption behaviours among the elderly. It has previously been suggested that women tend to take better care of themselves than men as they are more concerned with the nutritional facts of foods (Stran & Knol., 2013; Sawangsri & Tangngam, 2013; Westenhoefer, 2015). In addition, elderly with a higher level of education generally have better knowledge on health, thus leading to better food consumption behaviours (McCracken & Phillips, 2012).

It was also found that the elderly who lived with their children or relatives were 2.20 times more likely to have a good level of food consumption behaviours than those who did not live with their children or relatives. The reason was that in a family, they lived together and helped each other, and therefore had a better quality of life (Sasuad, 2017). Furthermore, in this research, it was found that food consumption behaviours in the elderly who did not have any diseases were better than those who had diseases. The reason could be either people who made healthier choices that resulted in better health or people who had better health ate better because they were less debilitated, or both (Pinho *et al.*, 2018). This was in accordance with a previous study showing that physical and mental health influenced food consumption behaviours of the elderly (Pui-ngam, 2010).

This study found that the elderly's knowledge about food and nutrition reached a good level, and it was 2 times higher than those who had a fair or poor level of knowledge. This showed that they knew what was good or not good for their bodies, and the effects towards their bodies (Loyola, 2010). They had good understanding and perception towards food and nutritional values, and that improved their food consumption behaviours (Brown, 2004). Moreover, the elderly's attitude towards food consumption was within a good range, which was 1.82 times higher than those who had a fair or poor attitude towards food consumption. It could be that the elderly

who had a good attitude towards food consumption also had good knowledge about food consumption (Chumkaew & Rungsayatorn, 2014). With respect to food preference, it was also significantly related to food consumption behaviours of the elderly in the Northeastern region. Elderly who had a good food preference had food consumption behaviour score that was 3.28 times higher than those who had a poor food preference. This may be because the elderly experience physical and mental changes which decrease their appetite. They do not feel like eating so they choose only what they want (Department of Older Person, 2017), thus, their food consumption behaviours reflected what they liked.

The socio-economic factors related to food consumption behaviours of the elderly in the Northeastern region included family caretaking, food sources and food factors. Elderly who took care of their family had better food consumption behaviours than those who were taken care of by their children. This was the same as a study by Sriugsorn & Kanjanawasee (2009), which found that family support was related to the food consumption behaviours of elderly in Bangkok. The reason was because most elderly in this research had a diploma level education and had better food factors than those elderly who were taken care of by their children. Furthermore, the elderly who took care of their family could still help themselves and could cook foods by themselves. Therefore, they were able to choose quality foods. Meanwhile, the elderly who were taken care of by their children had to eat with their children and they could not choose the foods they wanted. As a result, if the elderly's children or caretakers did not pay attention to their food consumption behaviours, the elderly might have problems in the future.

With respect to food sources, it was found that they were significantly related to the food consumption behaviours of the elderly in the Northeastern region. Food consumption behaviours of the elderly who bought foods from their village market was better than those who grew their own foods. A similar finding was obtained for the elderly who bought foods from the market in town versus the elderly who grew their own foods. The reason for these findings was that the market offered a wider variety of foods (Phumee & Thomol, 2017). During the survey, it was noted that there was a small market in the village where local people went to purchase some of their foods. Similarly, Wannawong (2009) found that sources of foods and food prices were significantly related to food consumption behaviours among the elderly in Yasothon, a city in the Northeastern region. The elderly who had good food factors had 2.37 times better food consumption behaviour than those who did not. These good food factors included food access, good quality of foods and reasonable prices. This result was in accordance with the outcome of a study by Warathornpiboon (2014), which showed that food price was an important determinant of food consumption behaviours. If food price was too high, food choices were limited and this resulted in poorer food quality among elderly consumers. Moreover, the quantity of foods in the market was another important factor related to food consumption behaviours. If there was sufficient food for people in a community, it could be said that the community had good food access and people had a better chance of choosing their foods (Warathornpiboon, 2014).

CONCLUSION

The results from this research found that sex, education level, living situation, health condition, knowledge, attitude, food preferences, family caretaking,

food sources and food factors were significantly associated with food consumption behaviours among the elderly in the Northeastern region of Thailand. Consequently, activities about food consumption behaviours of the elderly in the Northeastern region should be focused on small groups and the elderly with lesser formal education (lower than primary level), living alone and those having diseases, because these individuals have lower food consumption behaviours compared with elderly who stayed with their children and relatives, those who were married, and those who were generally healthy. People who work in the nutrition office and related offices, such as the municipal office and public health office, should pay more attention to food sources for the elderly. There should be enough markets, with sufficient food variety, for the elderly. Some elderly have low incomes, while some can grow their own foods with more variety and abundance. As a result, household vegetable production, small scale animal rearing, and preservation of natural resources should be promoted in parallel so that the elderly can have access to these food sources. The quality of foods and food prices should also be constantly checked so that the elderly can access sufficient amounts of good quality and sustainably-produced foods.

Acknowledgements

I am grateful to the volunteers for their kind cooperation and the Food and Nutrition Policy for Health Promotion in Thailand for financial support.

Authors' contributions

PS, principal investigator, conceptualised and designed the study, data collection, data analysis and interpretation, prepared the draft of the manuscript and reviewed the manuscript.

Conflict of interest

I declare that I have no conflict of interest.

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Mal J Nutr 26(2): 215-228, 2020

Randomised clinical trial of rice germ supplementation on nutritional status and performance in trained swimmers: A pilot study

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ABSTRACT

Introduction: Rice germ (RG) could be a safe and effective dietary supplement for swimmers. **Methods:** This randomised, parallel, placebo controlled pilot study investigated the effect of a five-week RG supplementation (25 grams/two times/day) in moderately trained swimmers on 50-m and 200-m front crawl at maximal speed, as primary outcome, and body composition, muscle function, post-concussion assessment, cognitive testing (ImPACT) and lactic acid levels, as secondary outcomes. Twenty seven moderately trained swimmers (7 women and 20 men) participated in the study. **Results:** For primary outcome on 200-m front crawl at maximal speed, a significant average decrease of 2.98 seconds (p=0.022) was detected in RG group, but it was not significant compared to placebo. On 50-m front crawl at maximal speed, no statistically significant intra- or inter-group differences were detected. Regarding secondary outcomes, no difference was demonstrated between pre-performance and post-performance lactic acid levels. Comparing the treatment with placebo across follow-up, mean mid-arm muscle circumference (MAC) increased weekly and significantly by 0.23 cm (p=0.026), as well as 0.36% for gynoid fat (p=0.005). In addition, a decrease of 0.13kg in fat-free mass (p=0.067) was also detected. No statistically significant intra- or inter-group differences were detected for secondary outcomes. **Conclusion:** This pilot study provided early evidence that RG supplementation may positively affect nutritional status and partially, the performance of moderately trained swimmers. Further research is needed to clarify the mechanisms of action, the optimal timing of supplementation, as well as the most effective dose.

Keywords: Rice germ, swimmers, nutritional supplement, lactic acid, fat-free mass

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doi: https://doi.org/10.31246/mjn-2019-0071

INTRODUCTION

In order to enhance the effects of training and improve performance, athletes often turn to nutritional supplements (Knapik *et al.*, 2016). According to the American College of Sports Medicine (ACSM), adequate selection of nutrients and supplements, and adjusting intake according to the exercise performed, are necessary for optimal performance in athletes (Rodriguez *et al.*, 2009). The most recent consensus from the International Society for Sports Nutrition (ISSN), American Dietetic Association (ADA) and ACSM on sports nutrition have been reviewed by Potgieter, stating that a single guideline is not sufficient to elaborate an individualised and focused nutritional management for athletes. Moreover, apart from the above mentioned guidelines, sport-specific nutritional strategies, including quantity, structure and timing of food (or supplement) intake should also be followed in order to maximise sports performance and recovery (Potgieter, 2013). The importance of dietary supplementation is of particular interest in swimming, where athletes usually undertake a training approach characterised by a high volume of training during aerobic development and high intensity training during the competition phase, coupled with strength training (Stellingwerff, Maughan & Burke, 2011).

The size and market value of the sports supplement industry is continuing to grow, with health, safety and contamination concerns (Prosser *et al.*, 2009) becoming more pressing. Therefore, it is important to identify dietary supplements that are safe and effective in supporting swimmers. Rice germ (RG) could be a safe and effective dietary supplement for swimmers. In the last few years, scientific research is trying to use rice waste products in the pharmaceutical and nutraceutical fields, considering the potential value of nutrients they contain (Perretti *et al.*, 2003). A recent study (Rondanelli *et al.*, 2019) demonstrated that RG has a high protein content (18 g per 100 g of edible product) with considerable amounts of essential amino acids (mainly lysine, histidine and valine, respectively), fatty acids (mainly monounsaturated and polyunsaturated fatty acids at 5.65g/100g and 7.65g/100g, respectively), and fibre (7 g per 100 g). Regarding water-soluble vitamins, RG has high amounts of thiamine (vitamin B1) and pyridoxine (vitamin B6), while vitamin E is the main fat-soluble vitamin present. Iron [77% of Recommended Dietary Allowance (RDA)] and magnesium (108% of RDA) are the two main minerals found in RG. The nutritional composition of RG is shown in Table 1, based on an evaluation done by Chelab (Treviso, Italy). Given its great nutritional value, it will be of interest for future studies to explore ways to incorporate RG into dietary supplements aimed at increasing nutritional intake for a specific population, such as athletes. In fact, all these nutrients contribute synergistically to muscle activity and play important roles in maintaining the health of athletes (Manore, Meyer & Thompson, 2009). Currently, despite these characteristics, no study has evaluated the potential beneficial effects of RG supplementation on athletes.

We chose swimmers as the athletes for this study because an analysis of the mechanics and energetics of swimming revealed that different factors play key roles in the success of competitive swimming events (Toussaint & Hollander, 1994). The reasons beyond the participation of master athletes in competitions and/or in regular exercise are the enjoyment and its health benefits (Tantrum & Hodge, 1993), as well as the will to enhance their performance (Maharam *et al.*, 1999). With an increase

Table 1. Nutritional composition of RG

Variable	*Rice Germ*
Humidity (g/100g)	10.5
Protein (g/100g)	18.2
Fats (g/100g)	17.5
Dietary fibres (g/100g)	7.0
Ashes (g/100g)	5.7
Carbohydrates (g/100g)	41.2
Energy value (kcal/100g)	409
Energy value (kJ/100g)	1711
Starch (g/100g)	25.5
Vitamin B1 (mg/100g)	5.8
Vitamin B6 (mg/100g)	0.5
Vitamin E (mg/100g)	31.9
Cadmium (mg/kg)	0.02
Iron (mg/100g)	6.2
Magnesium (mg/100g)	347.0
Lead(mg/100g)	n.r.
Sodium (mg/kg)	1.9
Aspartic acid (mg/100g)	95.8
Asparagine (mg/100g)	74.1
Glutamic acid (mg/100g)	130.3
Alanine (mg/100g)	41.5
Arginine (mg/100g)	115.4
Cystine (mg/100g) +Methionine (mg/100g)	<LoQ + 4.6
Proline (mg/100g)	21.0
Phenylalanine (mg/100g) + Tyrosine (mg/100g)	3.3 + 12.2
Glycine (mg/100g)	13.9
Glutamine (mg/100g)	5.3
Isoleucine (mg/100g)	6.4
Histidine (mg/100g)	12.7
Leucine (mg/100g)	8.5
Lysine (mg/100g)	161.2
Ornithine (mg/100g)	<LoQ
Serine (mg/100g)	20.7
Treonin (mg/100g)	10.3
Valine (mg/100g)	18.3
Gamma-aminobutyric acid (mg/100g) IUPAC: 4-aminobutanoic acid	35.4
Alpha-aminobutyric acid (mg/100g) IUPAC: 2-Aminobutanoic acid	<LoQ
Saturated fatty acids (g/100g)	4.15
Monounsaturated fatty acids (g/100g)	5.65
Polyunsaturated fatty acids (g/100g)	7.65

n.r. = not reported; LoQ = Limit of Quantification

in the ageing population and a current trend towards increasing physical activity in adulthood, it is important to understand the relationship between age and physical performance, and to identify the factors affecting it. Therefore, considering the nutritional composition of RG, it would be reasonable to expect that the nutritional status of swimmers and their swimming performance could be improved following RG supplementation.

Most papers evaluating the effectiveness of a dietary supplement in swimmers only considered its acute administration before competition and does not evaluate the efficacy of a chronic supplementation on the state of nutrition. Acute taurine supplementation at 120 minutes before performing a maximal effort did not improve swimmers' performance, but it increased glycerol plasma levels and reduced both the $\Delta[La^-]$ and lactic anaerobic system contribution (De Carvalho *et al.*, 2018). Acute supplementation of sodium citrate prior to a 200-m swimming performance led to a modest time improvement and higher blood lactate concentrations in only half of the swimmers, while chronic sodium citrate supplementation did not provide any ergogenic effect in a group of adolescent swimmers (Russell *et al.*, 2014). Gao *et al.* (1988) and Siegler *et al.* (2010, 2012) have demonstrated that swimmers ingesting $0.3 g \cdot kg^{-1}$ body mass of sodium bicarbonate (SB) one hour before performance enhanced their blood buffering potential and this positively influenced their interval swim performance. Lindh *et al.* (2008) have also shown that SB supplementation ($0.3 g \cdot kg^{-1}$ body mass) can improve a single 200-m freestyle performance time in elite male competitors, most likely by increasing the extra-cellular buffering capacity. SB supplementation prior to performing maximal sprint swimming with repetitions under 60 s improved performance. However, co-supplementation of SB with beta-alanine at 60 minutes before performance did not confer any added benefits on maximal swim performance (Mero *et al.*, 2013). Nitrate supplementation before performance increased nitric oxide bioavailability, but did not benefit short-distance swimming performance (Lowings *et al.*, 2017).

So, our study, differently from all previous literatures on this topic, wanted to consider the effectiveness of chronic supplementation, not acute supplementation, on both the performance and state of nutrition among swimmers. We have chosen five weeks because a previous study has shown that an average of a two-week period on amino acid dietary supplementation did not induce any changes in nutritional status and performance in swimmers (Tang, 2006), while a recent systematic review demonstrated that branched-chain amino acids supplementation for a long period of time (>10 days) was an efficient nutritional strategy (Fouré & Bendahan, 2017). Given this background, the purpose of this investigation was to ascertain whether performance and nutritional status in swimmers could be improved by a five-week RG supplementation. Regarding primary outcome, performance was evaluated by a 50-m and 200-m front crawl at maximal speed in order to assess both the anaerobic and aerobic energy contribution to swimming performance (Toussaint & Hollander, 1994).

MATERIALS AND METHODS

Study design and randomisation

This pilot study was parallel and placebo controlled, and sample size was not determined a priori because the subjects were >12 per arm as suggested by Julious

(2005). Subjects who met the inclusion criteria and who signed the informed consent to the study were assigned consecutively with an ascending number of randomisation, starting with number 1. The number was indicated on a label that identified the treatment and was written on the Case Report Form (CRF). Subjects were randomised to one of the two treatments (refined RG supplement or placebo) according to a randomisation list generated by the computer and according to a pattern that ensured a balance in treatment assignment (according to a 1:1 ratio).

Subjects

The inclusion criteria of swimmers were: 1. Moderate fitness level, judged on the basis of maximum oxygen uptake (VO_{2max}) evaluated by means of a standard incremental exercise test on a cycle-ergometer; 2. Regularly involved in regional and national competitions, and who trained an average of 6.5±0.8 h per week; 3. Training frequency of 3-4 times/week, with 3.000–5.000 m distance covered each time in a 25-metre indoor swimming pool [Federazione Italiana Nuoto (FIN) swimming pool of Pavia, Pavia, Italy]; 4. In the middle phase of the training season and have trained for >6 months. Swimmers with any history of cardiac or respiratory diseases and/or taking any medications, shown any abnormalities on physical examination or on resting electrocardiogram at the time of the study were excluded. Written informed consent was obtained from all of the participants after they were informed about the methods and aims of the study.

Training schedule

Athletes trained three or four times/week. Timing of training was the same for every subject, starting at 9:15 pm and ending at 11:00 pm.

Primary outcome

Performance measurements

Before and after two weeks and five weeks, swimmers swam in a 25-metre indoor swimming pool, under the same water condition (water temperature of 27°C) to assess a 50-m and 200-m front crawl at maximal speed and the time of performance.

Secondary outcomes

Anthropometric measurements

All measurements were assessed in the morning between 9:00 am and 10:00 am. Body weight was measured using standardised techniques on a precision scale to the nearest 0.1kg with participants wearing light clothing and without shoes. Waist measurements were taken at the midpoint between the lowest rib and the top of the hip bone (iliac crest), with the use of a standardised technique (Frisancho, 1984).

Anthropometric measurements were taken at baseline and after five weeks in both groups. Body weight and height were measured, and Body Mass Index (BMI) was calculated (kg/m^2). Skinfold thicknesses (biceps, triceps, suprailiac, subscapular) were measured twice using a Harpenden skinfold caliper at five-minute intervals at each site, following standardised techniques (Frisancho, 1984). Sagittal abdominal diameter was assessed at the L_{4-5} level in the supine position and waist girth was also measured. The mid arm circumference (MAC) was taken following standard procedures described by Lohman and colleagues (Lohman *et al.*, 1991). Anthropometric variables were measured by a single investigator.

Body composition evaluation

Body composition (BC) was assessed using a dual-energy X-ray absorptiometry (DXA) scan (Lunar Prodigy, Madison,

WI) in all subjects before treatment and again after five weeks intervention period. Evaluation of fat mass (FM), fat-free mass (FFM) were obtained by whole body scan.

Bioimpedance vector analysis (BIVA)
Whole body impedance measurements were made using standard protocols (Piccoli *et al.*, 1995). A 50 kHz, tetra-polar, phase-sensitive BIVA (BIA-101; AKERN-Srl, Florence, Italy) which introduced a sinusoidal, alternating current of 400 μA RMS was used to measure Resistance (R), Reactance (Xc) and Phase Angle (PA). Measurement errors of the system, determined with a precision resistor and capacitor, were <1% for R and <2% for capacitance. The amount of FFM was estimated with a prediction equation for BIVA in adults aged 20-94 years (Kyle *et al.*, 2001). Previous studies that we have performed evidenced that this equation was accurate in our sample (Camina Martín *et al.*, 2013). Fat mass and fat-free mass indices (FMI and FFMI, respectively) were calculated as FMI (kg/m^2) = FM/H^2, and FFMI (kg/m^2) = FFM/H^2. These indices were used to compare the BC data obtained in this study with the reference BC data for Caucasians (Schutz, Kyle & Pichard, 2002).

In this study, the reference bivariate tolerance ellipses (50, 75 and 95% of the distribution of the values in general population) for the adult and elderly men (Piccoli *et al.*, 1995) were used for the qualitative and semi-quantitative assessments of BC and hydration status in each individual subject. The 95% confidence ellipses for mean vectors of the supplementation group and the placebo group were drawn to compare between these groups.

Muscle function assessment
The JAMAR Hand Dynamometer (Jamar 5030J1; Sammons Preston Rolyan; accuracy 0.6 N) was used to assess muscle function with the use of a standardised procedure (Spijkerman *et al.*, 1991).

Post-concussion assessment and cognitive testing
Every day, post-concussion assessment and cognitive testing (ImPACT) were compiled (Spijkerman *et al.*, 1991) by swimmers. The ImPACT instrument is a computer-based programme used to assess neurocognitive functions and concussion symptoms. It consists of six tests that evaluate attention, working memory, and processing speed, yielding composite scores on the areas of verbal memory, visual memory, motor processing speed, reaction time, and impulse control (Iverson, Lovell & Collins, 2003).

Blood lactate evaluation
Capillary blood samples were collected from the fingertip before and after each swim (at the 1st minute of recovery) to assess the higher value of blood lactate concentration (AccutrendLactate® Roche, Germany).

Dietary supplement
The intervention group was given RG which consisted of an isocaloric wheat germ-based supplement, while the control group was given a placebo that consisted of an isocaloric amount of fibre with the same flavour and appearance as the intervention product. The RG and the placebo were supplied in vacuum jars weighting at 130g. These jars, once opened, were stored in the refrigerator (-3-4°C). Small containers were provided to act as dosers and served to determine the correct dose to be taken (25g, twice a day). The rice germ or placebo were continually taken every day, twice a day (25g in the morning with breakfast and 25g in the afternoon as snacks) for five weeks. To optimise compliance, instructions were reinforced weekly by

phone, by the same research dietitian. The RG was supplied by the company "Acquerello" (Tenuta Colombara, Livorno Ferraris, Vercelli, Italy).

Dietary schedule and intake of energy and macronutrients

Athletes ate five meals daily: breakfast between 7:00 and 8:00 am, a snack between 10:00 and 10.30 am, lunch between 12:00 noon and 2:00 pm, a snack between 4:00 and 4:30 pm, and dinner between 7:00 and 8:00 pm. Individual diet plans were drawn up for each subject by the research dietitian. The energy content and macronutrient composition of the diets adhered to the nutritional recommendations of the position statement for nutrition and athletic performance by ACSM, ADA and Dietitians of Canada (2000). Individual diet plans and dietary records were analysed using a food-nutrient database (Rational Diet, Milan, Italy). Adherence to the diet was checked weekly by a senior dietitian using a food diary.

Adverse events

Unwanted adverse events, such as headache, nausea, vomiting, dizziness, etc. were expressed as presence/absence or times in which symptoms appeared in the follow-up period, and they were evaluated as tolerability to treatment.

Informed consent and ethical statement

The investigations were carried out following the rules of the Declaration of Helsinki 1975, revised in 2013. This research was approved by the institutional review board at the University of Pavia and was conducted after approval from the Ethics Committee. The participants included in the study signed a consent form that allowed their personal data to be used in the research. The study was registered on ClinicalTrials.gov PRS: NCT03918785.

Statistical analysis

Descriptive statistics of the sample were performed using mean±standard deviation (*SD*) values and frequencies. Attrition was handled through complete cases analysis as indicated by the European Medicine Agency Guidelines for exploratory studies (European Medicines Agency, 2010). Associations between treatment (1=refined RG, 0=placebo) and dichotomous variables were analysed with odds ratio (OR) and Fisher's tests, while associations with continuous or counting variables were analysed with mean difference (MD) and paired *t*-test or Wilcoxon signed rank test (if normality assumption was rejected). We applied Linear Mixed Models (LMM) for repeated measures (Fitzmaurice, Laird & Ware, 2011) to assess athletic performances (i.e. 50-m front crawl times, and lactic acid levels pre- and post-performances) and BC markers (except height) between two treatments, at baseline and after five weeks (for BIVA markers after two weeks too), as secondary outcomes. We considered the sample (n=27, ×2=54 or ×3=81 obs., but only 27 independents) during five weeks follow-up in which, for each swimmer, the outcomes were measured. LMMs were fitted outcomes using the subjects as random effect. Treatment group, time of assessment (in weeks) and their interactions, were included as explanatory variables. Interaction terms were included into the models as "focus" predictors to evaluate the treatment effects (Δ), interpreted as mean differences by treatments (RG-placebo), by week. In addition, to get a best fitting model, variables concerned with the adverse events during follow-up, which resulted to be associated with treatment, were included in the models as potential confounders.

We carried out z-tests to evaluate statistical significance on model parameters and a p-value <0.05 was considered as significant. Analysis was

performed with R 2.15.3 (Team, 2013) using its nlme (Pinheiro *et al.*, 2007), Rcmdr (Fox, 2005) and lattice (Sarkar, 2008) packages.

RESULTS

Population

Twenty seven moderately trained swimmers were recruited to take part in this investigation. The level of their fitness was judged as moderate based on the basis of their maximum oxygen uptake (VO_{2max}), evaluated by means of a standard incremental exercise test on a cycle-ergometer. Their mean±*SD* of age, body weight, and height were 34.7±7.5 years, 69.4±6.1 kg, and 173.6±4.3 cm respectively, while VO_{2max} was 42.7±2.6 $mL \cdot kg \cdot min^{-1}$.

Baseline data

In Figure 1, the flow diagram of the trial is reported. The statistical analysis of the baseline descriptive data showed that the randomisation had been correctly operated and that the refined RG supplementation and placebo groups, except for 50-m free-style times, were homogenous (Tables 2 and 3).

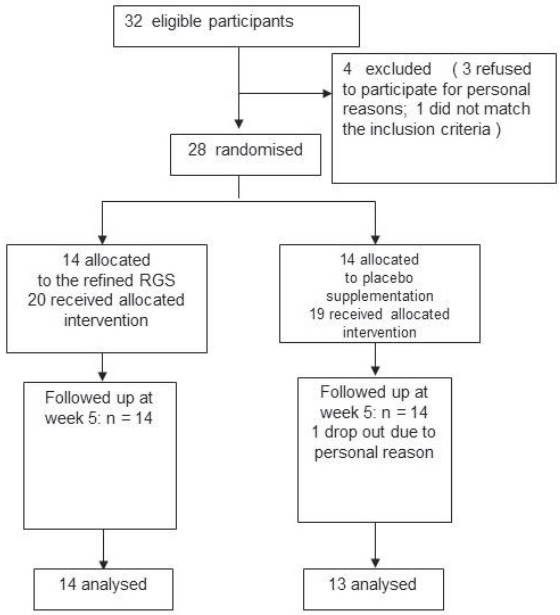

Figure 1. Flow diagram of the study

Adverse events

Enrolled subjects complained of some adverse events: weariness, psychological stress, headache, nausea, vomiting, laxative effects, insomnia, hypersomnia, drowsiness, noise hypersensitivity, balanced disorders or dizziness,

Table 2. Baseline characteristics of the sample (data are *n* or mean±*SD*)

Variable	*Refined RG (n=14)*	*Placebo (n=13)*
Demographic variables		
Sex		
Male	11	9
Female	3	4
Age (years)	31.86±8.06	30.23±5.10
Anthropometric measurements		
Height (cm)	176.70±8.28	174.50±9.73
Weight (kg)	74.88±11.35	72.32±12.26
Body mass index (kg/m^2)	23.89±2.67	23.61±2.31
Waist circumference (cm)	82.89±9.97	80.54±8.41
Hip circumference (cm)	97.71±5.76	96.38±7.62
Mid-arm circumference (cm)	29.07±2.63	29.19±3.47
Biceps skinfold (mm)	8.29±3.36	8.91±3.83
Triceps skinfold (mm)	12.29±4.81	13.55±5.38

*Statistically significant difference ($p<0.05$) between treatments

Table 3. Primary outcome and secondary outcomes (mean±*SD*) per treatment with Linear Mixed Models (LMM) output for expected week treatment effects (Δ)

	Rice germ supplementation		*Placebo*		*LMM*
	Baseline	After five weeks	Baseline	After five weeks	Δ (*p value*)
Primary outcomes					
50-m front crawl time (in seconds)	30.46±2.94	30.57±3.02	33.64±4.17	33.61±4.24	-0.03 (0.558)
200-m front crawl time (in seconds)	161.38±19.29	158.39±17.63*	178.85±43.01	178.02±42.96	-0.36 (0.195)
Lactic acid levels pre- performance (mmol/L)	2.04±1.67	1.47±1.28	1.99±1.45	1.60±1.15	-0.05 (0.743)
Lactic acid levels post- performance (mmol/L)	6.81±2.65	7.83±3.45	5.35±3.53	6.51 ±3.04	0.13 (0.706)
Lactic acid levels (post-pre) (mmol/L)	4.59±2.69	6.36 ±3.61	3.56 ±3.26	4.35±3.39	0.21 (0.552)
Secondary outcomes					
Weight (kg)	74.88±11.35	74.45±11.06	72.32±12.26	72.26±12.98	-0.07 (0.362)
Waist circumference (cm)	82.89±9.97	82.93±8.19	80.54±8.41	81.77±7.20	-0.24 (0.320)
Hip circumference (cm)	97.71±5.76	97.21±5.19	96.38±7.62	97.23±6.33	-0.25 (0.286)
Arm circumference (cm)	29.07±2.63	30.24±3.07*	29.19±3.47	29.19±3.05	0.23 (0.026)*
Biceps skinfold (mm)	8.29±3.36	7.71±3.52	8.91±3.83	8.73±4.29	-0.14 (0.575)
Triceps skinfold (mm)	12.29±4.81	12.5±3.85	13.55±5.38	13.09±6.46	0.14 (0.576)
Body mass index (kg/m^2)	23.89±2.67	23.76±2.57	23.61±2.32	23.56±2.52	0.35 (0.478)
Hand grip (right) (kg)	49.86±10.33	47.93±9.93	49.42±14.28	46.00±12.18	-0.02 (0.570)
Hand grip (left) (kg)	50.23±13.20	47.85±10.42	46.58±12.47	44.00±10.84	-0.01 (0.992)
BIVA					
Resistance (Ω)	551.59±133.33	510.79±61.41	519.38±60.61	512.91±77.36	-4.36 (0.489)
Reactance (Ω)	59.89±7.14	58.76±6.20	63.46±3.58	61.43±5.99	0.23 (0.606)
Phase angle (degree)	6.64±1.02	6.75±1.00	7.02±0.77	6.96±0.99	0.01 (0.874)
Total body water (%)	43.4±7.30	43.23±6.21	42.02±6.26	42.18±7.69	0.09 (0.885)
Extra-cellular water (%)	18.81±3.34	18.46±2.94	17.25±2.63	17.66±3.13	-0.17 (0.054)
Intra-cellular water (%)	24.59±4.95	24.38±4.58	24.4±4.44	24.55±5.01	-0.15 (0.307)
Fat mass (kg)	16.36±7.39	16.01±4.73	15.38±5.39	14.56±4.59	0.20 (0.337)
Fat mass (%)	24.46±11.19	20.77±4.62	21.08±5.36	20.23±5.61	-0.44 (0.428)
Fat-free mass without visceral fat (kg)	58.12±8.02	58.55±8.62	56.9±9.16	57.18±10.66	-0.08 (0.732)
Fat-free mass without visceral fat (%)	75.54±11.19	79.23±4.62	78.92±5.36	79.77±5.61	0.44 (0.428)
Fat-free mass with visceral fat (kg)	40.82±8.06	40.48±7.47	40.42±7.30	40.81±7.28	-0.24 (0.315)
Basal metabolism rate (u)	1718.50±197.40	1712.00±186.40	1715.40±178.80	1720.00± 200.70	-5.15 (0.370)
Body cell mass (kg)	33.44±6.86	33.18±6.44	33.32±6.14	33.47±6.92	-0.18 (0.367)
Body cell mass index (kg/m^2)	10.85±2.15	10.72±1.89	10.88±1.48	10.92±1.82	-0.06 (0.349)
Sodium/Potassium (u)	0.97±0.17	1.02±0.11	0.96±0.05	0.97±0.08	0.01 (0.395)
DXA					
Fat mass (kg)	14.09±6.24	14.08±6.14	13.72±5.22	13.47±5.55	0.05 (0.521)
Fat mass (%)	19.44±7.14	19.58±7.19	19.80±6.80	19.42±7.22	0.11 (0.279)
Fat-free mass (kg)	57.68±9.21	57.27±9.11	55.64±10.10	55.85±10.59	-0.13 (0.067)
Gynoid fat (%)	25.06±9.25	25.74±9.31	26.97±8.49	25.83±9.07*	0.36 (0.005)*
Android fat (%)	25.81±9.92	25.5±9.86	26.15±8.40	25.74±9.19	0.01 (0.960)

*Statistically significant difference, $p<0.05$ (paired *t*-test or Wilcoxon signed rank test for differences between baseline measurements and after five weeks; LMM for differences between treatments after five weeks)

memory disorders, concentration disorders, irritability, sadness, and reduction or increment in training intensity. Concerning headache, it was significantly more frequent in the refined RG supplementation group (mean±*SD*: 2.54±2.99 times). Adverse events were not observed at baseline, so we did not assert that headache was a side effect generated by refined RG. However, the headache variable was included in the LMM as a potential confounder because it was related to refined RG.

Primary and secondary outcomes

Table 3 reports descriptive statistics by arms at baseline and after five weeks of follow-up, as well as the LMM output.

When comparing post-intervention to pre-intervention measurements for each treatment, we observed that the 50-m front crawl time performance remained invariant, while on the 200-m, the refined RG supplementation group had a significant average decrease of 2.98 seconds ($p<0.05$) (Table 3) detected. However, this improvement was not detected by LMM (Table 3, Δ=-0.36, $p>0.05$) that simultaneously compared the arms across follow-up (adjusted for headache indicator).

Regarding lactic acid markers, we also noticed from Table 3 that the average pre-performance level recorded a slight decrease of 0.05 mmol/L but it was not significant ($p>0.05$). Instead, we revealed non-significant increases in the average post-performance level and average Δ-change of 0.13 and 0.21 mmol/L, respectively.

Regarding secondary outcomes, there were some interesting evidences for body arms. LMM in Table 3 shows that mean arm circumference was increased by 0.23 cm ($p<0.05$), even though biceps skinfold showed a decrease of 0.14 mm, non-significantly ($p>0.05$). Notably, Table 3 also highlights a significant decrease in mean weight of 0.43 kg in the refined RG supplementation group, but this significance vanished in LMM (Δ =-0.07, $p>0.05$) when treatment was compared with placebo across follow-up.

Concerning BIVA markers, we pointed out a weak evidence on an average decrease of 0.17 percentage units in extra-cellular water ($p>0.05$) (Table 3). Table 3 also highlighted a significant decrease in average reactance level in the placebo group, even though the difference between treatments were not significant by LMM (Table 3, Δ=0.23, $p>0.05$). Regarding DXA markers, we recorded a significant increase of 0.36% in gynoid fat ($p<0.05$), and a weak evidence of an average decrease of 0.13 kg in FFM ($p>0.05$). All other secondary outcomes did not provide any significant findings.

DISCUSSION

This pilot study was the first study in literature that provided early evidence that a five-week RG supplementation in a group of moderately trained swimmers may positively affect their nutritional status and partially, their performances compared with placebo.

The main result of this study was a significant average decrease of 2.98 seconds on a 200-m front crawl at maximal speed in the group supplemented with RG, even if it was not significant compared with placebo treatment. This improvement in performance can be considered meaningful for a moderately trained swimmer, as it equals to a reduction of 1.8% in performance time from baseline. The precise manner by which dietary RG supplementation can affect aerobic efficiency at sub-maximal workload remains unclear, but we have postulated several mechanisms to explain this phenomenon.

First of all, the nutritional composition of RG. A recent study (Rondanelli *et al.*, 2019) demonstrated that RG has

a high protein content (18g/100g of edible product, with a good content of essential amino acids: lysine, histidine and valine), a good lipid content (with mono-unsaturated and polyunsaturated fatty acids – in particular linoleic and linolenic essential fatty acids and oleic acid), and a good fibre content (7g/100g). Besides, the most notable water-soluble vitamins in it are thiamine (B1) and pyridoxine (B6), while vitamin E prevails for liposoluble vitamins. Specifically, an intake of 100g RG can meet the average needs of RDAs for the general population (483% for B1, 212% for vitamin E). It also contains quantitative discrete amounts of vitamin B6 (pyridoxine). Minerals that are most present are iron (77% of RDA) and magnesium (108% of RDA). As reported in the introduction, all these nutrients have a pivotal role in muscle functioning, therefore can influence sports performance.

The timing of supplementation appears to be crucial, especially for protein and amino acids intakes, as arising evidence strongly suggests that quantity, timing and types of protein intake in relation to exercise sessions have a marked effect on the efficacy of protein synthesis, optimising post-exercise recovery and consequently improving sports performance (Stellingwerff *et al.*, 2011). The RG supplementation was taken twice daily: 25g in the morning with breakfast and 25g in the afternoon as snacks, as suggested by the literature in order to optimise protein synthesis (Naderi *et al.*, 2016), and also to have beneficial effects such as reduced muscle soreness and markers of muscle damage that were more evident when supplemental protein was consumed after daily training sessions (Pasiakos, Lieberman & McLellan, 2014).

Another significant result concerns the nutritional status of swimmers, whereby there was an increase from baseline in the arm circumference of the RG group, which was also statistically significant when compared to the placebo group. The BC of athletes is an important determinant of health and performance (Malina & Geithner, 2011). The reason for this increase can't be completely elucidated, because there were no previous studies on this topic in the literature. In particular, we cannot assess if this increase was due to a variation in FFM or FM. Nevertheless, considering that the RG group experienced a statistically significant improvement in the 200-m performance and an increase in total FFM, though not statistically significant, we assumed that the increase in arm circumference could be due to an increase in arm FFM, which could be related to the high protein content of RG. However, we cannot affirm this with certainty.

Gynoid fat also had a statistically significant increase in the RG supplementation group compared to the placebo group. Unfortunately, literature is lacking in evidence that could explain this finding. No statistically significant intra- or inter-group differences were detected for the other secondary outcomes evaluated. We hypothesise that probably the five weeks of RG supplementation were not enough to detect significant changes in these parameters. However, there are no studies in the literature that allowed us to compare this topic.

Perspective

Results of the present research may have potential practical applicability as it indicated that RG supplementation may be suitable to enhance exercise performance in swimming. RG supplementation, considered as a concentrated mixture of B-group vitamins, minerals and vegetal proteins, showed itself as an interesting potential nutraceutical for swimmers and other power sports, even if the results of this study were limited and other

confirmations are needed. In particular, the number of subjects studied and the time taken for the dietary supplement must be increased.

Study limitations

The main limitation of this study was not evaluating certain physiological parameters, such as oxygen uptake (VO_2) and anaerobic threshold (AT), that would have been useful in understanding the mechanisms of action of RG on performance. However, these parameters were hampered by technical limitations during swimming due to difficulty of assessment of expired gases in a pool.

In addition, despite a non-significance difference in mean performance of the 200-m front crawl time between the two groups, a difference of almost 20 seconds between these two groups could have an impact on the interpretation of the results. Concerning that, non-significant results might have been due to the sample size, therefore future studies might take into account larger samples.

CONCLUSION

In conclusion, the RG dietary supplement met all the requirements that a dietary supplement must possess to be suitable for supplementation in athletes, according to the International Olympic Committee (IOC) consensus statement (Maughan *et al.*, 2018): 1. The management of micronutrient deficiencies (in particular, iron), 2. Supply of convenient forms of energy and macronutrients (in particular proteins), as demonstrated by the increase of arm circumference in the RG group from baseline, and 3. Provision of direct benefits to performance, as demonstrated by the significant decrease of 2.98 seconds on a 200-m front crawl at maximal speed.

Acknowledgements

This study was supported by the University of Pavia, the Italian Ministry of Scientific Research, and the Federazione Italiana Nuoto (FIN) of Italy. The results of the current study do not constitute endorsement of the product by the authors or the journal.

Authors' contributions

MR and SP, principal investigators, conceptualised and designed the study, prepared the draft of the manuscript and reviewed the manuscript; DS, GP, VI, MAF and MN, led the data collection, advised on data analysis and interpretation and reviewed the manuscript; GI and CG, reviewed the manuscript; DG, conducted data analysis and interpretation, prepared the draft and reviewed the manuscript.

Conflict of interest

None to declare.

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Mal J Nutr 26(2): 229-243, 2020

Prevalence and factors associated with folate deficiency among Filipino women of child-bearing age

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ABSTRACT

Introduction: Folate deficiency is associated with many complications of pregnancy. A cross-sectional survey was conducted to determine the prevalence and factors associated with deficiency in red blood cell (RBC) folate among Filipino women of child-bearing age in the Province of Batangas, Philippines. **Methods:** A total of 184 Filipino women aged 15 to 49 years were interviewed on their socio-economic and demographic profiles. Mean energy and folate intakes were obtained using food recalls over a three-month period. RBC folate was used to measure long-term folate status and analysed through immuno-assay method. **Results:** About two in ten women were folate deficient based on the normal cut-off points (<400 ng/mL) preventive of neural tube defect-affected pregnancies. Respondents have very low intake of folate at 81 and 239 micrograms dietary folate equivalent (µg DFE) from dietary sources and with folic acid supplementation, respectively. Vegetable gardening and livestock raising (p<0.10) and use of folic-acid containing supplements showed significant correlations with folate status (p<0.05). Further, regression analysis showed that among the significant factors, the non-usage of folic acid-containing supplements showed increased likelihood of RBC folate deficiency by six times compared to users (OR=6.391, p<0.10). **Conclusion:** The findings of the study suggest a high prevalence of folate deficiency among Filipino women. Folate is an essential nutrient for healthy pregnancy. It is important that women, capable of bearing a child must assure adequate folate intake from foods and folic-acid containing supplements. The study recommends a more aggressive campaign on the importance of folate among women of child-bearing age.

Keywords: Folate, dietary folate equivalent, neural tube defects, red blood cell folate deficiency, women of child-bearing age

INTRODUCTION

Nutrition plays an essential role in maternal and child health, peri-conceptionally. A woman's nutritional status before and during pregnancy and during lactation helps determine the outcome of her pregnancy and the long-term health of herself and her child (Reifsnider & Gill, 2000). Precociously, when a woman enters the stage when she is capable of bearing a child, she needs to be prepared for the demands of pregnancy and subsequent lactation.

Micronutrient deficiency in women of child-bearing age can lead to birth defects (Kraemer & Zimmermann, 2007).

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doi: https://doi.org/10.31246/mjn-2019-0075

Micronutrient deficiencies that present significant burdens to the totality of the child-bearing age women population are often included in nutrition surveys. Vitamin A, iron, iodine, vitamin C are examples. Folate is among the most missed nutrient in country-wide assessments. In the Philippines, for example, the most recent study on folate among Filipino women was conducted in 2008 as part of the 7th Food and Nutrition Research Institute (FNRI) National Nutrition Survey.

Evidences have been building on the importance of folate as an essential nutrient associated with healthy pregnancy outcomes. Folate is a member of the water-soluble B-vitamins. Folate, a term that denotes folate from foods and folic acid from fortified foods and supplements are expressed using dietary folate equivalents (DFE). DFE accounts for variances in folate bioavailability, of which dietary folate is low while the synthetic folic acid is more bioavailable. Women of child-bearing age within 15 to 49 years need 400 micrograms (µg) DFE/day from dietary folate and folic acid from supplements and fortified foods (Bailey, 1998). Certain conditions affect folate status: inadequate intake, increased needs, absorption and other factors associated with malabsorption and some medications (Allen, 2008).

Folate has been recognised in women of child-bearing age to be necessary for normal foetal development and to reduce the risk of babies born with neural tube defect (NTD). Folate deficiency is associated with several maternal and foetal conditions. These include fatal megaloblastic anaemia, pre-eclampsia, abruption placentae, spontaneous abortion, stillbirths, pre-term delivery, maternal morbidity, low infant birth weight, and developmental and adverse health outcomes such as birth anomalies (Molloy *et al.,* 2008).

The number of registered infant deaths in the Philippines has declined from 34 per 1000 live births in 1993 to 21 in 2017, which accounts for a total of 20,311 infant deaths (PSA, 2019). Congenital defects have been in the top ten leading causes of mortality in the country (IHG-UPM, 2019). In a study by Maceda & Alcausin (2017), one in every 36 infants was born with birth defect from the 2011-2014 data of the Philippine General Hospital, a state-own hospital, which is the largest tertiary and referral hospital in the Philippines. Specifically, NTDs (anencephaly Q00, encephalocoele Q01 and spina bifida Q05) are the 5th most common birth defect with 24 affected infants per 10,000 deliveries.

Folate status among women of child-bearing age is affected by different factors in varying degrees. These include socio-demographic and socio-economic factors such as age, income, education, among others. Genetic predisposition to gene polymorphism of 677C-T allele that encodes methylenetetrahydrofolate reductase (MTHFR) is a significant predictor of folate status. Certain physiological (rapid growth in adolescence, pregnancy and lactation) and pathological conditions (cancer, gastro-intestinal inflammation and disorder etc.) affect folate status through increased demands for folate intake and reduced absorption of folate, thereby reducing the circulating folate in the blood. Use of anti-folate drugs are associated with lower folate status. Anti-folate drugs include anti-cancer drugs, anti-epileptics, some anti-bacterial and anti-malarial drugs and oral contraceptive pills. Use of metformin, an anti-diabetic drug, also poses an issue on folate status (Bailey *et al.*, 2015). More importantly, diet affects folate status through inadequate intakes of folate-rich foods and folic acid supplements, as well as folate interaction with vitamins B_6, B_{12} and zinc. Lifestyle factors like smoking and alcoholism, also affect folate status through its effect on total dietary intake

and reduced folate absorption (Bailey *et al.,* 2015; WHO, 2012).

Recent evidence showed that mandatory folic acid fortification in flour significantly reduced cases of NTDs in 13 countries (FFI, 2018), especially in countries with mandatory folic acid fortification act. Philippines already has mandatory wheat flour fortification but only with iron and zinc. It is one of the few countries in the world that has mandatory fortification of wheat flour but does not include folic acid.

The aim of the study is to describe the characteristics of Filipino women of child-bearing age based on selected explanatory variables and to determine the factors associated with deficient RBC folate. To the knowledge of the authors, there has not been a study in the Philippines that targeted the assessment of total folate intake among women of child-bearing age in consideration to its sources and bioavailability. This study attempts to determine the mean intakes of folate in microgram DFE. In addition, this study also measured folate status using the recommended biomarker - erythrocyte or red blood cell folate, which makes the result comparable to similar studies in the global setting.

MATERIALS AND METHODS

Study design

A cross-sectional survey was used in this study.

Study subject and area

The study was conducted in eight randomly selected Barangays in the Province of Batangas, Philippines from April to November 2018. Sample size was computed with 7% margin of error, 0.25 variability (p=0.25), and 90% confidence level. Participants were selected using a two-staged sampling procedure. A total of eight Barangays were randomly selected from where 25 respondents were sampled from a list of women aged 15 to 49 years. A total of 184 healthy women aged 15 to 49 years participated in the survey with 148 women who completed blood collection for folate analysis. Total sample size included 5% allowance (n=14) for non-response due to participants who were never present during visits, those who were not able to return the informed consent form, and those who expressed disinterest to join. Further, sample size allowance was applied for the set exclusion criteria. Preliminary questions were asked to the respondents to exclude factors that may confound the results of their RBC tests. These questions included: 1. Have you had any illnesses in past three months?; 2. Do you have current medical ailments in relation to diseases of the cardiovascular, kidney, abdominal, or respiratory function?; and 3. Do you take medications for high blood pressure, cancer, epilepsy and other drugs for serious medical conditions? Respondents who answered "yes" in any of the questions were excluded from the study.

Data collection procedure and management

The study followed a three-section data collection procedure which consisted of 1. Survey on socio-demographic and socioeconomic, obstetric and lactation history; 2. Dietary recalls and use of supplements; and 3. Anthropometric measurements and blood collection for folate status analysis.

The first section included a face-to-face interview using a structured questionnaire. Age, religion, education, marital status, employment, income, access to market and electricity, house ownership and vegetable gardening and livestock raising were among the socio-demographic / economic information obtained from the respondents. Obstetric and lactation history questions were partly adapted from the University of California, Los Angeles (UCLA) Department of

Obstetrics and Gynaecology Patient History Questionnaire consisting of data on status of pregnancy, lactation experience, number of children, use of oral contraceptive pills (OCP), antenatal care visit (ANC) and history of stillbirths and miscarriages. Use of folic-acid containing supplements was recorded using mean intake in µg DFE, which was computed from the dosage per intake and frequency of intake.

The second section consisted of diet recalls collected either through personal visits or phone calls and smart phone applications (Facebook, messenger app etc.) three times in a month (non-consecutively) for three months. This was done to assure that the blood folate status of women reflected long-term intakes of dietary and supplemental folic acid. Mean energy intakes were analysed using the online MenuEvalPlus developed by the Food and Nutrition Research Institute-Department of Science and Technology (FNRI-DOST). Adequacy of mean dietary intakes was assessed based on local references for energy and nutrient requirements - the Philippine Dietary Reference Intakes (PDRI) (FNRI-DOST, 2015). Mean total folate intake was summed up from total folate in the diet analysed using the 2010 Folate Content of Foods Consumed by Filipinos produced by the FNRI-DOST, and folic acid from fortified foods and folic acid-containing supplements. Total folate intake was expressed as µg DFE using the folate conversion factor where 1 µg DFE is equivalent to 1 µg DFE folate from food, and 0.6 µg DFE folic acid from supplements and fortified foods (Suitor & Bailey, 2000).

The last section composed of anthropometric and biochemical data collection. In this study, anthropometric measurement procedures followed the National Health and Nutrition Examination Survey Anthropometry Procedure Manual (CDC, 2007). Respondent's height was measured using a microtoise (Seca 206 Mechanical Measuring Tape). Weight of the respondents was measured using a battery-operated digital weighing scale (OMRON HN289 Digital Scale). Among the non-pregnant respondents with an age of 15 to 19 years, BMI-for-age was used to interpret nutritional status, while the WHO BMI cut-off points for adults was used for respondents aged ≥20 years. Nutritional status of pregnant subjects was assessed using Magbitang weight-for-height tables.

Blood samples for biochemical analysis were collected at non-fasting state by a registered medical technologist and analysed as a special test in an accredited laboratory (Hi-Precision Diagnostics). Four ethylenediamine tetra-acetic acid (EDTA) tubes were prepared and filled with 4 mL of blood drawn following the venipuncture blood collection protocol. EDTA tubes were labelled with respondent's code, name, time and date of collection. Each batch of data collection was scheduled for utmost 3 or 4 hours to preserve the stability of samples. Samples were transported immediately to the nearest holding or analysing site at 2 to 8^0C in cold packs. Improperly labelled and clotted specimens, overly-filled and under-filled tubes, insufficient quantity of blood samples, and specimens stored and transported outside the required temperature were rejected. Results of RBC folate in ng/mL were interpreted as normal or deficient using the cut-off values sensitive to risk of NTD-affected pregnancy set at >400 ng/mL. RBC folate below this value was interpreted as deficient in folate status (WHO, 2015).

The implementation of the study protocol was approved and was given ethical clearance by the Ethics Review Committee (ERC) at the Research Institute for Health Sciences (RIHS), University of the East Ramon Magsaysay Memorial Medical Center, Inc. (UERMMMCI) with RIHS ERC Code: 0482/E/O/17/141.

Statistical procedure

The data were analysed descriptively and inferentially. Sampling weights were applied in the analysis to maintain representativeness of the samples and to account for non-responses. Descriptive statistics included frequencies and percentages for categorical variables, while mean and standard deviation were used to describe continuous variables. Test of association between a continuous variable and a categorical variable with two levels was carried out using Pearson's Correlation. Rao-Scott Chi-square test was performed to determine a significant association between two categorical variables in a single population. For categorical variables that presented values without zero, Fisher's exact test of association was used. Statistical results were interpreted with a 95% level of significance. Binary logistic regression was used to determine the factors that affected deficient RBC folate at 10% level of confidence. Individual logistic regression analysis was performed to identify the most significant factor that gave the highest variability, measured as R^2, that explains the likelihood of the variable of interest. All statistical analysis were performed using SAS statistical software v.9.4.

RESULTS

Respondents' profile

The mean age of the respondents was 32.9±0.9 years (95% CI: 31.2 years, 34.6 years). Majority of them belonged to the age group of ≥30 years, mostly married or living with a partner and were Catholics. At least one third of respondents reached college or postgraduate level of education and majority of them were also employed. There was a significant association between education and status of employment (p<0.0001). Those who had 12 years of education or more tended to be employed. Male-headed household still dominated. Only 19.0% (n=23) of women were heads of their households. Household headship was significantly associated with the level of education (p=0.0025) and status of employment (p=0.0034). About 42.2% (n=68) of the respondents had difficulty accessing the market. One in every three (37.8%, n=66) women of child-bearing age had a vegetable backyard garden and/or practised livestock raising. Table 1 summarises the characteristics of the respondents in terms of their socio-demographic and socio-economic profiles.

Obstetric and lactation history

The respondents' mean age at menarche was 13.0±0.1 years (95% CI: 12.7 years, 13.3 years). About 12.6% (n=28) of respondents were never pregnant, 78.8% (n=144) were not pregnant but have had previous pregnancies and 8.6% (n=12) were currently pregnant. For pregnant respondents, the mean age of pregnancy was 5.09 months. Majority of women (77.0%, n=124) lactated previously. Exclusive breastfeeding was defined in the study as breastfeeding alone from birth up to 6 months. It was observed that 44.0% of the respondents breastfed their infants exclusively. Table 2 summarizes the obstetric, lactation history and lifestyle-related behaviors of the respondents.

Lifestyle-related behaviours

About 2.8% reported being current smokers while majority (92.1%) have never smoked tobacco. Only about 0.7% of the respondents were regular alcohol drinkers, 29.9% were occasional drinkers and 69.4% never drinks alcoholic beverages.

Use of folic acid-containing supplements

Current use of supplements in general was observed among one third of the respondents (33.5%). Use of supplements

Table 1. Socio-demographic and socio-economic profiles of respondents, *N*=184

Variables	*Mean±SD (95% CI)*	*Frequency distribution n (%)*
Age, years	32.89±0.85 (31.21, 34.57)	
15.0 to 19.9 years		15 (7.0)
20.0 to 29.9 years		56 (26.7)
30.0 to 49.0 years		113 (66.3)
Civil status		
Single		44 (15.0)
Married/Lived-in		134 (79.0)
Separated/Widowed/Divorced		6 (6.0)
Religious affiliation		
Roman Catholic		171 (94.2)
Muslim		1 (0.6)
Iglesia Ni Cristo		4 (1.4)
Evangelicals		4 (2.2)
Others		4 (1.6)
Educational attainment		
No formal education		1 (0.6)
Have reached elementary education		9 (7.9)
Have reached high school education		117 (58.9)
Have reached college education or higher		57 (32.6)
Employment		
Student/unemployed		94 (41.4)
Employed/self-employed		90 (58.6)
Household head		
No		161 (81.0)
Yes		23 (19.0)
Monthly income	13,942±1468 (11044, 16838)	
Below poverty threshold		117 (56.5)
Above poverty threshold		67 (43.5)
House ownership		
Owned		105 (57.1)
Rented		29 (14.9)
Residing for free		23 (12.1)
Living with parents/in-laws		27 (15.9)
Vehicle ownership		
No		108 (56.6)
Yes		76 (43.4)
Access to electricity		
No		2 (2.8)
Yes		182 (97.2)
Access to market		
No		68 (42.2)
Yes		116 (57.8)
Backyard vegetable gardening and/or livestock raising		
No		118 (62.2)
Yes		66 (37.8)

Table 2. Obstetric, lactation history and lifestyle-related behavior of respondents, *N*=184

Variables	*Mean±SD*	*Frequency distribution n (%)*
Age at menarche, years	13.0±0.14	
Menstruation cycle		
Irregular		38 (26.5)
Regular		146 (73.5)
Pregnancy		
Never pregnant		28 (8.6)
Currently pregnant		12 (12.6)
Not pregnant but had previous pregnancy		144 (78.8)
Number of children		
No children		30 (9.5)
1 to 2 children		89 (52.8)
≥3 children		65 (37.7)
Bleeding complications during pregnancy, *n=156*		
No		122 (75.3)
Yes		34 (24.7)
Still birth/ Miscarriage, *n=156*		
No		124 (79.6)
Yes		32 (20.4)
Reproductive health check-up if never been pregnant, *n=28*		
No		25 (89.4)
Yes		3 (10.6)
ANC visit, *n=156*		
No		0 (0.0)
Yes		156 (100.0)
Lactation		
Never lactated		42 (15.9)
Currently lactating		18 (7.0)
Previously lactating		124 (77.1)
OCP use		
Never		91 (48.9)
Former user		58 (32.7)
Current user		35 (18.4)
Tobacco smoking		
Never		174 (92.1)
Former smoker		8 (5.1)
Current smoker		2 (2.8)
Alcohol drinking		
Never		140 (69.4)
Occasional		42 (29.9)
Regular		2 (0.7)

was defined in this study as any nutrient supplements taken during the time of interview. The use of multivitamin tablets was the most common supplement taken by the respondents (55.0%). Not all the supplements recorded contained folic acid. In fact, only about 17.0% of women took folic acid-containing supplements. The mean folic acid dosage from supplements was computed at 337 μg. Intake of folic acid-containing supplements was noted to

Table 3. List of folic acid-containing supplements consumed by the respondents

Brand name	*Manufacturer*	*Dosage*	*Folic acid content (µg)*
†Obimin Plus	UNILAB	One capsule daily	1000
†Hemarate FA	UNILAB	One capsule daily	600
‡Stresstabs	Pfizer Consumer	One tablet daily	400
‡Centrum Advance	Pfizer Consumer	One tablet daily	400

Reference: †unilab.com.ph; ‡mims.com

be intentional, either due to medical reasons or current pregnancy. Among the multivitamin brands that contained folic acid and were consumed by the respondents were Obimin, Hemarate FA, Stresstabs, Centrum and C24/7 as shown in Table 3.

Body mass index (BMI)

In general, mean weight of the population was 59.9 kg (95% CI: 57.3 kg, 62.5 kg) and mean height was 154.5 cm (95% CI: 153.5 cm, 155.4 cm). Mean BMI was also computed at 25.1 kg/m^2 (95% CI: 24.1 kg/m^2, 26.2 kg/m^2). Among the non-pregnant respondents, 55.8% (*n*=96) were at normal nutritional status. About 6.4% (*n*=11) were underweight and about one-third (37.8%) were overweight or obese. Based on BMI-for-age alone, 73.4% (*n*=11) had normal nutritional status while 26.6% (*n*=4) belonged to overweight nutritional status. At the age range of 15.0 to 19.0 years, there was no reported status of underweight. Among non-pregnant respondents aged between 19.1 to 49.0 years, 54.3% (*n*=85) fell under normal nutritional status, 7.1% (*n*=11) were underweight and 38.6% (*n*=61) were either overweight or obese (Table 4). There was no correlation noted between BMI and folate status.

Total energy and folate intake

Mean total energy intake was 1542 kcal (95% CI: 1465 kcal, 1620 kcal). Energy intake was lower compared to the recommended energy intake (REI) of 1870 kcal (for 30-49 years), (FNRI-DOST, 2015). With an additional 300 and 500 calories for pregnant and lactating women, respectively, the mean energy intake was much lower for these population groups. Folate intake was expressed in µg DFE, which measured both dietary folate and folic acid from fortified foods and supplements. Resulting mean folate intake was 239 µg DFE (95% CI: 117 µg DFE, 360 µg DFE). Results showed that 84% (*n*=172) of respondents had inadequate folate intakes, while only 16% (*n*=12) had adequate or above intakes based on the 320 µg/day estimated average requirement (EAR) for females aged 19-49 years. From dietary sources alone, mean folate intake was only 81 µg DFE (95% CI: 67 µg DFE, 95 µg DFE), which contributed to 25% of EAR for folate. The mean total folate intake of women of reproductive age in Batangas was observed as low when compared to the estimated average intake of 320 µg DFE (FNRI-DOST, 2015). There was no folic acid from fortified foods recorded in the study. Moreover, mean intake was much lower when compared to the estimated average requirement for pregnant and lactating women at 520 µg DFE and 450 µg DFE, respectively (FNRI-DOST, 2015). Table 4 shows the respondents' BMI, total energy and total folate intakes.

The respondents were distributed according to the status of their red blood cell folate. About 36 (19.3%) respondents were folate deficient and 112 (80.7%) have normal folate status. According to age group, there were more folate deficient women age 15.0 to 19.9 years than their normal counterparts. For adult respondents age 20.0 to 49.0 years, there were more normal folate

Table 4. BMI, total energy and folate intakes of respondents and red blood cell folate status, *N*=184

Variables	*Mean±SD*	*Frequency distribution n (%)*
BMI, kg/m^2	25.1±0.5	
Normal		96 (55.8)
Underweight		11 (6.4)
Overweight and Obese		77 (37.8)
BMI for age (15.0 to 19.0 years), kg/m^2		
Normal		11 (73.4)
Underweight		0 (0.0)
Overweight and Obese		4 (26.6)
BMI (Non-pregnant, 19.1 to 49.0 years), kg/m^2		
Normal		85 (54.3)
Underweight		11 (7.1)
Overweight and Obese		61 (38.6)
Total energy, kcal	1542±39	
Total folate intake, µg DFE	239.0±61.6	
Below EAR		172 (84.4%)
Above EAR		12 (15.6%)
Folate intake from dietary sources, µg DFE	81.0±7.1	
RBC folate, ng/mL, *n=148*	485.0±15.5	
Normal		112 (80.7)
Deficient		36 (19.3)

status than those with deficient folate. Folate deficient respondents were spread across different level of education. Among pregnant respondents, there was no recorded folate deficiency while those who were lactating at the time of interview, about 22.2% were detected folate deficient. All but one (97.2%) alcoholic drinkers were folate deficient. Conversely, mean total energy intake of folate deficient respondents were higher than those with normal folate status while mean total folate intake was almost two times higher among respondents with normal folate status than those who were folate deficient. In addition, almost all folate deficient respondents were not taking folic acid supplements. Table 5 summarises the distribution of respondents according to their red blood cell folate across selected variables.

Among the explanatory variables included in this study, religious affiliation, education, access to electricity, pregnancy and lactation status, total folate intake and use of folic acid-containing supplements showed significant correlations with deficient folate status. Results showed that Catholicism, high school education and access to electricity increased the likelihood of folate deficiency among women of child-bearing age. However, the results for education, access to electricity and religion were statistically significant due to the homogeneity of the sampled population where 94.2% of respondents were affiliated in Catholicism, 91.5% have at least reached high school education and 97.2% had access to electricity.

Vegetable backyard gardening and alcohol drinking were both significant predictors of deficient folate status (p<0.1). Women who reported without vegetable backyard gardening and/

Table 5. Distribution of respondents according to their RBC folate status across selected variables, *n*=148

Variables	*Normal RBC folate (≥400 ng/mL), n=112*	*Deficient RBC folate (<400 ng/mL), n=36*
	Frequency distribution, n (%)	*Frequency distribution, n (%)*
Age, years		
15.0 to 19.9 years	8 (7.1)	6 (16.7)
20.0 to 29.9 years	31 (27.7)	13 (36.1)
30.0 to 49.0 years	73 (65.2)	17 (47.2)
Educational attainment		
No formal education	1 (0.9)	0 (0)
Have reached elementary education	6 (5.4)	1 (2.8)
Have reached high school education	68 (60.7)	27 (75.0)
Have reached college education or higher	37 (33.0)	8 (22.2)
Backyard vegetable gardening and/or livestock raising		
No	65 (58.0)	25 (69.4)
Yes	47 (42.0)	11 (30.6)
Currently pregnant		
Yes	12 (10.7)	0 (0.0)
No	100 (89.3)	36 (100.0)
Currently lactating		
Yes	10 (8.9)	8 (22.2)
No	102 (91.1)	28 (77.8)
Alcohol drinking		
No	2 (1.8)	1 (2.8)
Yes	110 (98.2)	35 (97.2)
Mean total energy intake	1397 kcal	1467 kcal
Mean total folate intake	118.7 µg/day	82.1 µg/day
Taking folic acid-containing supplements		
No	103 (92.0)	34 (94.4)
Yes	9 (8.0)	2 (5.6)

or livestock raising had twice as much likelihood of being red cell folate deficient than those who did (regression coefficient 0.3411; *OR*=1.978, $p<0.10$).

In this study, both pregnancy (regression coefficient -6.2348) and lactation (regression coefficient -0.6773) correlated with deficient folate status among women of child-bearing age at opposing directions. Odds ratio suggested that women who were pregnant were less likely to become folate deficient compared to non-pregnant women (*OR* <0.001, $p<0.05$), and that lactating women were more likely to be folate deficient compared to non-lactating women *(OR*=0.258, $p<0.05$). Table 6 shows the results of regression analysis between selected variables and folate status.

Total folate intake showed a statistically significant correlation to RBC folate status ($p<0.012$). The result only showed that adequate folate intake supports normal blood folate level and that inadequate intake leads to more likelihood of becoming folate deficient (*OR*=-1.088, $p<0.05$). The odds of being RBC deficient was six times more likely for those not using folic acid supplementation than those who used it (regression coefficient 0.9274; *OR*=6.391, $p<0.10$), as shown in Table 7.

DISCUSSION

The mean RBC folate among women of child-bearing age (*n*=148) was 485±16 ng/mL (95% CI: 454 ng/mL, 515 ng/mL). About 80.7% of respondents had normal RBC of >400 ng/mL. Based on the blood analysis, 19.3% of women suffered from folate deficiency, which may be contributory to NTD-affected pregnancies. More than a decade ago, at the national level, about 20.9% of Filipino women were folate deficient using RBC folate as a biomarker. However, the cut-off used was much lower at 175 ng/mL compared to the present study which used 400 ng/mL (Cheong *et al.,* 2008), which suggests that the prevalence of folate deficiency in the Philippines back in 2008 may be lower than the actual 20.9% prevalence noted using a different cut-off point. The results may suggest that folate deficiency may have increased at present since 2008. Kyrgyzstan and Guatemala, both lower middle income countries like the Philippines, showed prevalences of deficient RBC folate at 9% and 49%, respectively between 2009 and 2010 (Rogers *et al.,* 2018). Apart from risks of NTDs and other pregnancy-related complications, folate as a vitamin can cause megaloblastic anaemia, glossitis, angular stomatitis and mouth ulcers when deficient (Green & Miller, 1999).

Total folate intake was generally low due to low consumption of folate-rich foods as evidenced by the mean total dietary folate intake of 81 µg DFE. Supplementation of folic acid was also low and folic acid from fortified foods was negligible to none. Perhaps awareness on folic acid supplementation is low, thus the consumption, and the lack of policy on mandatory folic acid fortification on foods. Similarly, a study on folate intake and status of Malaysian women of child bearing-age found that total folate intake among the subjects only met 16.5% of the Malaysian recommended nutrient intake without folic acid supplementation (Khor *et al.*, 2006). It is notable that without fortification and supplementation of folic acid, intake is observed to be very low.

Majority (69.4%) of respondents without backyard garden and/or livestock production were folate deficient. The study showed evidence of increased folate consumption from food alone, and total folate intake from foods and supplements among women with vegetable backyard gardening and/or livestock production. Smoking and drinking were more common in women <30 years old. Mean dietary folate intake among those women with vegetable backyard gardening and/

Table 6. Regression analysis of factors influencing RBC folate deficiency

Variable	*Category*	*Reference Category*	*Odds Ratio (OR)*	*Coefficient*	*Standard error*	*p-value*	*R-square*
Religion	Catholic	Religion other than catholic, Muslim, INC and Evangelicals	0.239	6.520	0.706	<0.001***	0.022
	Muslim		<0.001	-4.823	0.448	<0.001***	
	INC		<0.001	-4.823	0.889	<0.001***	
	Evangelicals		<0.001	-4.823	0.448	<0.001***	
Education	No formal education	College/Post Grad	<0.001	-0.608	0.774	<0.001***	0.003
	Elementary		0.710	1.578	0.896	0.122	
	Highschool		0.328	3.109	0.509	0.01**	
Access to electricity	No	Yes	<0.001	-6.169	0.531	<0.001***	0.002
Vegetable gardening and/or livestock raising	No	Yes	1.978	0.341	0.166	0.079	0.015
Pregnancy	Pregnant	Non-pregnant	<0.001	-6.234	0.227	<0.001***	0.048
Lactation	Non-lactating	Lactating	0.258	-0.677	0.219	0.017*	0.032
Alcohol drinking	No	Yes	3.067	0.560	0.280	0.085	0.026
Total folate intake, µg DFE			0.997	-0.003	0.001	0.012*	0.041

*Statistically significant at $p<0.05$; **Statistically significant at $p<0.01$; ***Statistically significant at $p<0.001$

Table 7. Result of the regression analysis of the variable 'intake of folic acid-containing supplements'

Parameter	*Category*	*Odds Ratio*	*Estimate*	*Standard Error*	*Wald Chi²*	*p-value*
Intercept			-2.230	0.659	11.439	0.007**
Folic acid-containing Supplement	No	6.391	0.927	0.556	2.785	0.095

**Statistically significant at $p<0.01$

or livestock raising was 74.8 µg DFE, which was 18% higher compared to the mean intake of women without vegetable backyard gardening and/or livestock raising at 61.5 µg DFE. The same pattern was observed when total folate intake (including folic acid from supplements) was compared from those with and without vegetable backyard gardening and/or livestock raising. In this case, mean intake for total folate was 19% higher among those with vegetable backyard gardening and/or livestock raising compared to those without. To date, no similar study has found direct correlations between vegetable backyard gardening and/or livestock raising with RBC folate deficiency.

All pregnant women who participated in the study had adequate folate intakes and normal RBC status. Majority of them were taking folic acid-containing supplements. Perhaps the physiological drive to increase folate intake from foods and folic acid supplements influenced their intakes and thus, their folate status. The increased need for folate to be transferred to the breastmilk during lactation may be achieved at the expense of maternal folate stores. Lactating women with deficient folate status were also those who had experienced recent child birth. Child birth may lead to loss of blood during delivery and during the course of pregnancy for nourishment of the foetus. In the study of Metz, Zalusky & Herbert (1968), apparently healthy women can become folate depleted in the early postpartum period (Metz *et al.,* 1968).

Finally, the odds of being RBC deficient was higher among those who did not use folic acid supplementation compared to those who did (*OR*=6.391, $p<0.10$). Moreover, 5% of the variation in RBC deficiency can be explained by intake of folic acid-containing supplements, the highest variability among all selected variables used in this study. The result of regression analysis was consistent with the results of studies conducted in different regions in the recent years (Cummings *et al.,* 2017; Ma *et al.,* 2017).

CONCLUSION

The high prevalence of folate deficiency reported in this study is alarming. Folate is an essential nutrient, which must be supplied adequately in the diet and through supplementation before pregnancy. It is therefore important to remind those women planning for pregnancy of consumption of foods rich in folate and to take folic acid-containing supplements to avoid complications such as NTDs. Folic acid supplementation is one way to achieve adequate folate levels because of its high bio-availability and folic acid content. With supplementation, women are less at-risk of folate deficiency and the risk of NTD-affected pregnancies can be lowered. Moreover, conducting campaigns should be in place to educate women of child-bearing age on the importance of folic acid supplementation.

The results of the study suggested that women of child-bearing age who did not take folic acid supplementation were six times more likely to become RBC folate deficient compared to those who took folic acid supplementation. This warrants a more detailed assessment of the role of folic acid supplementation on folate status of women. Questions such as intention to supplement, duration, prescription, among others can be surveyed, which may help establish a deeper discussion on the association of folic acid supplementation with RBC folate status. However, further studies may be conducted taking into consideration the composition of population involved since this study was conducted both in pregnant and non-pregnant women of child-bearing age.

Acknowledgement

The authors thank the women who participated in this study and the Barangay officials and health workers for their warm accommodation and support in the implementation of the study. This research was granted local support from the Department of Science and Technology and international funding agencies, Sight and Life and Neys-van Hoogstraten Foundation. Special thanks to the Exchange Visitors Program Commission of the Philippines for providing financial assistance during the conception of this study.

Authors' contribution

AKMB, contributed to the conception, design and protocols of the study; conducted data collection, analysis and interpretation, as well as the write up of draft manuscript; NPG, contributed to the conception, design and protocols of the study and supervised the write up of the draft manuscript; LMA, contributed to the conception, design and protocols of the study, and supervised the write up of the draft manuscript; MTMT, contributed to the conception, design and protocols of the study, and supervised the write up of the draft manuscript; MCR, contributed to the conception, design and protocols of the study, and supervised the write up of the draft manuscript. All of the authors contributed to the final manuscript.

Conflict of interest

There is no conflict of interest in the conduct of the study.

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Mal J Nutr 26(2): 245-256, 2020

Association between quality of life and handgrip strength among malnourished gynaecological cancer outpatients, National Cancer Institute

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ABSTRACT

Introduction: Malnutrition is common among cancer patients and it is reported in a significant proportion of patients with gynaecological cancer (GC). The aim of this study was to determine the association between quality of life (QOL) and hand grip strength (HGS) among malnourished GC outpatients in the National Cancer Institute (NCI). **Methods:** This study was carried out in a Multidisciplinary Clinic of NCI. HGS was measured using Jamar Hand Dynamometer. Nutritional status was assessed using the scored Patient-Generated Subjective Global Assessment (PG-SGA). QOL was measured using the validated European Organisation for Research and Treatment of Cancer Questionnaire (EORTC-QLQ C30). **Results:** A total of 69 patients were selected for the study. Fifty eight (84.1%) were classified as moderately malnourished or at risk of malnutrition (PG-SGA B) and 11 (15.9%) were classified as severely malnourished (PG-SGA C). There was a moderate, significant positive relationship between HGS and functional status (r_s=0.275, p=0.022) observed in this study. Besides, in malnourished GC patients with low HGS, results indicated that they had problems with social functioning as well (r=0.255, p=0.035). Appetite was suggested as a predicting factor for low HGS among malnourished GC patients (F=12.253, p=0.001). **Conclusion:** HGS is a simple objective indicator of functionality and is, therefore, a valid item to be measured when assessing QOL of malnourished GC outpatients.

Keywords: Gynaecological cancer, nutritional status, quality of life, handgrip strength

INTRODUCTION

Gynaecologic cancer (GC) involves cancer of the ovarian, uterine, vaginal, cervical, and vulvar (Kehoe, 2006). GC accounts for 19% of new cases in female cancer worldwide (Sankaranarayanan & Ferlay, 2006). In 2018, the most commonly diagnosed cancer globally in females was cervix uteri, besides breast, colorectal and lung cancers. It is also one of the top four causes of death in females worldwide. Cervical cancer is the

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doi: https://doi.org/10.31246/mjn-2019-0096

fourth most commonly diagnosed cancer in women, with the highest incidence and mortality rate in Africa. Meanwhile, 295,414 estimated new cases of ovary cancer were reported in 2018 worldwide, with 58% of new cases having occurred in developing countries (Freddie *et al.*, 2018).

In Malaysia, cervix uteri and ovary cancers were the ten most common cancers in the years 2012-2016 (Azizah *et al.*, 2019). Cervix uteri was the third most common cancer in females while ovary cancer was the fourth most common cancer in females registered at the National Cancer Registry of Malaysia. When compared among the major ethnic groups, the highest incidence rate was among the Chinese population, followed by Indians and Malays. More than 50% of females with cervical cancer were already at stages three and four at the point of first diagnosis (Azizah *et al.*, 2019).

Malnutrition is common in cancer patients and it is reported that the incidence ranges from 20% to >70% (Arends *et al.*, 2017). Prevalence of malnutrition is commonly reported in patients with colon, nasopharyngeal (NPC) and gastric cancers (Zaid *et al.*, 2017; Norshariza *et al.*, 2017; Nicolini *et al.*, 2013). The reported prevalence of malnutrition among GC patients varies (Laky *et al.*, 2007; Fuchs-Tarlovsky *et al.*, 2013; Nho, Kim & Kwon, 2014). A significant proportion of patients with GC were found to have malnutrition (Laky *et al.*, 2007; Fuchs-Tarlovsky *et al.*, 2013) and patients with advanced ovarian cancer were particularly at risk (Laky *et al.*, 2007; Fuchs-Tarlovsky *et al.*, 2013; Nho *et al.*, 2014). Besides, it has been documented that the prevalence of malnutrition among GC patients was higher in developing countries, whereby between 62% and 88% of patients were presented with malnutrition at diagnosis (Obermair *et al.*, 2017).

Malnutrition Screening Tools (MST) is both a sensitive and specific tool used to screen patients with malnutrition (Ferguson *et al.*, 1999). Screening patient for risk of malnutrition is very crucial as it provides an indication of the nutritional status of the patients (Davies, 2005). Once a patient has been screened as high risk for malnutrition, complete nutrition assessment should be carried out by a dietitian to provide an accurate diagnosis. There are various methods of assessing nutritional status in cancer patients such as Subjective Global Assessment (SGA) and Mini Nutritional Assessment (MNA).

To date, the scored Patient-Generated Subjective Global Assessment (PG-SGA) is the best validated tool to assess nutritional status and was developed specifically for cancer patients (Ottery, 1996). The Oncology Nutrition Dietetic Practice Group of the American Dietetic Association has accepted scored PG-SGA as the standard nutrition assessment tool for patients with cancer (Huhmann, 2008). However, the nutrition assessment using PG-SGA is made on the basis of lengthy consultation, which involves a degree of subjectivity (Thompson, 2013).

Previous studies reported multiple complications associated with malnutrition including poor wound healing, higher post-operative infection risk, increased mortality rate, and longer hospital stay (Kathiresan *et al.*, 2011; Santoso *et al.*, 2010; Laky *et al.,* 2007). Besides, malnutrition can also affect the quality of life (QOL) of patients and results in reduced muscle function. Cancer itself causes an alteration in the physiological and psychological functions of patients and subsequently, will give a negative impact on the patient's nutritional status. A decline in nutritional status is also associated with decreased functional status as determined by the European Organisation for Research and Treatment of Cancer (EORTC) Questionnaire–scale Physical Function (Norman *et al.*, 2010). Questions asked in Physical Function scale are regarding both muscle function of the lower

extremities and upper extremities. Thus, it is reported that malnourished cancer patients with altered body composition will result in reduced hand grip strength (HGS). Lower HGS was also reported in the reduction of other QOL scales in Korean women (Kang, Lim & Park, 2018).

HGS is the most frequently used tool to measure muscle function as it is quick and cheap to perform. Traditionally, HGS is used for functional examination, but recent study supported the use of HGS as an early indicator of malnutrition. This is due to the faster reaction of muscle function in response to a decrease in food intake compared with other nutritional parameters (Norman *et al.*, 2010). Low HGS is commonly associated with malnutrition in the elderly population (Pieterse, Manandhar & Ismail, 2002). Besides that, disease-related malnutrition is also associated with decreased muscle function, where a study found a 25.8% lower absolute HGS value in malnourished hospitalised patients compared to well-nourished patients (Norman *et al.*, 2010). Decreased HGS has also been observed in malnourished cancer patients, but the study involved various types of cancers in inpatient setting (Norman *et al.*, 2010).

In this study, we aimed to investigate muscle function assessed by HGS in malnourished GC outpatients at the National Cancer Institute (NCI). A previous study highlighted the association of HGS and QOL, but the study involved the general population (Kang, Lim & Park, 2018). Thus, to our knowledge, no published article has explored the association between QOL and HGS specifically among malnourished GC outpatients, and particularly within the local setting. Besides, it is our interest to determine the predicting factors for the reduction in muscle function among malnourished GC patients.

MATERIALS AND METHODS

Respondents

This was an observational study, carried out between December 2017 till September 2018, in a Multidisciplinary Clinic (MDC) of NCI. A total of 69 patients meeting the inclusion criteria (aged ≥18 years of age, diagnosed with GC stages one to four, presented for diagnosis or therapy or follow-up at MDC, and patients with MST ≥ 2 were recruited into the study. MST ≥ 2 was defined as having lost weight within the last 6 months and eating poorly because of decreased appetite.

Ethical approval and permission to conduct the study was given by the Medical Research and Ethics Committee, Ministry of Health (NMRR-17-1113-36196). Written informed consent was obtained from patients prior to data collection.

Measurements

Anthropometric measurements

Weight and height were measured by a dietitian and taken according to standard techniques described by Gibson (2005). Body weight was measured with a calibrated TANITA electronic weighing scale to the nearest 0.1 kg with patients in light clothing, and height was measured with SECA stadiometer to the nearest 0.1 cm. During height measurement, patients were without shoes and were required to stand erected with their feet together and eyes in a parallax state. Body mass index (BMI) was computed as weight (kg) divided by height (m) squared.

Mid-upper arm circumference (MUAC) was taken twice to the nearest 0.1 cm and the average of the measurement was recorded. MUAC was measured at the midpoint between the shoulder and elbow, with a non-stretchable but flexible tape. Arm muscle area (AMA) and arm fat area were calculated using the formula by Gibson (Wang *et al.*, 2018).

S*cored Patient Generated-Subjective Global Assessment (PG-SGA)*

PG-SGA was derived from the SGA (Bauer, Capra & Ferguson, 2002) and was developed specifically for cancer patients (Ottery, 1996). PG-SGA is a valid procedure to determine nutritional status. The first four sections of PG-SGA include four items - weight change, dietary intake compared with usual intake, gastrointestinal symptoms, and functional destruction. The remainder part of the questionnaire includes all relevant diagnosis, metabolic stress, and physical examination. Physical examination in SGA method has three items, which include loss of subcutaneous fat (orbital, triceps and lower ribs area), muscle wasting (temporal areas, deltoids, and quadriceps with a loss of bulk and tone by palpation), and fluid status (oedema (ankle/sacral) and ascites).

Each component of the PG-SGA was scored from 0 to 4, based on the impact of symptoms on nutritional status. The total score was derived from adding the scores from these respective sections. Total scores were calculated and patients were classified as well nourished (A), moderately or suspected of being malnourished (B) or severely malnourished (C).

Hand grip strength (HGS)

HGS is an indicator of overall muscle strength and was measured using Jamar Hand Dynamometer. Patient was asked to be seated, with elbows by the side and flexed to right angles and in neutral wrist position (Pieterse *et al.*, 2002). HGS of the dominant hand was measured in triplicate and the mean of three trials was calculated and recorded. Results were compared to the reference value (Hillman *et al.*, 2005). Patients with HGS <85% of age and gender-related normal values were indicated as having muscle dysfunction (Norman, 2005).

Quality of life (QOL)

QOL was assessed using the EORTC Quality of Life Questionnaire version 3.0 (EORTC QLQ-C30). The EORTC QLQ-C30 is a QOL instrument specific for the cancer population (Ottery, 1996; Helena, 2015). This 30-item instrument examines six function scales (physical, emotional, cognitive, social, role and global health QOL), three symptom scales (e.g. fatigue, pain, nausea/vomiting) and six items assessing symptoms, along with the financial impact of the disease.

The questions appeared in Likert scale format with answers as follows: “Not at all”, “A little”, “Quite a bit” and “Very much”. The scales ranged from 1 to 4 except for the global health status scale, which has 7 points ranging from 1 (“very poor”) to 7 (“excellent”) (Aaronson, *et al.*, 1993). Results of the EORTC QLQ-C30 were linearly transformed to obtain quantified scores within the range of 0 to 100. The scoring procedure was performed according to the scoring manual of EORTC QLQ-C30 for the QOL questionnaires. Then, overall scores were calculated according to the EORTC guidelines. The raw score for each scale was calculated. Then a linear transformation of a 0-100 score was computed for each category in the scale. Thus, the range of scores for each scale varied from 0 to 100. A higher score on the function scales indicated better functioning whilst higher score on the symptom scales and single items denoted increased symptomatology or worsened financial impairment (Ravasco, Monteiro-Grillo & Camilo, 2004).

Data analysis

All statistical analyses were performed using IBM SPSS Statistics for Windows Version 24.0. Data were checked for normality by Kolmogorov-Smirnov analysis. All data were normally distributed as indicated by $p>0.05$ unless otherwise stated. If the data were not normally distributed, non-parametric analyses were used.

Descriptive statistics including mean, standard deviation and frequencies

were used to present the patient's characteristics, PG-SGA, nutritional and functional status. Pearson's correlation and Spearman's correlation were used to examine the relationship between age, body composition, PGSGA, QOL and HGS among GC patients. The level of statistical significance was set at $p<0.05$. Meanwhile, multiple logistic regression analysis was used to identify predicting factors of HGS.

RESULTS

Patient characteristics

Out of 235 patients screened, only 29.4% (n=69) of patients who met the inclusion criteria agreed to participate in the study. Another 166 patients (70.6%) were excluded from the study either due to not meeting the inclusion criteria or they declined to participate. Patient characteristics are presented in Table 1. The mean age of the patients was 52.6±13.3 years. Majority of patients were Malays (58.0%) and have had secondary education (58.0%). The majority of subjects had ovarian cancer (32.9%), followed by endometrial cancer (31.4%), cervical cancer (22.9%) and others (11.4%). A total of 26.1% and 17.4% of patients were already in cancer stages four and three, respectively.

Table 2 shows the nutritional characteristics of GC patients. Of the 69 patients selected, 58 (84.1%) were classified as moderately malnourished or at risk of malnutrition (PG-SGA B) and 11 (15.9%) were classified as severely malnourished (PG-SGA C). The mean weight of GC patients was 63.8±14.9 kg and mean BMI was 20.48±4.62 kg/m^2. There were 52 malnourished GC patients who exhibited HGS <85% standard value.

Table 1. Background characteristics of GC patients at the NCI, Putrajaya, Malaysia (N=69)

Characteristics	*n (%)*	*Mean±SD*
Demographic characteristics		
Age (years)		52.6±13.3
Ethnicity		
Malay	40 (58.0)	
Chinese	15 (21.7)	
Indian	12 (17.4)	
Others	2 (2.9)	
Level of education		
Primary	14 (20.3)	
Secondary	40 (58.0)	
Tertiary	15 (21.7)	
Clinical characteristics		
Diagnosis		
Cervical cancer	16 (22.9)	
Endometrial cancer	22 (31.4)	
Ovarian cancer	23 (32.9)	
Vaginal cancer	2 (2.9)	
Uterine cancer	4 (5.7)	
Vulvar cancer	1(1.4)	
Fallapion tube cancer	1 (1.4)	
Cancer Stage		
Stage 1	29 (42.0)	
Stage 2	10 (14.5)	
Stage 3	12 (17.4)	
Stage 4	18 (26.1)	

Table 2. Nutritional characteristics in patients with GC (*N*=69)

Variable	*n (%)*	*Mean±SD*
Age (years)		52.6±13.3
% weight loss past 6 months		6.1±5.1
Weight (kg)		63.8±14.9
BMI (kg/m^2)		20.48 ±4.62
BMI Category		
Underweight<18.5 kg/m^2, n(%)	23 (33.3)	
Normal weight (18.5 – 24.9 kg/m2)	34 (49.3)	
Overweight (≥25 kg/m2)	12 (17.4)	
AMA (mm^2)		161.62±168.04
MUAC (cm)		28.23±5.12
Albumin (g/l)		39.68±4.89
Albumin <35 g/l	9 (13.0)	
PG-SGA B	58 (84.1)	
PG-SGA C	11 (15.9)	
Hand grip strength (kg)		15.92±7.46
Handgrip strength<85%	52 (75.4)	

Relationship between HGS and independent variables

Table 3 shows the relationship between HGS, age, body composition, PG-SGA and QOL among GC patients. There was a strong, significant negative relationship between age and HGS (r=-0.787, p=0.015). Besides, there was a moderate but significant correlation between HGS and BMI (r=0.388, p=0.001); the higher the BMI of patient, the stronger the HGS score.

There was a moderate and significant relationship shown between malnutrition and HGS (r=-0.391, p=0.001), as presented in Table 3. Malnourished GC patients had significantly lower muscle function. Meanwhile, the indicators of functional status, EORTC-Scale Physical Function showed a moderate, significant positive correlation with HGS (r_s=0.275, p=0.022). This indicated that patients with better functional status had higher HGS score. Besides, other QOL scales namely role functioning, emotional functioning, cognitive functioning, social functioning, fatigue and appetite were associated with HGS.

Factors related to HGS in GC patients

In the multiple logistic regression analysis, malnutrition was a significant factor predicting lower muscle function in patients with GC (PG-SGA, F=9.376, p=0.003) (Table 4). Appetite scale in EORTC-QLQ C30 was also a predicting factor for lower HGS among GC as presented in Table 4 (F=12.253, p=0.001).

DISCUSSION

A wide variety of methods are available for nutritional evaluation including anthropometry, albumin, pre-albumin and others. Specifically, the PG-SGA has been used extensively worldwide for assessing the nutritional status among GC patients (Laky *et al.*, 2007; Das *et al.*, 2014). On the other hand, measuring HGS represents the newest approach for evaluating nutritional status, as it is able to address a functional evaluation of malnutrition. In Malaysia, there is a recent emerging concern on determining the nutritional status among GC patients. There is one recent study

Table 3. Relationship between HGS and independent variables

Variables	*Relationship (r)*	*Significant (p-value)*†
Age	-0.787	0.015*
BMI	0.388	0.001**
PG-SGA	-0.391	0.001**
Physical functioning	0.275	0.022*
Role functioning	0.263	0.029*
Emotional functioning	0.337	0.005**
Cognitive functioning	0.238	0.049*
Social functioning	0.255	0.035*
Fatigue	0.322	0.007**
Appetite	-0.405	0.001**

†Spearman's correlation test
*p<0.05
**p<0.01

using PG-SGA to assess the nutritional status among patients prior to pelvic radiotherapy treatment, which included endometrium and cervix cancer patients (Rosli *et al.*, 2017). Although there are few studies which included GC patients, none actually evaluated the association between HGS and nutritional status in GC patients.

In the present study, majority (84.1%) of these GC patients were classified at PG-SGA B and 15.9% were already at PG-SGA C (Table 2). All selected GC patients in this study were malnourished as determined by PG-SGA. As reported by various studies, the prevalence of malnutrition among GC patients is high, especially in developing countries (Obermair *et al.*, 2017). In a study from India, the nutritional status of GC outpatients at the Gujarat Cancer Research Institute was also reported to be high (Das *et al.*, 2014). Their results showed that 48.3% of patients were at risk of malnutrition or moderately malnourished (PG-SGA B), whereas 40.0% of patients were severely malnourished (PG-SGA C). The majority (88.3%) of GC patients visiting the outpatient clinic for the first time were already malnourished or were at risk of malnutrition, who needed intervention by a dietitian. The prevalence of malnutrition among cancer patients was high because of pre-existing poor nutritional status and also the late stages of diagnosis. As evidenced in this study, 43.5% of patients were already in stages three and four (Table 1). Das *et al.* (2014) in their study highlighted that patients with severe malnutrition had advanced stages of cancer (stages three and four).

Even though all our patients were classified malnourished, but at the same time, most of them (66.7%) had normal

Table 4: Factors related to HGS in GC patients

Variables	*Unstandardised coefficient β*	*Standard error*	*Standardised coefficient β*	*p*	*R*	*R^2*	*Adj R^2*	*F*	*p*
Constant	31.32	5.105		0.000					
PG-SGA	-7.137	2.331	-0.350	0.003	0.350	0.123	0.110	9.376	0.003
Constant	21.65	1.842		0.000					
Appetite	-0.132	0.038	-0.393	0.001	0.393	0.155	0.142	12.253	0.001

or overweight/obese ranges of BMI (Table 2). This finding is supported by a study conducted by Fuchs-Tarlovsky *et al.* (2013), which found that GC patients were more likely to have a BMI classified as overweight and obese. Patients who had a BMI above the normal range, might lose considerable amount of weight which contributes to the loss of lean muscle mass, but may be masked by excess body fat. According to the European Society for Clinical Nutrition and Metabolism (ESPEN) Guidelines (Arends *et al.*, 2017), a patient is classified as malnourished if BMI is <18.5 kg/m^2. This contradicts our finding where only 33.3% of patients were classified as malnourished according to BMI classification. Hence, using BMI as a sole measure of nutritional status in patients with GC cancer might cause an overlook on malnourished cancer patients who fall within the normal or overweight BMI ranges.

Albumin is often used as well in clinical studies to measure long-standing malnutrition. In this study, GC patients reported normal serum albumin (Table 2). Again, even though malnutrition can cause a decrease in the rate of albumin synthesis, the change observed in albumin levels is small (Hellerstein, 1997). However, it is still an important part of the general evaluation of GC patients, as low serum albumin is a predictor of surgically related morbidity.

We found a significant association between malnutrition and HGS among GC patients, as defined by the PG-SGA categories (Table 3). It indicated that, as nutritional status of GC patients declines, the value of HGS also reduces significantly. These results were supported by the findings from Helena *et al.* (2015) and Pieterse *et al.* (2002), who investigated the relationship between nutritional status and HGS in older people. Both studies concluded that poor nutritional status was associated with poor HGS (Helena *et al.* 2015; Pieterse *et al.*, 2002). Besides, another study conducted among pre-dialysis patients also showed that patients who had some degree of malnutrition tended to have reduced HGS (Flood *et al.*, 2014).

The association demonstrated between PG-SGA categories and HGS was likely to be linked to the relationship between muscle function and nutritional status. In a cancer patient, reduced nutritional intake is common due to primary anorexia, nausea, side effects of the treatment and many more. This will result in a loss of whole-body protein, which is mainly losses from muscle mass. Muscle function represents a dynamic indicator of muscle mass. Hence, loss of weight or muscle mass will result in decreased muscle function or muscle strength. Therefore, Norman and colleagues in a systematic review recommended that HGS be used for detecting and monitoring changes in nutritional status (Norman *et al.*, 2011).

Further analysis was carried out to determine the relationship between HGS and other variables (Table 3). We found that HGS tended to decline with age. This finding was supported by a study conducted by Pieterse *et al.* (2002). The decrease of muscle mass and muscle strength with age is mainly due to the loss of muscle fibres. Moreover, BMI also showed a significant positive correlation with HGS, which suggested that with increasing BMI, there is an increase in HGS (Table 3). This finding was consistent with the studies by Pieterse *et al.* (2002), and Lad, Satyanarayana & Shisode-lad (2013). These studies concluded that this is due to greater muscle mass, which is a major determinant of muscle strength.

Malnourished patients are believed to have impaired functional status as determined by the EORTC-Functional scales (Norman *et al.*, 2010). In our study, we demonstrated that HGS was associated with reduced physical functioning (Table 3). Besides, our study also found that low HGS was associated with low role functioning score. Recent

evidence suggests that HGS predicts activities of daily living because functional impairment correlates with several muscle strength indices (Barbat-Artigas *et al.*, 2013). Walking and doing daily activities require some level of muscle strength. Even though HGS does not represent the lower extremities, a study however concluded that decreased functionality is related with reduced muscle strength (Sallinen *et al.*, 2010).

In our study, reduced HGS was also associated with malnourished GC patients having problems in doing daily activities. Besides, reduced cognitive function was also associated with HGS among GC patients in this study. It is therefore suggested that HGS predicts a higher-level intellectual activity and social roles, in addition to usual daily activities (Sugiura *et al.*, 2013). A study conducted in Japan concluded that HGS was significantly correlated with a decline in higher-level competence.

Reduced appetite is significantly reported in patients with malnutrition. A study conducted by Nho *et al.* (2014) indicated that loss of appetite among GC patients was associated with malnutrition. In this study, malnourished GC patients were significantly associated with a reduction in appetite as well. Emotional functioning scale was also associated with HGS in the study as demonstrated in Table 4. Nho *et al.* (2014) in their study found that depression was associated with malnutrition in GC patients. Depression is one of the items in the emotional functioning scales. Even though we did not specifically look into depression of our patients in this study, it is however, important to appropriately evaluate the psychological status of GC patients in future studies. In addition, Laviano & Pichard (2007) stated that psychological aspects underline the importance of nutritional support in cancer patients, while a study conducted by Metz *et al.* (2005) concluded that cancer patients believe that nutrition and maintenance of nutritional status has a role in anticancer therapeutic strategy. Hence, by providing nutritional care and support, patients' confidence in the positive outcomes of their disease could be enhanced, leading to better emotion and subsequently better appetite. So, it is important to consider providing appropriate nutritional intervention as it helps improve patients' emotion and appetite.

Finally, nutritional status assessed using PG-SGA reported that malnutrition is an independent risk factor for reduced muscle strength in cancer patients (Norman *et al.*, 2010). This aligns with our study where malnutrition was a predicting factor for the reduction in HGS. Even though this result is not able to suggest that HGS can replace the current nutrition assessment practices, it is important to remember that HGS provides information on functionality as well, unlike PG-SGA. Besides, it is quick to perform, unlike PG-SGA that requires longer time. Thus, HGS may play an important role in outpatient setting. Furthermore, appetite as assessed using EORTC-QLQ C30 was also significant in predicting low HGS in GC patients. Appetite and malnutrition among GC patients were closely related with one another, where patients with malnutrition were often presented with poor appetite.

Limitations of our study were that we did not demonstrate how HGS can be used to predict the changes in nutritional status. As muscle function reacts earlier to nutritional restoration, thus using HGS as a target variable for monitoring changes in nutritional status is very tempting. Besides, since measuring HGS requires consistency, thus posture, arm side, handle position while taking measurements are crucial as it can affect maximum grip strength. Nevertheless, our study was able to demonstrate an overall association between HGS and QOL among malnourished GC outpatients at NCI.

CONCLUSION

In conclusion, low HGS increased with age, and was associated with BMI in GC patients. Malnourished GC patients with low HGS had low physical, role, emotional, cognitive and social functionings. HGS not only acts as an indicator of functionality, but is also a valid tool to predict nutritional status and QOL of GC outpatients.

Acknowledgement

We would like to thank the Director General of the Health Ministry of Malaysia for permission to publish this article.

Authors' contributions

AMM, as principal investigator, conducted the study, data analysis and interpretation, drafting of the manuscript and review the manuscript; ZAZ, prepared, advised and reviewed the manuscript; HCY, assisted in conducting the study; ZI, prepared, advised and reviewed the manuscript; ZAMD, prepared, advised and reviewed the manuscript; NBMY, prepared, advised and reviewed the manuscript; NJ, assisted in conducting the study; ZAR, assisted in conducting the study.

Conflict of interest

There is no conflict of interest.

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Mal J Nutr 26(2): 257-271, 2020

Factors associated with malnutrition among head and neck cancer in-patients before radiotherapy in National Cancer Institute, Putrajaya

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ABSTRACT

Introduction: Head and neck cancer (HNC) patients are often malnourished during diagnosis and before treatment. This study determined the prevalence of malnutrition and factors associated with malnutrition among HNC patients. **Methods:** A cross-sectional study among HNC in-patients before radiotherapy was conducted. Malnutrition status of the patients was determined using scored Patient Generated-Subjective Global Assessment (PG-SGA). Nutritional parameters of muscle mass, fat mass, albumin, energy and protein intakes were collected. Nutrition impact symptoms (NIS) of the patients were assessed using a validated Head and Neck Symptoms Checklist© (HNSC©). **Results:** Fifty HNC patients were recruited in this study and the age range of patients was 21 to 78 years old, with gender distribution of 78% males and 22% females. More than half of the patients were malnourished, with 20% severely malnourished before radiotherapy. The lack of dietitian referral before treatment was found to significantly affect nutritional status (p=0.027). There was a significant negative relationship between energy intake (r=0.342, p=0.015) and protein intake (r=0.386, p=0.006) with PG-SGA, indicating lower energy and protein intakes related with poor nutritional status. The result showed a significant positive relationship between NIS score (r=0.731, p<0.001) and PG-SGA, indicating the lower the NIS, the better the nutritional status among HNC patients. More than half of the HNC patients had difficulty chewing. **Conclusion:** A strong association between nutritional status and NIS showed the importance of dietary management in HNC patients. Early identification of the nutritional status of HNC patients can ensure optimal nutritional status to improve treatment outcomes.

Keywords: Head and neck cancer, nutritional status, nutrition impact symptoms, energy intake, protein intake

INTRODUCTION

Head and neck cancers (HNC) are malignancies in the head and neck region, which includes the oral and nasal cavities, sinuses, salivary glands, pharynx, larynx and lymph nodes in the neck (Stewart & Wild, 2014). It is the sixth most common cancer worldwide.

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doi: https://doi.org/10.31246/mjn-2019-0094

The incidence of oral cavity and pharyngeal cancers has been the highest in Southeast Asia, Western and Central Europe, and South America (Chaturvedi *et al.*, 2013). A total of 103,507 new cancer cases were diagnosed among Malaysians from 2007 to 2011, and the report indicated that HNC contributed 10% (10,608) of the cases (Azizah *et al.*, 2015). Nasopharynx cancer is one of the HNC and is the third most common cancer among Malaysian men (Azizah *et al.*, 2015).

The current treatment of advanced HNC requires multimodal therapy. Surgery, radiotherapy (RT), concurrent chemotherapy and radiotherapy (CCRT) have become standards of care for HNC patients. Prior to RT or CCRT treatment, HNC patients undergo either surgery or neoadjuvant chemotherapy to shrink the size of their tumour, depending on patients' clinical conditions. According to Prevost's review study, optimal nutritional status before treatment is able to improve the effectiveness of treatment and treatment outcomes (Prevost *et al.*, 2014).

However, HNC patients are often malnourished at the time of diagnosis, before treatment or during treatment due to the catabolic state induced by the malignancy and the potential for dysphagia caused by an obstructing tumour (Bower & Martin, 2009). In individuals with HNC, their weight may be affected by the tumour location and related symptoms that interfere with dietary intake. These symptoms are referred to as nutritional impact symptoms (NIS), which include loss of appetite (LOA), nausea, vomiting, taste change, anxiety, depression, difficulty swallowing, pain, dry/sore mouth, difficulty chewing, dental problems, thick saliva, and constipation (Kubrak *et al.*, 2010).

Various studies that have been done previously have shown the prevalence of weight loss before HNC treatment to be between 19% and 45%, which is an indicator of subacute malnutrition (Jager-Wittenaar *et al.*, 2007; Lees, 1999; van den Berg *et al.*, 2006). Malnutrition before treatment due to insufficient food intake is mostly related to mechanical obstruction of food or pain caused by the tumour (Luis, Izaola & Aller, 2007). Cachexia that is associated with muscle wasting with or without the loss of fat mass has contributed to malnutrition as well (Evans *et al.*, 2008). Swallowing problems and pain in the mouth are identified as main risk factors for malnutrition in HNC patients before treatment (Jager-Wittenaar *et al.*, 2007; Kubrak *et al.*, 2010; Righini *et al.*, 2013). Jager-Wittenaar *et al.* (2007) has suggested that total nutrition impact symptoms score could be assessed and addressed as part of a comprehensive care plan in order to optimise the nutritional status of patients before commencing treatment.

Nutrition is a significant aspect in HNC patient management. It determines a patient's functional status, tolerance towards treatment, and overall prognosis. A survey conducted by Spiro *et al.* (2006) demonstrated insufficient detection of malnutrition among 334 oncologists, with only one third having assessed weight loss during consultation, and 65% indicated the importance of malnutrition. Currently, HNC patients in the National Cancer Institute (NCI), Putrajaya are seldom referred to dietitians at diagnosis, instead, they are only referred when having inadequate dietary intake during RT. Dietitian referral is important to identify those who have malnutrition problems in order to optimise nutritional status before treatment. Therefore, nutritional assessments including dietary assessment and nutrition impact symptoms before treatment are important for early nutrition intervention to improve the effectiveness of treatment (Righini *et al.*, 2013).

There is a lack of study in Malaysia to evaluate the prevalence of malnutrition among patients with HNC at the time of initial management (pre-treatment). The purpose of the present study is to determine the prevalence of malnutrition among HNC patients before RT and to examine the associations between pre-treatment weight loss, laboratory parameters, dietary intake, protein intake, and NIS score with malnutrition.

MATERIALS AND METHODS

Study design and setting

This study was part of a prospective study about the changes in nutritional status among HNC patients during RT. Consecutive sampling was used to enrol every HNC patient who was admitted to receive RT or CCRT at NCI, Putrajaya, from March until December 2018, based on inclusion criteria and their informed consents, until the desired sample size was achieved. RT patients received a RT dosage between 60Gy to 70Gy in daily factions of 2.0Gy within seven weeks, while CCRT patients received additional weekly cisplatin or carboplatin during the seven weeks of RT. The inclusion criteria were HNC patients who were admitted into the ward for undergoing RT for seven weeks with or without chemotherapy for curative treatment intentions and aged ≥18 years. Besides that, patients were also on 100% oral intake at the time of the study, and without any forms of enteral tube feeding or total parenteral nutrition. Patients were excluded from this study if they were involved in another research project and ongoing artificial nutrition (enteral/ parenteral) before RT or CCRT.

Ethical approval

This study was registered with The National Medical Research Registry (NMRR ID 17-2647-37667). Ethical approval for the study was obtained from the Medical Research Ethics Committee (MREC), Ministry of Health Malaysia and the Medical Research Ethics Committee of the Faculty of Medicine & Health Sciences, Universiti Putra Malaysia. Permission to conduct the study was obtained from the Director, NCI, Putrajaya, Malaysia.

Socio-demographic and clinical characteristics

Socio-demographic data collected included age, gender, ethnicity, marital status, occupation, and education level. For clinical characteristics, they included tumour location and stage, type of treatment, duration and dosage of RT. These were obtained from the computerised Hospital Information System (HIS). Co-morbidities, smoking status, alcohol consumption and family history before RT were collected.

Nutritional status

Malnutrition status

The malnutrition status of patients was determined by using the Patient-Generated Subjective Global Assessment (PG-SGA). The PG-SGA is a global rating and scoring nutritional assessment tool specialised for cancer patients (Bauer, Capra & Ferguson, 2002). This instrument is a subjective questionnaire with closed-ended structure. The first part of the questionnaire included weight loss history, dietary intake, activities and functions, while the second part was about the patient's disease and its relation to nutrition requirements. The metabolic demand (stress) and physical examination were filled out by a physician, trained nurse or dietitian who assessed the patient's metabolic and physical demands (Ottery, McCallum & Polisena, 2000). Patients were subjectively categorised as well-nourished (PG-SGA category A), moderately or suspected of being malnourished (PGSGA category B) or severely malnourished (PG-SGA category C) upon the completion of the assessment. The scored PG-SGA is a further development of the subjective

global assessment (SGA) concept that incorporates a numerical score. A score ranging from 0 to 4 was given for each domain, depending on the impact on nutritional status. A high score indicated a lower nutritional status of the patient, thus requiring nutrition intervention. Scores with 0 to 1 point requires no intervention, health education for those with 2 to 3 points, dietetic intervention for those with 4 to 8 points, and nutrition support for those with >9 points.

Anthropometric measurements

Anthropometric measurements used in this study included body weight, height, and body composition. Body height was measured using a stadiometer (Seca 222, medical scales & measuring systems Seca, United Kingdom). Measurements of body weight and body composition were assessed with a calibrated TANITA total body composition analyser (model SC-300, bioelectrical impedance analysis scales, Japan), which can provide body weight in kg (up to 0.1 kg), fat percentage (up to 0.1 %), and total muscle mass (up to 0.1 kg). The patients were required to be bare footed and to stand upright and front facing during measurement. The patients were requested to have minimal clothing, emptied their pockets, and stand upright while barefooted on the metal plate of the scale.

Body mass index (BMI) was calculated as actual body weight/height^2 in (kg/m^2). BMI was then classified as either underweight (BMI <18.5 kg/m^2), normal (BMI 18.5–24.9 kg/m^2), overweight (BMI 25 – 29.9 kg/m^2) or obese (BMI >30 kg/m^2) (WHO, 2004). Percentage weight loss was calculated as (normal body weight – actual body weight)/ (normal body weight) x 100. Normal body weight was defined as the body weight one month before treatment and was retrieved from medical records. Actual body weight was assessed at the beginning of treatment.

Laboratory parameters

Data on serum albumin, haemoglobin (Hb) and white blood cells (WBC) count at the beginning of treatment were extracted from the patient's medical record. This is a standard routine procedure for blood sampling to monitor the patient's clinical condition.

Dietary intake (energy and protein intakes)

Dietary intake was measured through a one day 24-hour dietary recall. Foods and beverages consumed in the last 24 hours, starting from the last midnight and finishing at midnight, were identified by 24-hour dietary recall. This questionnaire consisted of six meals including breakfast, lunch, dinner and three snacks. Intakes of foods in household servings, and subsequently in grams, were collected for every meal to estimate energy and macronutrient intakes. Household measurements were used to calculate the grams of foods consumed. For this purpose, a set of household measurement tools (glass, soup bowl, plate, cup, teaspoon and tablespoon) and food models were used to guide patients in estimating portion sizes. Then, the intakes of energy and macronutrients were determined. The Nutritionist Pro software was used to analyse information on the amount of macronutrient intakes (in gram) and total energy intake (kcal) by entering the meals' recipes with the exact gram intake of all food items. The software calculated the nutrition facts of all the foods taken in a day from recall. Data on total energy and protein intakes were recorded to compare with the energy requirement of patients.

Functional status

Functional status was measured by handgrip strength using the Jamar hand dynamometer (Fred Sammons Inc, Burr Ridge, Illinois, USA). Patients sat with their shoulder adducted and neutrally rotated, elbow flexed at 90°, forearm in neutral position. Standard verbal instructions were given to the

patients to squeeze the dynamometer as hard as possible for three times after an interval of five seconds in between grips. The average of three successive attempts on the non-dominant hand was used as the final result. The handgrip strength results were then descriptively compared with reference values from the other two studies among cancer patients, whereby low hand-grip strength was defined as grip strength <25 kg (Chen *et al.*, 2011). High strength was defined as above 19.84 kg in women and 34.39 kg in men; while intermediate strength was considered between 14.68 kg and 19.84 kg in women and between 25.00 kg and 34.39 kg in men (Mendes, Alves & Amaral, 2014).

Nutrition impact symptoms (NIS)

The NIS were measured with the Head and Neck Symptoms Checklist© (HNSC©). This validated instrument aids in the early identification of symptoms that place HNC patients at risk of reductions in dietary intake, weight, and functional performance (Schmidt *et al.*, 2013). This checklist had 12 of the symptoms included in the PG-SGA (pain, dry mouth, LOA, constipation, feeling full, diarrhoea, sore mouth, nausea, altered smell, vomiting, difficulty swallowing, and taste change) plus five additional symptoms (lack of energy, depression, difficulty chewing, thick saliva, and anxiety) which were not included in the PG-SGA but reported in the literature as being associated with reduced dietary intake (Schmidt *et al.*, 2013). The HNSC© also provided space for patients to record any additional NIS interfering with eating. Patients were asked to rate the severity of each symptom and the degree to which it interfered with eating (dietary intake) using a five-point Likert scale ranging from "1=not at all" to "5=a lot". A symptom was considered "present" if the severity score was at least 2 (Kubrak, Olson & Baracos, 2013). All 17 symptom scores in the checklist were added together to make the total NIS score, which varied from 17 (no symptoms) to 85 (highest score of 5 for every symptom in the list) (Farhangfar *et al.*, 2014).

Statistical analysis

All statistical analyses were performed using the IBM SPSS for Windows, version 23 (SPSS Inc, Chicago, USA). Data were checked for normality via Shapiro-Wilk analysis. All data were normally distributed as indicated by $p>0.05$, unless otherwise stated. If the data was not normally distributed, analysis was carried out on natural logarithm of the values to improve the symmetry and homoscedasticity of the distribution.

Descriptive statistics including percentages, means and standard deviation were used to describe demographic data, clinical characteristics, nutritional status, anthropometric data, biochemical data, NIS, energy and protein intakes. The mean values from both groups were compared by using an independent *t*-test. For ordinal data or data that were not normally distributed, Mann-Whitney U-test was carried out to test the differences between groups. Spearmen's rho was performed to evaluate the association between two numerical variables. Chi-square test was used to test the significant differences between groups for categorical data. A statistical probability of $p<0.05$ was considered as significant.

RESULTS

Fifty-four patients consented to participate in this study. A total of four patients were excluded as they did not meet the study's criteria. The recruitment for this study showed that there were more male than female patients with HNC (78% versus 22%) and the median age of the population was 60 years with a range of 21-78 years old. More than half of the HNC patients in this study had nasopharynx ca ncer and 84% were in an advanced stage of the tumour. In

Table 1. Patient socio-demographic and clinical characteristics

Characteristics	*Overall (n=50)*	*Well nourished (n=22)*	*Malnourished (n=28)*	*p-value*
Age (years)†, median (IQR)	60 (49-67)	54 (44-67)	61 (52-66)	0.163
Gender§, n (%)				
Male	39 (78.0)	16 (72.7)	23 (82.1)	0.425
Female	11 (22.0)	6 (27.3)	5 (17.9)	
Ethnicity§, n (%)				
Malay	21 (42.0)	9 (40.9)	12 (42.9)	0.501
Chinese	19 (38.0)	10 (45.5)	9 (32.1)	
Indian	10 (20.0)	3 (13.6)	7 (25.0)	
Education level§, n (%)				
Primary or below	20 (40.0)	8 (36.4)	12 (42.9)	0.642
Secondary or above	30 (60.0)	14 (63.6)	16 (57.1)	
Marital status§, n (%)				
Single	13 (26.0)	4 (18.2)	9 (32.1)	0.264
Married	37 (74.0)	18 (81.8)	19 (67.9)	
Working status§, n (%)				
Yes	14 (28.0)	6 (27.3)	8 (28.6)	0.919
No	36 (72.0)	16 (72.7)	20 (71.4)	
Co-morbidities§, n (%)				
Yes	29 (58.0)	12 (54.5)	17 (60.7)	0.661
No	21 (42.0)	10 (45.5)	11 (39.3)	
Smoking history§, n (%)				
Active smoker	7 (14.0)	3 (13.6)	4 (14.3)	0.164
Non-smoker	25 (50.0)	14 (63.6)	11 (39.3)	
Ex-smoker	18 (36.0)	5 (22.7)	13 (46.4)	
Alcohol history§, n (%)				
Yes	12 (24.0)	6 (27.3)	6 (21.4)	0.631
No	38 (76.0)	16 (72.7)	22 (78.6)	
Family history§, n (%)				
Yes	14 (28.0)	7 (31.8)	7 (25.0)	0.753
No	36 (72.0)	15 (68.2)	21 (75.0)	
Tumour location¶, n (%)				
Tongue	7 (14.0)	3 (13.6)	4 (14.3)	0.623
Mouth	6 (12.0)	2 (9.1)	4 (14.3)	
Salivary gland	3 (6.0)	1 (4.5)	2 (7.1)	
Tonsil	2 (4.0)	0 (0.0)	2 (7.1)	
Oropharynx	2 (2.0)	0 (0.0)	2 (7.1)	
Nasopharynx	26 (52.0)	15 (68.2)	11 (39.3)	
Sinuses	1 (2.0)	0 (0.0)	1 (3.6)	
Larynx	3 (6.0)	1 (4.5)	2 (7.1)	
Stage of tumour§, n (%)				
1-2	8 (16.0)	5 (22.7)	3 (10.7)	0.277
3-4	42 (84.0)	17 (77.3)	25 (89.3)	
Type of treatment§, n (%)				
Radiotherapy	17 (34.0)	7 (31.8)	10 (35.7)	0.773
Chemoradiotherapy	33 (66.0)	15 (68.2)	18 (64.3)	

Table 1. Patient socio-demographic and clinical characteristics (cont'd)

Characteristics	*Overall (n=50)*	*Well nourished (n=22)*	*Malnourished (n=28)*	*p-value*
PG-SGA global rating				
A (well-nourished)	22 (44.0)			
B (moderately malnourished)	18 (36.0)			
C (severely malnourished)	10 (20.0)			
Triage intervention				
No intervention (Score of 0–1)	4 (8.0)			
Health education (Score of 2–3)	13 (26.0)			
Dietetic intervention (Score of 4–8)	10 (20.0)			
Critical interventions (≥ 9)	23 (46.0)			
BMI category ¶				
Underweight (<18.5 kg/m2)	12 (24.0)	3 (13.6)	9 (32.1)	0.224
Normal weight (18.5-24.9 kg/m2)	25 (50.0)	13 (59.1)	12 (42.9)	
Overweight (25-29.9 kg/m2)	5 (10.0)	1 (4.5)	4 (14.3)	
Obese (>30 kg/m2)	8 (16.0)	5 (22.7)	3 (10.7)	
Pre-treatment weight loss ¶				
None	14 (28.0)	12 (54.4)	2 (7.1)	<0.001
<5% in 1 month or <10% in 6 months	30 (60.0)	10 (45.5)	20 (71.4)	
≥5% in 1 month or ≥10% in 6 months	6 (12.0)	0 (0.0)	6 (21.4)	
Nutrition Impact Symptoms (NIS) §				
Yes	40(80.0)	14 (63.6)	26 (92.9)	0.014
No	10 (20.0)	8 (36.4)	2 (7.1)	
Dietitian referral §				
Yes	23 (46.0)	14 (63.6)	9 (32.1)	0.045
No	27 (54.0)	8 (36.4)	19 (67.9)	

Note: NA: not applicable
† Mann-Whitney U test
§Chi-square test for proportions
¶Fisher's exact test.
$p<0.05$ shows the significant difference between well-nourished (PG-SGA category A) and malnourished patients (PG-SGA category B/ PG-SGA category C)

addition, 33 (66%) received CCRT while 17 (34%) received RT only. All patients received a total of 60Gy and above 30 fractions radiation dosage (Table 1).

The prevalence of pre-treatment malnutrition was 56% (PG-SGA category B and PG-SGA category C), with 20% severely malnourished (PG-SGA category C) (Table 1). The median score for PGSGA was 7, indicating a requirement for dietetic intervention. More than 50% of the malnourished HNC patients were in advanced stage. There were no significant differences between malnutrition status with gender and ethnic groups.

Mean body weight was 60.24±14.73 kg with 43.03±8.12 kg muscle mass. Half of the HNC patients had a normal BMI before treatment, followed by 24% underweight, 16% obese and 10% overweight (Table 1). About 72% HNC patients had weight loss before treatment,

Table 2. Anthropometric measurements, laboratory parameters, handgrip strength, dietary intake, PG-SGA score, NIS score of well-nourished and malnourished patients

Measurements	*Overall (n=50)*	*Well nourished (n=22)*	*Malnourished (n=28)*	*p-value*
Mean±SD†				
Body weight (kg)	60.24±14.73	62.69±12.30	58.32±16.36	0.303
Muscle Mass (kg)	43.03±8.12	43.32±6.90	42.79±9.11	0.823
Albumin (g/L)	40.68±2.65	41.86±1.93	39.75±2.80	0.003
WBC (10^9/L)	7.29±2.51	7.53±2.33	7.11±2.68	0.566
Hb (g/dL)	12.86±1.61	13.16±1.46	12.62±1.70	0.539
Handgrip strength (kg) Male Female	25.17±7.46 27.50±6.67 16.88±2.62	26.20±8.20	24.35±6.86	0.390
Energy intake (kcal/kg BW/day)	24±9	27±9	21±8	0.032
Protein intake (g/kg BW/day)	1.03 ± 0.43	1.13±0.33	0.95±0.49	0.115
Median (IQR)‡				
Pre-treatment weight loss (%)	1.85 (0.00-3.42)	0 (-2.35-1.33)	3.23 (1.84- 4.43)	<0.001
BMI (kg/m2)	21.58 (18.60-25.00)	23.68 (19.90-28.87)	20.0 (17.32- 24.95)	0.118
Fat Mass (kg)	13.3 (9.3-18.5)	14.1 (9.7-15.2)	13.2 (7.8-15.2)	0.301
PGSGA score	7 (2.75-14)	2 (2-3.25)	14 (10-18)	<0.001
NIS score	20 (18-25)	18 (17-20)	23 (20.25-27)	<0.001

†Independent T-test
‡Mann Whitney U-test
$p<0.05$ shows the significant difference between well-nourished (PG-SGA category A) and malnourished patients (PG-SGA category B/ PG-SGA category C). Abbreviations: WBC: White blood cells, Hb: Hemoglobin, PG-SGA: patient-generated subjective global assessment, BMI: body mass index, NIS: nutrition impact symptoms

Table 3. Nutrition Impact Symptoms (NIS) interference scores from the Head and Neck Symptoms Checklist (HNSC©) of the patients (*n*=50)

NIS interference score (1-5)	*Prevalence n (%)*	*Median (IQR)*	*Well nourished (n=22)*	*Malnourished (n=28)*	*p-value*
Taste change	5 (10)	1 (1-1)	1 (1-1)	1 (1-1)	0.039
Difficulty swallowing	9 (18)	1 (1-1)	1 (1-1)	1 (1-2)	0.004
Difficulty chewing	26 (52)	2 (1-3.25)	1 (1-2)	2.50 (1-4)	0.017
Constipation	8 (16)	1 (1-1)	1 (1-1)	1 (1-1.75)	0.048
Loss of appetite	19 (38)	1 (1-2)	1 (1-1)	2 (1-3)	0.001
Dry mouth	19 (38)	1 (1-2)	1 (1-1)	2 (1-2)	0.011
Pain	11 (22)	1 (1-1)	1 (1-1)	1 (1-2.75)	0.007
Anxious	9 (18)	1 (1-1)	1 (1-1)	1 (1-1)	0.455
Nausea	4 (8)	1 (1-1)	1 (1-1)	1 (1-1)	0.197
Lack of Energy	14 (28)	1 (1-2)	1 (1-1)	1 (1-2)	0.057
Sore mouth	6 (12)	1 (1-1)	1 (1-1)	1 (1-1)	0.155
Diarrhoea	0 (0)	1 (1-1)	1 (1-1)	1 (1-1)	1.000
Thick saliva	12 (24)	1 (1-1.25)	1 (1-1)	1 (1-2)	0.107
Depressed	2 (4)	1 (1-1)	1 (1-1)	1 (1-1)	0.863
Fullness	4 (8)	1 (1-1)	1 (1-1)	1 (1-1)	0.455
Vomiting	3 (6)	1 (1-1)	1 (1-1)	1 (1-1)	0.704
Smell bothersome	6 (12)	1 (1-1)	1 (1-1)	1 (1-1)	0.716

Note: Prevalence of NIS when severity scores ≥2; Mann-Whitney U test for skewed data
$p<0.05$ shows the significant difference between well-nourished (PG-SGA category A) and malnourished patients (PG-SGA category B/PG-SGA category C)

with 12% having critical weight loss of ≥5%. The median percentage of weight loss at the beginning of treatment from all 50 patients was 1.85%, with a range of 0% to 3.42% (Table 2). There was a significant difference in pre-treatment weight loss between well-nourished and malnourished patients. There was a weak positive relationship between pre-treatment weight loss and NIS (r=0.332, p=0.019), which indicated that those with higher NIS scores experienced higher pre-treatment weight loss (Table 5). However, there were no significant associations between pre-treatment weight loss with albumin, energy intake, and protein intake (Table 5).

About 80% HNC patients had NIS before the start of treatment, with only 20% of patients experiencing none of the 17 symptoms listed (Table 2). Almost all malnourished HNC patients had NIS symptoms compared to 63.6% among those well-nourished. Well-nourished patients had a statistically better total NIS score compared to malnourished patients. There were seven significant differences in NIS between well-nourished and malnourished patients including taste change, constipation, difficulty chewing, difficulty swallowing, dry mouth, LOA and pain around tumour (Table 3). More than half of the HNC patients had the symptom of difficulty in chewing before treatment (Table 3).

The energy intake and protein intakes of HNC patients in this study were 24±9 kcal/day and 1.03±0.43 g/day, respectively. About 72% HNC patients were on normal diet, 10% on soft diet,

Table 4. Correlation between independent variables and PG-SGA total score (*n*=50)

Independent variables	*Relationship (r)*	*Significance (p)*
NIS score	0.731	<0.001
Albumin (g/L)	-0.278	0.05
Energy intake (kcal/kg BW/d)	-0.342	0.015
Protein intake (g/kg BW/d)	-0.386	0.006

Spearmen's rho $p<0.05$ shows significant association
Abbreviations: PG-SGA: patient-generated subjective global assessment, NIS: nutrition impact symptoms

Table 5. Correlation between independent variables and pre-treatment weight loss (*n*=50)

Independent variables	*Relationship (r)*	*Significance (p)*
NIS score	0.332	0.019
Albumin (g/L)	-0.245	0.087
Energy intake (kcal/kg BW/d)	0.20	0.892
Protein intake (g/kg BW/d)	0.068	0.638

Spearmen's rho $p<0.05$ shows significant association
Abbreviations: PG-SGA: patient-generated subjective global assessment, NIS: nutrition impact symptoms

6% on minced diet, 10% on blended diet and 2% on full liquid diet. The energy and protein intakes for well-nourished and malnourished patients were 27±9 kcal/kg BW/day and 1.13±0.33 g/kg BW/day, and 21±8 kcal/kg BW/day and 0.95±0.49 g/kg BW/day (Table 2). Significant difference was found in energy intake between well-nourished and malnourished patients ($p<0.05$). A majority of HNC patients (90%) were not on any oral nutritional supplement (ONS) support at the beginning of treatment. There were only 14.2% malnourished HNC patients on ONS before treatment.

All HNC patients had normal albumin with a mean±standard deviation (*SD*) of 40.7±0.4 g/L. Furthermore, mean Hb value for both male (13.1±0.3 g/L) and female (12.0±0.4 g/L) patients were at normal values as well. WBC was within the normal range with means of 7.3±0.4 10^9/L. There were no significant differences between WBC and Hb of patients who were well-nourished ($p=0.566$) and malnourished ($p=0.539$), according to PG-SGA. Based on gender, the overall reading for males was better than females, which were 27.50±6.67 kg and 16.88±2.62 kg, respectively.

Out of 50 HNC patients, only 23 patients (46%) had been referred to a dietitian before the start of treatment (Table 1). However, around 70% malnourished patients had no dietitian referral. There was a significant difference in dietitian referral between well-nourished and malnourished patients, $p=0.045$.

Table 4 shows there were significant negative relationships between energy intake ($r=0.492$, $p<0.001$) and protein intake ($r=0.478$; $p<0.001$) with PG-SGA; which indicated lower energy and protein intakes related with poor nutritional status (lower mean score of PG-SGA). A significant strong association with PG-SGA was observed for NIS score ($r=0.731$, $p<0.001$), indicating the better the nutritional status, the lower the NIS of the HNC patients.

DISCUSSION

The prevalence of malnutrition in this study was high (56%). Similar findings were obtained from other studies using PG-SGA on patients with cancer, which also reported 42% to 76% patients either being malnourished or at risk of being malnourished (Bauer *et al.*, 2002; Luis *et al.*, 2007). It is a concern that >50% HNC patients had malnutrition problems before starting RT or CCRT, which can further worsen their nutritional status with treatment-related symptoms. Untreated malnutrition has been associated with reduced response towards treatment, poor survival and a diminished quality of life (Santarpia, Contaldo & Pasanisi, 2011). Therefore, it is crucial to maintain an optimal nutritional status for patients before treatment for better outcomes and reduce complications such as treatment interruption (Lin *et al.*, 2005).

Weight loss remains a clinically relevant, simple, and reliable marker of malnutrition. Our study reported that 12% HNC patients had a critical weight loss ≥5% in one month. Langius *et al.* (2016) revealed a similar result in a study of HNC patients where 16% of the patients had critical weight loss (>5%) before treatment. Another study reported that at the time of diagnosis, 34% of patients with oral/oropharyngeal cancer had already lost ≥10% of body weight in six months or ≥5% in one month (Jager-Wittenaar *et al.*, 2007). Weight loss of ≥10% in six months or ≥5% in one month has been shown to increase complication rates, such as impaired wound healing, reduced immune function and decreased tolerance towards surgery, RT and chemotherapy. The outcomes may lead to higher mortality and reduced quality of life (van Bokhorst-de van der Schueren *et al.*, 1997).

Although there was no significant difference for handgrip strength among well-nourished and malnourished groups, the handgrip strength of HNC patients in this study was categorised as intermediate strength when compared to a previous study on cancer patients (Mendes *et al.*, 2014). This indicated that cancer patients may experience some muscle wasting due to diminished synthesis of muscle protein and increased degradation of proteins (Kilgour *et al.*, 2013; Chen *et al.*, 2011).

There was a significant difference in NIS (taste change, difficulty swallowing, difficulty chewing, constipation, LOA, dry mouth and pain) between well-nourished and malnourished patients. Neoadjuvant chemotherapy prior to RT is one of the reasons HNC patients experience LOA, dry mouth, lack of energy, thick saliva, and pain. Farhangfar *et al.* (2014)'s study reported that LOA, difficulty chewing, dry mouth and pain were symptoms associated with reduced dietary intake. Most of the malnourished patients experienced reduced dietary intake due to these symptoms. This study found that the malnourished group had a lower dietary intake compared to the well-nourished group. The average daily energy and protein intakes in this study were below the European Society for Clinical Nutrition and Metabolism (ESPEN) recommended guidelines of 30 – 35 kcal/kg of body weight and 1.2 – 1.6 g/kg body weight. Advanced staging showed a significant association with decreased energy and protein intakes, and nutritional depletion, according to Ravasco *et al.* (2003)'s study on HNC patients. In our study, majority of HNC patients were in advanced stage and were found to have a higher tendency of nutritional depletion with inadequate energy and protein intakes, which marked the same nutrition intake deficits with the earlier mentioned study.

In our study, there was a significant relationship between pre-treatment weight loss with NIS score. Multiple NIS are more likely to reduce dietary intake and induce weight loss. Half of the HNC patients had the symptom of difficulty in

chewing. Most patients with oral cancer are edentulous or partially dentate, which adversely affects their masticatory function (Farhangfar *et al.*, 2014). Post-dental extraction before treatment might expose patients to difficulty in chewing hard solid foods and thus lead to pre-treatment weight loss. Patients having chewing problems have been seen changing their diet into a soft, mashed or liquid diet. As nutritional density of a mashed or liquid diet is lower than that of a solid diet, these patients are at a high risk of malnutrition too. For those patients who have received early nutrition management before treatment where they are advised to use energy and protein enriched liquid dietary supplements, the use of these supplements increases energy and protein intakes and in turn decreases the risk for malnutrition (Nejatinamini *et al.*, 2018). For a patient who is having NIS prior to RT, especially one who is malnourished, ONS initiation should be implemented as soon as at the beginning of RT.

The timing of nutritional intervention is fairly important. This study revealed that malnutrition could happen before RT commencement and perhaps at the time of diagnosis. Jager-Wittenaar *et al.* (2017)'s exploratory study suggested a high prevalence of cachexia (42%) in patients with newly diagnosed HNC. There was about 54% HNC patients in this study who have had no dietitian referral prior to RT and this remains a concern in clinical oncology. Majority of malnourished patients in this study were unable to start their treatment in optimal nutritional status due to the lack of dietitian referral, with only 32.1% receiving nutrition management. This result is similar to other studies that reported only 30% to 60% of cancer patients at risk of malnutrition having received nutritional treatment, and even patients diagnosed with severe malnutrition failed to receive an appropriate nutritional intervention (Attar *et al.*, 2012; Segura *et al.*, 2005). A significant number of cancer patients at risk of malnutrition remain undetected due to the lack of nutrition screening during diagnosis and absence of nutritional evaluation as part of routine practice in the clinical setting (Koom, Ahn & Song, 2012). According to the Clinical Oncology Society of Australia, malnutrition screening should be undertaken by all patients at diagnosis to identify those at nutritional risk, and then repeated at intervals through each stage of treatment.

The factors associated with malnutrition in this study included high pre-treatment weight loss, high NIS score, reduced energy and protein intakes. Our study is consistent with another HNC patients study which found that malnutrition was significantly associated with multiple NIS, reduced dietary intake, and involuntary weight loss (Schmidt *et al.*, 2013). Patients with HNC should be nutritionally screened using a validated screening tool (PG-SGA or SGA) and NIS checklist at diagnosis.

The strength of the current study was the rich data of nasopharynx patients among all other categories of HNC such as laryngeal, tonsil and tongue. The results serve as a reference and benchmark for further research on particular types of nasopharynx cancer. At the same time, NIS of HNC patients were observed clearly with a validated HNSC© that allowed us to design a more effective nutrition intervention in future. To the best of our knowledge, our study was the first in Malaysia to examine the association between nutritional status with energy intake, protein intake and NIS in HNC patients at the beginning of RT.

Limitations of this study were the inherently limited single-institution design with only HNC in-patients as opposed to having data on outpatients across multiple institutions, thus making it difficult to draw stronger conclusions. This study has only observed the

nutritional status of HNC patients at the beginning of RT, therefore, it is suggested that a further observational study at diagnosis could be done in order to generate a more comprehensive data on the nutritional status among HNC patients. Long-term follow-up is proposed to enable an investigation of any associations between pre-treatment nutritional status with treatment outcomes.

CONCLUSION

In summary, 56% of patients from this study were malnourished and 20% were severely malnourished at the beginning of RT. However, the lack of dietary counselling has led to higher risks of malnutrition among HNC patients before RT. In addition, this study showed that malnourished HNC patients experienced higher NIS scores, and reduced energy and protein intakes at the beginning of RT. More than half of the HNC patients had the symptom of chewing difficulty. Our study provided important preliminary data suggesting that early identification of malnutrition and dietitian referral before treatment commencement are warranted. Our results have presented the need for active nutritional status screening including NIS assessment at cancer diagnosis apart from at the beginning of treatment. Early identification of the nutritional status of patients at presentation ensures optimal nutritional status to improve overall treatment outcomes.

Acknowledgements

The author would like to express a sincere appreciation to the General Director of the Ministry of Health, Malaysia for approval of this study, as well as the department of administration, National Cancer Institute, Putrajaya for assistance in this study. Besides, we thank all the patients who have participated and contributed in this study.

Authors' contributions

NMK, principal investigator, conceptualised and designed the study, prepared the draft of the manuscript and reviewed the manuscript; ZAR, NJ, advised on the data analysis and interpretation, and reviewed the manuscript; SNAS, AA, HCY, BSHL, NWH, AMM, led the data collection and reviewed the manuscript; ZAZ, advised on data analysis and interpretation, assisted in drafting of the manuscript, reviewed the manuscript; NBMY, ZI, ZAMD reviewed the manuscript.

Conflict of interest

All authors declare that they have no conflict of interest with any party in relation to this manuscript.

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Mal J Nutr 26(2): 273-287, 2020

Dietary diversity, vitamin D intake and childhood stunting: a case-control study in Bantul, Indonesia

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ABSTRACT

Introduction: Stunting is known to be a major public health problem among Indonesian children. We aimed to examine the association between dietary diversity and vitamin D intake with stunting in children aged 6-23 months. **Methods:** This case-control study was conducted in Bantul District, Yogyakarta Special Region, Indonesia. A total of 79 subjects aged 6-23 months were selected for each case and control group based on their stunting status. We assessed potential explanatory variables at the child, parental, household, and community levels. **Results:** Factors which were significantly associated with stunting included young children aged 18-23 months (adjusted *OR* = 3.84; 95% CI: 1.17-12.26), birth length ≥48 cm (adjusted *OR* = 0.36; 95% CI: 0.16-0.83), inadequate intake of vitamin D (adjusted *OR* = 5.18; 95% CI: 1.03-26.02), and diversified diet (adjusted *OR* = 0.17; 95% CI: 0.03-0.92). Other variables such as household economic status, living residency, history of exclusive breastfeeding, and infectious diseases, as well as intakes of energy and protein were not significantly related to stunting. **Conclusion:** Minimum dietary diversity, vitamin D intake from complementary foods, and birth length were associated with stunting status among children. Therefore, it is crucial to focus on stunting prevention programmes in the first two years of life, or even since the preconception period.

Keywords: Stunting, dietary diversity, vitamin D, determinants, Indonesia

INTRODUCTION

Stunting is a public health problem in Indonesian children. According to the Indonesian National Basic Health Survey in 2018, the prevalences of stunting and severe stunting in children under two years old were 17.1% and 12.8%, respectively (NIHRD, 2019), which meant that one in three Indonesian children under 2-year-old experienced chronic undernutrition. Stunting has been associated with increased adverse effects including failure of reaching growth potential, decreased neurocognitive functions, and greater risk of obesity and non-communicable diseases in later life (de Onis & Branca, 2016). In addition, it is responsible for 14.5% of deaths and 12.6% of disability-adjusted life-years (DALY) in children under the age of 5 years (Black *et al.*, 2008).

Stunting is an interlinked process of growth which may begin *in utero*, then continue to neonatal, infant and childhood, pubertal, and adulthood, where each stage is influenced by different mechanisms (Prendergast & Humphrey, 2014). Nonetheless, it is important to

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doi: https://doi.org/10.31246/mjn-2020-0021

realise that for a nutritional challenge such as stunting, its causes are deeply embedded in situational structures. A previous review on stunting determinants among Indonesian children highlighted that birth outcomes, infant and young child feeding practices, hygiene and sanitation, and sociodemographic factors may influence childhood stunting (Beal *et al.*, 2018).

A large-scale study in Indonesia found that the odds of stunting was greater in children who were living in a household with three or more toddlers, had five to seven household members, mothers who attended <4 times of antenatal care during pregnancy, boys, and children who were born <2500 g in weight (Titaley *et al.*, 2019). However, another similar study concluded that feeding factors such as exclusive breastfeeding were not related to childhood stunting (Paramashanti, Hadi & Gunawan, 2015). Specifically, an earlier study conducted in Yogyakarta Special Region reported that one of key determinants of childhood stunting included poor dietary diversity (Paramashanti, Paratmanitya & Marsiswati, 2017).

Vitamin D intake may have a potential effect on stunting prevention and treatment (Yu *et al.*, 2017). However, none of the previous studies in Indonesia showed this significant association (Ramadhani, Bahar & Dachlan, 2019; Chairunnisa, Kusumastuti & Panunggal, 2018). Due to the inconsistent results and limited variables used, as well as the cross-sectional designs used by most of these studies, we could not draw any conclusion.

Bantul is one of the five districts/ municipalities in Yogyakarta Special Region recruited by the Indonesian government as an intervention area to resolve stunting, even though the prevalence of stunting in this area is not so high. In the national programme of tackling stunting, our local government initiated a nutrition-improved village model in several regions in Yogyakarta Special Region. The public health office of Yogyakarta Special Region made an additional nutrition programme for pregnant women and children by giving fortified biscuits especially in areas with high malnutrition cases. The prevalence of stunting among children under 5 years old for Bantul District in 2017 was 10.41%, the lowest prevalence amongst other districts in Yogyakarta Province (MOH Indonesia, 2017). A previous study showed that the odds of stunting increased significantly in children aged 12-24 months (Titaley *et al.*, 2019), but there are no public data available yet about the prevalence of stunting for children under 2 years old for Bantul District.

Reducing stunting from a not-so-high prevalence sounds challenging, therefore it is necessary to identify the proper risk factors in order to achieve this target. The intervention to reduce stunting will address some of the risk factors mentioned above, but also some other important risk factors that have not been investigated yet. Previous studies that have investigated the risk factors of stunting among Indonesian children had limitations such as unavailability of children's nutrient intake data, infectious diseases being limited only to diarrhoea in the past two weeks before data collection, and child's length at birth was not analysed (Beal *et al.*, 2018; NIHRD, 2013). Therefore, this study aimed to examine whether dietary diversity and vitamin D intake were associated with stunting in children under the age of 2 years in Bantul District, Yogyakarta Special Region, Indonesia.

MATERIALS AND METHODS

A case-control study was conducted in Bantul District, Yogyakarta Special Region, Indonesia. The Yogyakarta

Special Region is located 565 km from Jakarta, the capital city of Indonesia. The region consists of five municipalities/ districts: Bantul, Sleman, Kulonprogo, Gunungkidul, and Yogyakarta City. Specifically, the Bantul District was selected as the study location as it mirrored urban and rural areas. This study was done between July and September 2019.

The population in this study were young children aged 6-23 months residing in Bantul District, with samples recruited under the areas of Sewon, Pandak, and Bambanglipuro sub-districts. We defined case as a child whose height-for-age Z-score was <-2 SD, whereas control was a child with a height-for-age Z-score ≥-2 SD, based on the World Health Organization (WHO) growth chart (WHO, 2006). For both cases and controls, we excluded children who did not own a maternal and child health book, were not *de jure* residents and diagnosed with congenital diseases that limited them for height measurement.

Sample size was calculated using OpenEpi version 3 with proportions of non-exclusive breastfeeding based on a previous study (Paramashanti *et al.*, 2015). We set 95% level of confidence (CI), 80% power, and 1:1 ratio between case and control groups within the Kelsey formula. Thus, we obtained 80 subjects for each case and control group. Samples were selected by using multistage cluster sampling, where we divided our samples based on sub-districts as clusters. Firstly, three of 17 sub-districts were chosen randomly, namely Sewon, Pandak, and Bambanglipuro sub-districts. Secondly, two villages were selected randomly by lottery in every sub-district to represent each the rural and urban areas. Lastly, we obtained the village-level nutritional status data listed in the February 2019 report from each village's primary health centre.

To minimise potential bias in this study, we reassessed the lengths of children to determine stunting status. In this study, 37 *Posyandu* (integrated health posts at the village level) were identified to be included. As *Posyandu* was held routinely to monitor children's body weight, to provide supplementary foods for wasted children, and to deliver counselling for mothers, thus it was feasible to interview mothers and to measure their child's height during data collection. Then, we differed children based on their stunting status. A computerised simple random sampling was used to select cases in each *Posyandu*, whereas controls were chosen within the same *Posyandu*.

Screenings from public health centres of both case and control groups showed that we obtained 122 stunted and 718 normal children. We randomly selected 80 subjects for each group. Unfortunately, one subject from the case group was excluded due to incorrect measurement result, thus resulting in only 79 children for each group (a total of 158 children) being analysed (Figure 1).

The primary outcome of this study was childhood stunting. A child was considered as stunted if the height-for-age Z-score was <-2 SD below the growth reference curve (WHO, 2006). At the time of the interview, the length of the child was measured by using an infantometer. Meanwhile, our predictors were dietary diversity and intake of vitamin D among the children. Dietary diversity is defined as the consumption of at least four food groups of a total of seven food groups: 1) grains, roots and tubers; 2) legumes and nuts; 3) dairy products; 4) flesh foods; 5) eggs; 6) vitamin-A rich fruits and vegetables; and 7) other fruits and vegetables (WHO, 2008). Dietary diversity was estimated by a semi-quantitative food frequency

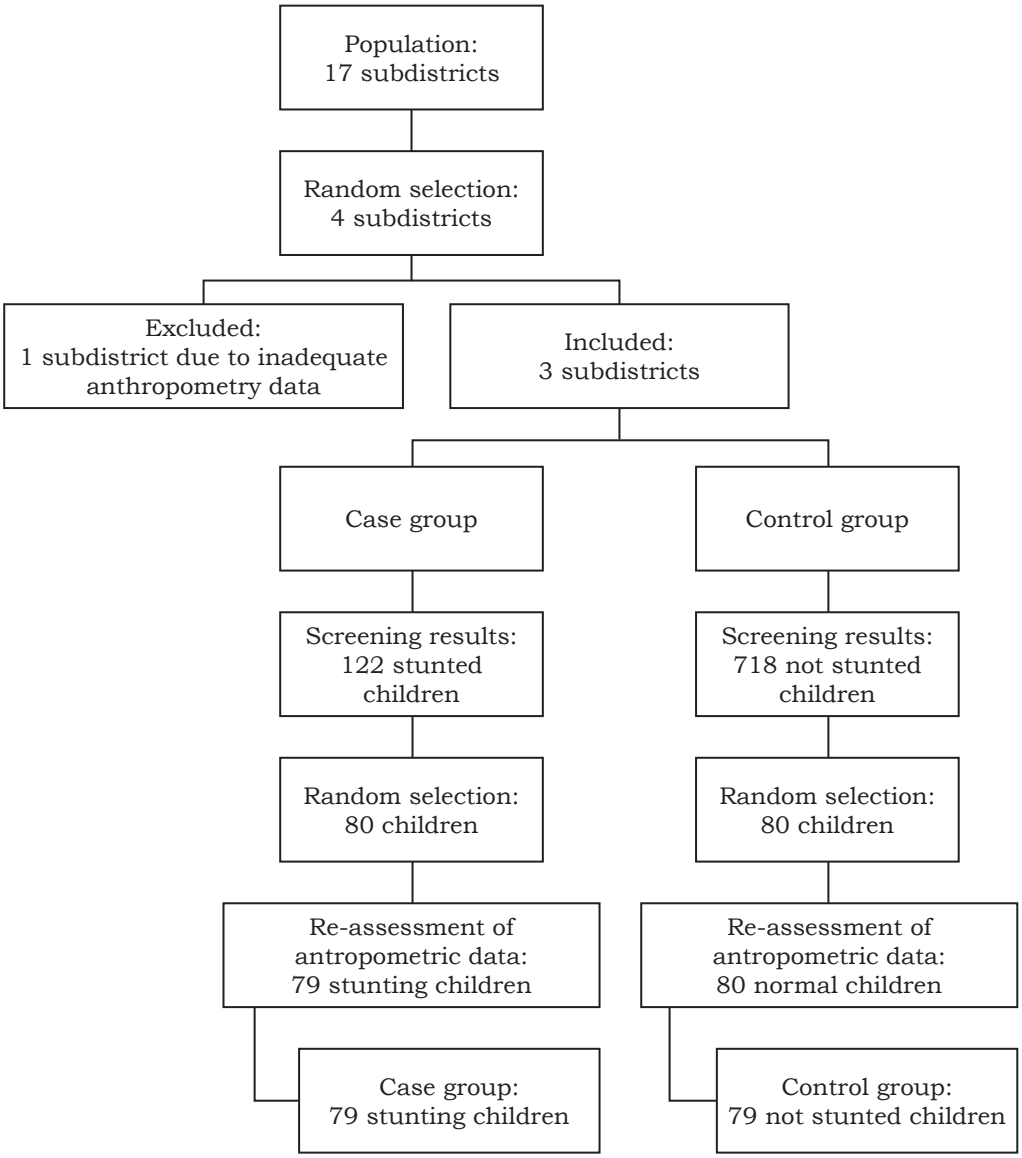

Figure 1. Diagram of case-control study subjects

questionnaire (semi-FFQ) with a three-month timeframe. A minimum of ten grams per day was considered as consumption of each food item. Using the same semi-FFQ, intake of vitamin D was assessed using the Nutrisurvey Indonesia software and compared to the Recommended Dietary Allowance (RDA) of Indonesian population (MOH Indonesia, 2013). We set a cut-off of 80% to categorise vitamin D intake.

Other variables collected in this study included child, parental, household, and community factors. Child factors were sex, age, feeding practices, infections, and history of birth outcomes. Infectious diseases were the occurrence of fever, cough, flu, and diarrhoea for the last

one month. Feeding practices included history of exclusive breastfeeding, timing of introduction to complementary foods, and intakes of energy, protein, calcium, iron, phosphorus, and animal source foods. Animal source foods intake was the consumption of at least three of a total of six food groups: 1) breast milk and any other milk from animals; 2) other dairy products; 3) flesh foods; 4) organs; 5) fish or shellfish; and 6) eggs (Sebayang *et al.*, 2019). Birth outcomes which included birth length, birth weight, and gestational age at birth were collected by enumerator's observation on the maternal and child health book. Parental factors were education levels of mothers and fathers. Educational attainment was considered as high if mothers or fathers completed at least senior high school education. Household and community factors included the number of children under 5 years, household economic status, and rural-urban living residency. Household economic status was calculated based on the household expenditure, then divided into three tertiles, which were poor, middle, and rich.

We described child, parental, household and community factors by using descriptive statistics. To analyse the relationship between each variable and stunting, we used the univariate logistic regression. All variables with a *p*-value <0.25 were included in the multiple logistic regression that controlled for the undesirable effects of potential confounding factors. A significance level was set at 5% to determine significant predictors. All analyses were performed by using STATA 14.2 (Stata Corporation, College Station, TX).

Ethical statements

This study was conducted according to the guidelines laid out in the Declaration of Helsinki and all procedures involving research study participants were approved by Alma Ata University Research Ethics Committee (No: KE/AA/VII/986/EC/2019). All mothers in this study gave their written informed consent and subject anonymity data form prior to data collection.

RESULTS

Population characteristics

A total of 158 children (79 cases and 79 controls) were included in this study. More than half of the cases were males (54.4%), whereas controls were females (53.2%). Majority of children, 71 (89.9%) cases and 62 (74.5%) controls, were aged between 12-23 months. Mothers of 70 (88.6%) cases and controls, and fathers of 61 (77.2%) cases and 65 (82.3%) controls completed senior high school education. Majority of cases (84.8%) and controls (88.5%) had one child under the age of 5 years within their household (Table 1).

The differentiation of covariate variables in stunted and non-stunted children

More than half of the stunted children had a birth length <48 cm, whereas 67.1% non-stunted children had a birth length ≥48 cm. Approximately 90% of both cases and controls were born with normal birth weights (≥2500 g) and term gestational age (≥37 weeks). Seventy-six (96.2%) cases and controls ever received breastmilk. Exclusive breastfeeding proportion was 64.6% among cases and 70.9% among controls. Majority of young children had adequate intakes of energy (70.9% and 79.8%, respectively in cases and in controls) and protein (81.0% and 84.8%, respectively in cases and in controls) from complementary foods (Table 2).

Factors associated with stunting among young children

Univariate logistic regression between

Table 1. Socio-demographic characteristics of young children in Bantul District

Characteristics	*Stunted (n=79)*	*Not stunted (n=79)*	*p*
	n (%)	*n (%)*	
Child factors			
Sex			0.340
Male	43 (54.4)	37 (46.8)	
Female	36 (45.6)	42 (53.2)	
Child's age			0.000
6-11 months	8 (10.1)	17 (21.6)	
12-17 months	15 (19.0)	31 (39.2)	
18-23 months	56 (70.9)	31 (39.2)	
Parental factors			
Mother's education level			1.000
Not completed elementary school	0 (0.0)	1 (1.3)	
Completed elementary school	5 (6.3)	2 (2.5)	
Completed junior high school	4 (5.1)	6 (7.6)	
Completed senior high school	50 (63.3)	46 (58.2)	
Completed tertiary education	20 (25.3)	24 (30.4)	
Father's education level			0.428
Not completed elementary school	1 (1.3)	0 (0.0)	
Completed elementary school	2 (2.5)	2 (2.5)	
Completed junior high school	15 (19.0)	12 (15.2)	
Completed senior high school	51 (64.5)	52 (65.8)	
Completed tertiary education	10 (12.7)	13 (16.5)	
Household and community factors			
Number of children under 5 within household			0.502
1	67 (84.8)	69 (88.5)	
≥2	12 (15.2)	9 (11.5)	
Household economic status			0.505
Poor	31 (40.2)	21 (28.0)	
Middle	24 (31.2)	26 (34.7)	
Rich	22 (28.6)	28 (37.3)	
Living residency			0.203
Rural	44 (55.7)	36 (45.6)	
Urban	35 (44.3)	43 (54.4)	

potential associated determinants and status of stunting in children are shown in Table 3. This study showed that children 18-23 months old (*COR*: 3.84, p=0.005) and with birth length ≥48 cm (*COR*:0.47, p=0.022) were associated with stunting. However, after using adjusted odds ratio, children 18-23 months old (*AOR*: 3.80,

Table 2. Distribution of covariates across stunted and non-stunted young children in Bantul District

Variables	*N*	*Stunted n (%)*	*Not stunted n (%)*
Birth outcomes			
Birth length	76		
<48 cm		39 (51.3)	25 (32.9)
≥48 cm		37 (48.7)	51 (67.1)
Birth weight	76		
<2500 g		7 (9.2)	5 (6.3)
≥2500 g		69 (90.8)	74 (93.7)
Gestational age	76		
<37 weeks		6 (10.0)	6 (7.9)
≥37 weeks		70 (90.0)	70 (92.1)
Feeding practices			
Prelacteal	79		
Yes		6 (7.6)	7 (8.9)
No		73 (92.4)	72 (91.1)
Ever breastfed	79		
Yes		76 (96.2)	76 (96.2)
No		3 (3.8)	3 (3.8)
Exclusive breastfeeding	79		
Yes		51 (64.6)	56 (70.9)
No		28 (35.4)	23 (29.1)
Introduction of complementary food	79		
<6 months		20 (25.3)	16 (20.2)
≥6 months		59 (74.7)	63 (79.8)
Energy intake from complementary food	79		
<80% RDA		23 (29.1)	16 (20.2)
≥80% RDA		56 (70.9)	63 (79.8)
Protein intake from complementary food	79		
<80% RDA		15 (19.0)	12 (15.2)
≥80% RDA		64 (81.0)	67 (84.8)
Calcium intake from complementary food	79		
<80% RDA		50 (63.3)	45 (57.0)
≥80% RDA		29 (36.7)	34 (43.0)
Iron intake from complementary food	79		
<80% RDA		42 (53.2)	45 (57.0)
≥80% RDA		37 (46.8)	34 (43.0)

Table 2. Distribution of covariates across stunted and non-stunted young children in Bantul District [Cont'd]

Variables	*N*	*Stunted n (%)*	*Not stunted n (%)*
Phosphorus intake from complementary food	79		
<80% RDA		25 (31.6)	23 (29.1)
≥80% RDA		54 (68.4)	56 (70.9)
Vitamin D intake from complementary food	79		
<80% RDA		75 (94.9)	68 (86.1)
≥80% RDA		4 (5.1)	11 (13.9)
Dietary diversity	79		
<4 food groups		7 (8.9)	4 (5.1)
≥4 food groups		72 (91.1)	75 (94.9)
Animal source food	79		
<3 food groups		47 (59.5)	39 (49.4)
≥3 food groups		32 (40.5)	40 (50.6)
Infectious diseases			
Fever	79		
Yes		15 (19.0)	10 (12.7)
No		64 (81.0)	69 (87.3)
Cough	79		
Yes		10 (12.7)	9 (11.4)
No		69 (87.3)	70 (88.6)
Flu	79		
Yes		12 (15.2)	10 (12.7)
No		67 (84.8)	69 (87.3)
Diarrhoea	79		
Yes		4 (5.1)	5 (6.3)
No		75 (94.9)	74 (93.7)

RDA: recommended dietary allowance

p=0.026), vitamin D intake <80% of RDA from complementary foods (*AOR*: 5.18, *p*=0.046), dietary diversity status ≥4 food groups (*AOR*: 0.17, *p*=0.040), and birth length ≥48 cm (*AOR*: 0.36, *p*=0.016) were associated with stunting. Older children had a four-fold increased risk to be stunted than 6-11 months old children. Longer birth lengths had a protective effect against stunting in children, with a two-fold increased chance of being non-stunted compared to children who had shorter birth lengths. Similar result was found in the association between birth length and stunting in children even after adjusting for confounding variables. Children who had lower vitamin D intakes from complementary feeding had about five times higher risks of developing stunting than children who had ≥80% RDA of vitamin D intake. Moreover, a protective effect was found

Table 3. Bivariate and multivariate results of factors associated with stunting

Variables	*COR*	*p*	*AOR*	*p*
Child factors				
Sex				
Male (ref)				
Female	0.74 (0.40-1.38)	0.340		
Child's age				
6-11 months (ref)				
12-17 months	1.03 (0.36-2.92)	0.958	0.80 (0.22-2.89)	0.733
18-23 months	3.84 (1.49-9.91)	0.005*	3.80 (1.17-12.26)	0.026*
Parental and household factors				
Mother's education level				
Low (ref)				
High	1.00 (0.38-2.67)	1.000		
Father's education level				
Low (ref)				
High	0.73 (0.33-1.59)	0.429		
Household and community factors				
Number of children under 5 within household				
1 (ref)				
≥2	1.37 (0.54-3.47)	0.503		
Household economic status				
Poor (ref)				
Middle	0.63 (0.29-1.37)	0.240	0.66 (0.25-1.80)	0.419
Rich	0.53 (0.24-1.17)	0.116	0.69 (0.26-1.85)	0.463
Living residency				
Rural (ref)				
Urban	0.67 (0.36-1.25)	0.204	0.90 (0.43-1.91)	0.790
Birth outcomes				
Birth length				
<48 cm (ref)				
≥48 cm	0.47 (0.24-0.90)	0.022*	0.36 (0.16-0.83)	0.016*
Birth weight				
<2500 g (ref)				
≥2500 g	0.67 (0.20-2.20)	0.505		
Gestational age				
<37 wk (ref)				
≥37 wk	0.86 (0.27-2.68)	0.791		
Feeding practices				
Exclusive breastfeeding				
Yes (ref)				
No			1.48 (0.66-3.32)	0.338
Introduction of complementary food				
<6 months (ref)				
≥6 months	0.75 (0.35-1.58)	0.449		

Table 3. Bivariate and multivariate results of factors associated with stunting [Cont'd]

Variables	*COR*	*p*	*AOR*	*p*
Energy intake from complementary food				
≥80% RDA (ref)				
<80% RDA	1.62 (0.78-3.36)	0.198	1.03 (0.33-3.21)	0.956
Protein intake from complementary food				
≥80% RDA (ref)				
<80% RDA	1.31 (0.57-3.01)	0.527	1.58 (0.40-6.26)	0.510
Calcium intake from complementary food				
≥80% RDA (ref)				
<80% RDA	1.30 (0.69-2.47)	0.417	0.96 (0.33-2.75)	0.933
Iron intake from complementary food				
≥80% RDA (ref)				
<80% RDA	0.86 (0.46-1.61)	0.631	0.97 (0.31-3.04)	0.954
Phosphorus intake from complementary food				
≥80% RDA (ref)				
<80% RDA	1.13 (0.57-2.22)	0.729	0.80 (0.25-2.55)	0.707
Vitamin D intake from complementary food				
≥80% RDA (ref)				
<80% RDA	3.03 (0.92-9.98)	0.068	5.18 (1.03-26.02)	0.046*
Dietary diversity				
<4 food groups (ref)				
≥4 food groups	0.55 (0.15-1.95)	0.354	0.17 (0.03-0.92)	0.040*
Infectious diseases				
Fever				
No (ref)				
Yes	1.62 (0.68-3.86)	0.279		
Cough				
No (ref)				
Yes	1.13 (0.43-2.94)	0.807		
Flu				
No (ref)				
Yes	1.24 (0.50-3.05)	0.646		
Diarrhoea				
No (ref)				
Yes	0.79 (0.20-3.06)	0.732		

*p<0.005

COR: crude odds ratio; AOR: adjusted odds ratio; RDA: recommended dietary allowance

in the group of children who consumed ≥4 food groups compared to those who had <4 food groups of dietary diversity.

DISCUSSION

Our results showed that low dietary diversity was associated with stunting. A significant association between dietary diversity and childhood stunting was documented previously in an earlier studies (Paramashanti *et al.*, 2017). Dietary diversity is a good indicator of micronutrient density in the diet, thus reflecting diet quality (%) (Moursi *et al.*, 2008). Nonetheless, apart from micronutrient sufficiency, dietary diversity has a positive effect on stunting as we found vitamin D was the only micronutrient linked with stunting. Dietary diversity may also capture energy and macronutrient intakes as one eats different sources of foods (Muslimatun & Wiradnyani, 2016), but there was no relationship between energy and protein intakes with stunting in our study. It becomes important to consider other factors such as gut microbiome, which could mediate the pathway between a diversified diet and a child's linear growth. Some studies suggested that greater dietary diversity promotes a more diverse gut microbial community in the human body, thus affecting linear growth (Reese & Dunn, 2018; Robertson *et al.*, 2019).

In this study, we found that children whose intakes of vitamin D were below the recommended guideline were more likely to become stunted. This result confirmed a previous study conducted in low- and middle-income setting (Mokhtar *et al.*, 2018). Meanwhile, some trials have reported different results (Ganmaa *et al.*, 2017; Hyppönen *et al.*, 2011). The prevalence of inadequate vitamin D intake (<80% Indonesian RDA or <480 IU) were present in both case (94.94%) and control groups (86.08%) of our study. Throughout childhood, the risk of deficiency among both males and females may increase significantly due to dietary intake insufficiency and poor access to sunshine (Koo & Walyat, 2013; Viljakainen & Hyppönen, 2013). Vitamin D is an essential micronutrient for bone mineralisation, growth, and development (Koo & Walyat, 2013). However, hypovitaminosis D, if not addressed while growing, could give negative impacts on growth and development (Viljakainen & Hyppönen, 2013).

Human growth is a multifaceted process beginning in the foetal period and ending in adolescence. In children, linear growth is regulated by growth hormone (GH) and insulin-like growth factor (IGF-1) (Esposito *et al.*, 2019). Vitamin D may have a direct influence on GH/IGF-1 axis but the interplay between both remains incompletely understood (Ciresi & Giordano, 2017). Indirectly, vitamin D plays some roles in calcium metabolism, which is also important in stature growth. However, there was no significant relationship between calcium intake and stunting in this study.

Birth length and stunting were linked in this research. Short-statured neonates may grow as stunted children if they are not provided with adequate breastfeeding and complementary foods, proper stimulation and nurturing, and prevention practices of infectious illnesses (Prendergast & Humphrey, 2014). Consequently, infants born with a short length may not have the opportunity for catch-up growth during the window of opportunity period. As many previous studies have concluded (Aryastami *et al.*, 2017), this could be explained by the intergenerational process of linear growth. A study in Myanmar showed that not only low birth weight, but also short birth length, increased the risk of stunting (Khaing *et al.*, 2019). The Bogor Longitudinal Study

on Child Growth and Development which was conducted in Bogor City, Indonesia to study the dominant risks of stunting among 650 children aged 0-23 months found that birth weight, length at birth and maternal short stature were the most dominant risks of developing stunting (Utami *et al.*, 2018). However, in this current study, we found no relationship between birth weight and stunting status. Having a short birth length might indicate poor nutritional status during pregnancy, where mothers had inadequate energy and micronutrient requirements (Paramashanti *et al.*, 2017; Utami *et al.*, 2018). This can be worsened if they had low-quality antenatal care during pregnancy (Eka *et al.*, 2018). Prenatal nutrition is an important period as stunting often begins *in utero*. Therefore, optimum nutrition is strongly suggested even before conception as it has a vital role to promote optimum growth *in utero* that will be represented in the outcomes of a newborn's birth size and should be continued for at least the first two years of post-natal life (Aryastami *et al.*, 2017; Titaley *et al.*, 2019).

Older children (18-23 months) were more likely to become stunted compared with younger children. A study in Afghanistan showed a higher chance of being stunted among children aged 25-59 months compared with younger age groups (Akseer *et al.*, 2018). This indicated that height-for-age Z-score may become lower as the child gets older, confirming that stunting is a chronic undernutrition problem. Growth faltering may occur as soon as an infant is born, but it mostly takes place between 3 and 18-24 months (Victora *et al.*, 2010). While 20% of stunting rates that occur at birth indicate prenatal malnutrition, the prevalence increases to 58% between 18 to 23 months (de Onis & Branca, 2016), and this later stunted growth could be explained by poor breastfeeding and complementary feeding practices. In our study, besides dietary diversity and intake of vitamin D that may affect stunted growth, there could be a possible explanation of early weaning practices among older children. In India, weaning children after six months of age increased the risk of stunted growth (Padmadas, Hutter & Willekens, 2002). This finding highlighted the importance of the continuation of breastfeeding up to 2 years old as the primary nutritional source alongside complementary feeding, especially when complementary foods do not meet the nutritional values and safety criteria. Nevertheless, we did not collect data on breastfeeding continuation in this study.

There was no significant difference in exclusive breastfeeding between stunted and non-stunted children. This could be due to the influence of complementary feeding quality (Rusmil *et al.*, 2019). Based on Black *et al.* (2008) in the Lancet series, the risk of becoming stunted still exists even among exclusively breastfed children if they do not receive an adequate complementary feeding both in quality and in quantity, whereas among 6-8 months and 9-10 months old infants, breastmilk can only fulfil 70% and 50%, respectively, of energy requirement, which should be complemented by foods. For this issue, if an infant fails to meet the energy requirement provided from complementary foods, she/he may have a state of growth faltering (PAHO/WHO, 2004).

Household economic status was not related to stunting. Low economic status is generally linked with consuming cheaper foods and low diversity diet. However, high economic status does not always guarantee a good nutritional status (Ibrahim & Faramita, 2015). Results from the Indonesia Basic Health Research showed that 20%

of young children from middle- and higher economic status were stunted. The underlying factors included low quality of dietary intake, which was higher in carbohydrate, sugar, and fat intakes. These inappropriate practices of complementary feeding may start since the beginning of the introduction to complementary foods (NIHRD, 2019).

Living residence of young children was not associated with stunting. This may be caused by the homogeneity of geographical areas in our study locations, so there was not much difference between urban and rural areas. Busy schedules that are much more associated with urban parents is arguably proposed as a factor that could predispose children to malnutrition (Adenuga *et al.*, 2017). On the other hand, limited access to health facilities such as primary health centres or hospitals and nutrition knowledge in rural areas may contribute to stunting problems. Although this cannot be fully explained from the data collected in this case-control study, it does suggest that the risks of stunting vary widely across communities. This needs further investigation, particularly along urban-rural divides (Samuel, 2013).

Despite the insignificant results from macronutrient and micronutrient intakes, except for vitamin D, we could not neglect the importance of these nutrients on growth. However, our data might have been influenced by recall bias from the food frequency questionnaire which we used. Both feeding practices and history of infections were self-reported by mothers, thus adding to the possibility of recall bias in this study. Moreover, we did not take into account the duration and frequency of infections, which might have limited our understanding of the association between infectious diseases and childhood stunting in this study. However, this study succeeded to cover variables at the individual level including dietary intakes, household level, and community level, which have been adjusted during the analysis, in order to provide the best data possible in relation to stunting.

CONCLUSION

In conclusion, minimum dietary diversity, vitamin D intake from complementary foods, and birth length were associated with stunting among young children in Bantul District, Yogyakarta Special Region, Indonesia. Therefore, promoting adequate and varied dietary intakes with a focus in the first thousand days of life since preconception is highly recommended to improve child nutritional status.

Acknowledgements

The authors would like to acknowledge the Ministry of Research, Technology, and Higher Education of Indonesia Republic for the research funding under the scheme of *dosen pemula* 2018/2019 (Grant No: 111/A/SP2H/DRPM/2019), with the project name of Indonesian early career lecturers research grant. Special thanks to all selected *Posyandu* and midwives in the public health centres of Bantul District.

Authors' contributions

EN, principal investigator, conceptualised and designed the study, prepared the draft of the manuscript and reviewed the manuscript; BAP, led the data collection in Bantul, data analysis and interpretation, and reviewed the manuscript; DA, led the data collection in Bantul and reviewed the manuscript; ASA, assisted in drafting of the manuscript and reviewed the manuscript.

Conflict of interest

The author(s) declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Mal J Nutr 26(2): 289-302, 2020

Anti-inflammatory effects of functional milk drink enriched with soya bean sprout protein in breastfeeding mothers

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ABSTRACT

Introduction: Increased metabolism during pregnancy and breastfeeding results in increased oxidative stress among mothers. However, daily intake of foods containing antioxidants can improve antioxidant and inflammatory status. The objectives of this research were to formulate a soya bean sprout protein milk (SSPM) functional drink; to know its protein and isoflavone contents; and its effect on interleukin 6 (IL-6) level in plasma and breast milk (BM) of breastfeeding mothers. **Methods:** The study begun with the production of soya bean sprout protein extract (SSPE), followed by preparing five formulated SSPM, namely SSPE, low-calorie sweetener, fructose, skim milk, and salt. The formulated products were subjected to organoleptic test on a scale of 1 (extremely dislike) to 5 (extremely like). Fifty mothers aged 20-35 years who had a newborn up to six months old, in good health condition, and with informed consent were recruited. They were randomly divided into two groups: group I was fed SSPM for two months, 150 ml/day every morning, and group II was treated as placebo. Data were analysed with one-way analysis and paired sample *t*-test. **Results:** The preferred SSPM composed of 65.0% SSPE, 1.5% low-calorie sweetener, 6.0% fructose, 27.0% skim milk, 0.5% salt, and containing 13.77±0.001% protein and 229.9±0.001mg/g isoflavone content. Two months after intervention, there was a decrease in the level of IL-6 by 82.5% in the plasma (p=0.015) and 68.1% in BM (p<0.05). Body mass index (BMI) decreased from 22.77 to 20.64 kg/m^2 (p=0.019). **Conclusion:** SSPM is a potential anti-inflammatory agent and has health benefits for breastfeeding mothers.

Keywords: Formula of functional drinks, soya bean sprout protein milk, isoflavone, IL-6, BMI

INTRODUCTION

Increased metabolism during pregnancy and breastfeeding may result in oxidative stress in the body (Stuebe & Rich-Edwards, 2009). This condition makes the antioxidant status of breastfeeding mothers unable to compensate for the formation of free radicals. Oxidative stress that occurs in the mother's body during pregnancy is indicated by high levels of free radicals (Winarsi, Sasongko & Purwanto, 2016). Free radical reactivity damages the placental cell membrane, which then impairs placental function (Winarsi, 2007). Besides causing susceptibility towards

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doi: https://doi.org/10.31246/mjn-2019-0110

diseases, oxidative stress also affects the growth and development of the baby. Oxidative stress is also exacerbated by the increase in body weight (BW) (Huang *et al.*, 2015). According to Vincent, Morgan & Vincent (2017), obesity is characterised by increased dietary fat intake, increased fat storage, and excessive intracellular triglycerides, and dyslipidemia. Oxidative stress may be due to the metabolic impact of intracellular triglycerides (Bakker *et al.*, 2000). For example, by suppressing the mitochondrial adenine nucleotide transporter, excessive triglycerides may increase $O_2^{\bullet-}$ production within the mitochondrial electron transport chain, and this decreases intra-mitochondrial adenine diphosphate. Electrons then accumulate within the electron transport chain and react with adjacent O_2 to form radical $O_2^{\bullet-}$.

On the other hand, the increase in BW also disrupts the physical appearance of mothers, especially those who have to return to work in offices after their maternity leave period is over. Therefore, they will strive to lose weight without interfering with breast milk production. Breast milk is the best nutrient for babies aged 0-6 months old because the nutritional content is suitable for the growth of babies. Daily intake of foods containing sufficient antioxidants can improve the antioxidant status of the mother and baby. Therefore, it is important to enhance the antioxidant status of breastfeeding mothers with antioxidant-rich foods.

According to Hu *et al.* (2013), soya bean protein is capable of reducing BW more than carbohydrate. Mikkelsen, Toubro & Astrup (2000) stated that soya protein is similar to animal protein in terms of energy expenditure (EE). This is because protein is thermogenic and makes one feels full. Protein stimulates pancreatic beta cells for insulin secretion (Newsholme *et al.*, 2005) and induces pancreatic alpha cells for glucagon secretion (Calbet & MacLean, 2002). Glucagon regulation prevents against hypoglycaemia as glucagon stimulates glucose output by increasing glycogenolysis and gluconeogenesis in the liver (Jiang & Zhang, 2003). Glucagon also plays a role in lipolysis and amino acid metabolism, both of which have different EEs. Glucagon increases EE by stimulating gluconeogenesis and protein oxidation. Thus, adequate protein intake can provide energy faster, namely by glycogenolysis, gluconeogenesis, and protein oxidation, thus promoting weight loss. Regarding energy expenditure, it is known that protein has the highest and longest-lasting thermal effect (20-30%), followed by carbohydrates (5-15%) and fat (3%) (Steinert *et al.*, 2011). Studies that measured diet-induced thermogenesis (DIT) for more than 24 hours (Westerterp *et al.*, 1999), more than a few hours (Johnston, Day & Swan, 2002), or after one protein preload (Luscombe *et al.*, 2003) all suggested that a diet that is higher in protein has a greater effect on energy expenditure, than does a diet that is lower in protein. These findings showed that protein has a lower energy efficiency than carbohydrates or fats.

However, soya bean milk is still less favoured by many people due to its beany flavour. One way to reduce this flavour is through germination. Germinated soya beans are known to be rich in antioxidants, as reflected in its higher protein, amino acids, and isoflavones content compared to non-sprout soya beans (Winarsi, Purwanto & Dwiyanti, 2010). It is stated that the protein and isoflavone contents of soya bean increase as it is germinated. Isoflavones with antioxidant characteristics are reported to have an anti-inflammatory potential, which can reduce plasma interleukin 6 (IL-6) level (Yu *et al.*, 2016). But so far, there is no information whether or not isoflavones in soya bean sprout

protein milk (SSPM) can reduce levels of IL-6 in the plasma and breast milk of breastfeeding mothers.

According to Winarsi *et al.* (2010), isoflavones in germinated soya beans have higher antioxidant activity than those non-germinated. It is reported that soya bean protein composes of several peptides with potential as antioxidant agents. The high content of protein and isoflavones, supported by low beany flavour, makes soya bean sprout a good candidate for functional food. However, to date, no formula of SSPM that is preferred by the public has been reported. Besides, the protein and isoflavone contents of SSPM, as well as its effect on IL-6 levels and BW of breastfeeding mothers are not yet known. This study aimed to obtain the SSPM formula which is most preferred by the community. Analysis of protein and isoflavone contents were also carried out on the preferred SSPM. Finally, the effects of SSPM administration on IL-6 levels in plasma and breast milk, and body mass index (BMI) of nursing mothers were studied.

MATERIALS AND METHODS

Production of soya bean sprout protein extract (SSPE)

SSPE was obtained by extracting protein from germinated soya bean of the Slamet variety using physiological sodium chloride (NaCl) and phosphate buffer. SSPE yielded soft white creamy powder. Soya bean (Slamet variety) seeds were thoroughly cleaned, placed on a bamboo tray, and stored in a rather humid room. The soya bean seeds were frequently splashed with water to germinate them. The germinated soya beans were added with physiological NaCl (1:5), stirred for 15 minutes, and then extracted in a blender to form a porridge. The porridge was added with phosphate buffer to reach pH 5 and centrifuged at 10.000 rpm at 4°C for 20 minutes. The pellet was separated from the supernatant, oven-dried at 50-70°C, then crushed in the blender to obtain soft white creamy SSPE powder (Winarsi & Purwanto, 2015).

Formulation of functional drinks enriched with SSPE

To obtain a favourable and highly nutritious functional drink enriched with SSPE that can improve bodily functions, five formulas which composed of SSPE, sweetener (Tropicana® sugar), fructose, skim milk, and salt were made (Table 1). Ingredients were mixed and stirred until homogenous. The most favourable formula was selected from the five through an organoleptic test.

Table 1. SSPE proportion in several formulas of beverage enriched with soya bean sprout protein extract

Ingredients (%)	*Formula code*				
	A	*B*	*C*	*D*	*E*
SSPE	60.0	65.0	70.0	75.0	80.0
Tropicana® sugar	1.5	1.5	1.5	1.5	1.5
Fructose	6.0	6.0	6.0	6.0	6.0
Skimmed milk	32.0	27.0	22.0	17.0	12.0
Salt	0.5	0.5	0.5	0.5	0.5
Total	100.0	100.0	100.0	100.0	100.0

Note: SSPE, soya bean sprout protein extract

Sensory test of functional drink enriched with SSPE

Sensory test (hedonic test) was performed to investigate consumer acceptability on colour, flavour, and taste of the functional drink, which was presented in an infused formula (25g of formula plus 125ml of hot water and stirred until homogeneous). The panelists were 55 individuals, consisting of students, laboratory workers, and university employees in the researcher's workplace. They were inquired to express their personal opinions of like or dislike on a hedonic scale of 1-5, where 1=extremely dislike, 2=moderately dislike, 3=neutral, 4=moderately like, and 5=extremely like. To verify the acceptability of each product and to standardise the evaluation of sensory attribute, an acceptable factor (AF) was determined according to the Dutcosky (1996) formula as follows:

AF= A. 100. B–1 .....(1)

notes: A, mean of each attribute; B, the maximum mean of each attribute

The most preferred formula was subjected to the proximate and isoflavones content analysis test. The analysis for protein and fat was carried out by the Association of Official Analytical Chemists (AOAC) official methods of analysis (AOAC International, 2000), while isoflavones content was determined by the Küçükboyac *et al.* (2013) method.

This research was conducted in a randomised clinical trial double-blind method. Authors and subjects did not know which product was given. Ethical clearance for this research was approved by the ethics committee of the Medical Faculty of Diponegoro University, Semarang, Indonesia.

Research subjects and intervention

Fifty lactating mothers aged between 20-35 years old, having either a newborn or older baby (up to six months old), in good health condition, lived in Purwokerto, Central Java, Indonesia, and agreed to sign an informed consent were asked to be respondents.

All subjects were randomly divided into two groups (25 each). During the time of this research, group I was given SSPM in their daily diet, while group II was given a placebo. Both groups consumed 150ml/day of each of their drinks for two consecutive months. The placebo and SSPM were ready-to-drinks, given every morning between 6:00 to 8:00 a.m., delivered by the enumerator to the subject's home. In this study, the enumerator witnessed the subjects drinking the given product. Besides, subjects also recalled food consumption eight times - four times on weekdays, and four times on holidays. If any adverse events occurred on the subject, the subject was then excluded and handled by a designated doctor.

Sample of blood and breast milk

Blood and breast milk samples were taken three times at zero (before intervention), one and two months after intervention. All samples were taken in the morning, before breakfast. Sampling was done by taking 3ml of blood intravenously using a venoject tube containing ethylenediaminetetraacetic acid (EDTA)-10%, and then centrifuged at 0.503 x g for ten minutes to separate the plasma.

Breast milk sample as much as 3ml was taken manually by the subjects. The sample was also taken in the morning before breakfast, and then centrifuged at 0.503 x g for ten minutes at 4°C. The lipid layer on the surface was used for sample testing.

Determination of IL-6 levels in plasma and breast milk

IL-6 levels in plasma and breast milk were measured using specific kits, i.e.

Biovision Assay and Uscn Life Science Inc. Elisa reader Labotron LB-6200 was used to read the data.

Body weight measured as BMI

BMI is a ratio of weight in kilograms to height in meter squared. Subject's weight was weighed on a balance scale stampede Camry 0-130kg, while height was measured using a 0-200 cm scale microtoise. Weight and height measurements were performed in conjunction with the time of blood sampling.

Data analysis

The research data were analysed by one-way analysis of variance with repeated measures and by paired sample *t*-test. Differences between means were considered significant at $p<0.05$.

RESULTS

The SSPE yield was 28.6±0.003% (Winarsi *et al.*, 2010). Organoleptic or sensory test on colour, flavour, and taste of all the five infused formulas were expressed as average value±standard devation (SD) and acceptability factor (AF), as presented in Table 2. The hedonic test revealed that the most preferred formula based on colour and taste of the product was formula B, a SSPM drink that contained 65.0% SSPE, 1.5% low-calorie sweetener, 6.0% fructose, 27.0% skim milk, and 0.5% salt. The panelists generally gave a high score to this SSPM formula with 65.0% SSPE, followed by 75.0%, 60.0%, 80.0%, and 70.0%. The sensory test revealed that the highest preference was taste, followed by the colour and flavour of SSPM. Functional foods are not merely about deliciousness or high sensory scores, but must be nutritious and functional for the body. The nutritional value of the selected formula was observed based on the analysis of proximate and isoflavones (Table 3).

Traditional soya food products like bean curd and soya protein isolates generally contain 0.25-40.00mg isoflavones, while soya milk has 0.1-2.0mg/g soya protein. This research reported that the content of isoflavones in SSPM was as much as 229.9mg/g protein, much higher than that of traditional products. Isoflavone is a prevalent substance in soya, and often utilised in oestrogenic and antioxidant supplements (Winarsi *et al.*, 2016). As an oestrogenic supplement, isoflavone is

Table 2. Acceptance (average values±SD) and acceptability factors (AF) for formulas of milk beverage enriched with SSPE (n=55)

Preference Score	*Formula code*†				
	A	*B*	*C*	*D*	*E*
Colour	3.6±1.1[a] (100)	3.6±0.8[a] (100)	3.3±1.2[a] (91.7)	3.5±0.8[a] (97.2)	3.3±0.8[a] (91.7)
Flavour	3.2±1.1[a] (100)	3.2±0.8[a] (100)	2.8±0.9[a] (87.5)	3.2±0.7[a] (100)	3.2±0.8[a] (100)
Taste	3.6±0.9[a] (97.3)	3.7±0.9[a] (100)	3.2±1.0[b] (86.5)	3.6±0.8[a] (97.3)	3.6±1.0[a] (97.3)

†A is a formula with 60.0% SSPE; B is a formula with 65.0% SSPE; C is a formula with 70.0% SSPE; D is a formula with 75.0% SSPE; E is a formula with 80.0% SSPE

Values from the same row with different letters show significant differences at p=0.05

Score: 1=extremely dislike, 2=moderately dislike, 3=is neutral, 4=is moderately like, 5=is extremely like; SSPE, soya bean sprout protein extract

Table 3. Proximate and isoflavone content of functional milk beverage enriched with SSPE

Components	*Milk enriched with SSPE*	*Soya Milk*	*Placebo† (%)*
Water (%)	80.1±0.0[a]	85.2±0.0[a]	81.4±0.0[a]
Ash (%)	0.07±0.0[a]	6.2±0.0[b]	0.1±0.0[a]
Protein (%)	13.8±0.0[a]	3.6±0.0[b]	11.5±0.0[a]
Lipid (%)	0.9±0.0[a]	2.0±0.0[b]	0.8±0.0[a]
Carbohydrate (%)	5.1±0.0[a]	2.9±0.0[b]	6.2±0.0[a]
Isoflavone (mg/g protein)	230.0±0.0[a]	60.1±0.0[b]	

†Placebo was powdered cow's milk without SSPE
Note: n=3
Numbers with similar letter show non-significant differences (p>0.05)

bound with the oestrogen receptor in the body, which affects the body's dependency on oestrogen. As an antioxidant, isoflavone has several medical functions such as anticancer (Goodman *et al.*, 2011), anti-diabetes, body weight control, anti-atherosclerosis (Winarsi *et al.*, 2016), and anti-inflammatory (Yu *et al.*, 2016). Accordingly, besides protein, lipid, and carbohydrate, SSPM is also rich in isoflavones that exceed the amount contained in non-germinated soya milk. With that, it was given to breastfeeding mothers to find out its effects on IL-6 levels in plasma and breast milk.

At baseline, the level of IL-6 of lactating mothers was 18.8pg/mL. This value was higher than the plasma levels in non-pregnant or non-breastfeeding healthy women (1.0-0.2pg/mL), but lower than in women with type 2 diabetes mellitus with obesity (22.0pg/mL). High levels of IL-6 at baseline are a natural compensation in the body of breastfeeding mothers who have new babies. In postpartum conditions, the levels of inflammatory cytokines are higher as a result of activated inflammatory cells. Esposito *et al.* (2004) suggested that normally, IL-6 levels are very low, but the level is increased as the body experiences infection, trauma, ageing, and stress. Breastfeeding mothers experience stress with their conditions as new mothers. However, IL-6 plasma level decreased significantly from 10.2 to 1.8pg/mL (p=0.015), after two months of SSPM consumption, possibly due to the isoflavone content in the drink (Figure 1).

Lactating mother's weight expressed as BMI was initially 22.8kg/m^2, which did not indicate obesity. However, taking into account the pre-pregnancy BMI which was 19.3kg/m^2, it can be said that the BMI of subjects increased significantly (p<0.004) from pregnancy to lactation. There was a decrease in BMI among lactating mothers, from 22.8 to 20.6kg/m^2 (p<0.006) in the group who consumed SSPM for two months, while the control group did not show any significant changes (Figure 2).

DISCUSSION

SSPE yield was 28.6±0.003%, relatively higher than non-germinated soya (22.2±0.04%) (Winarsi *et al.*, 2010). The protein content in germinated soya powder and non-germinated soya powder were 42.0% and 35.6%, respectively. The content of germinated soya protein increased compared to that in soya powder, probably due to

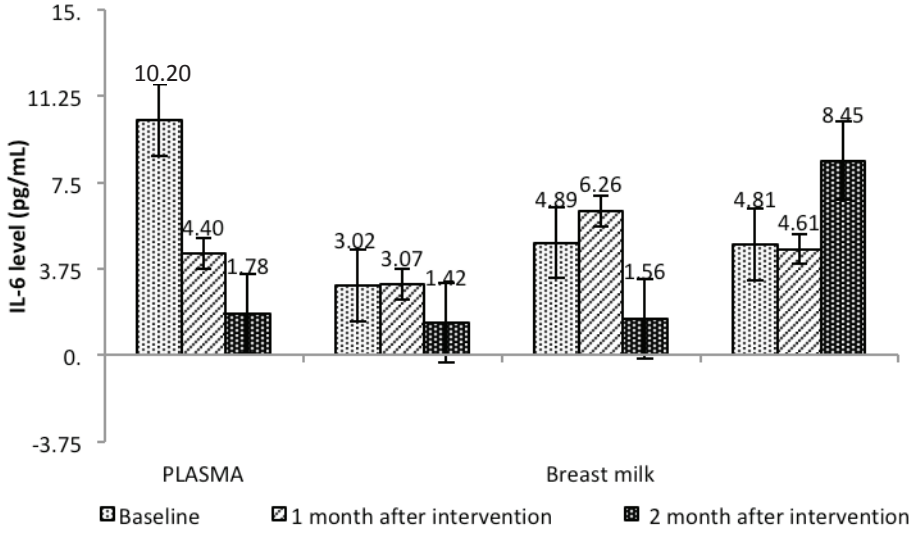

Figure 1. IL-6 level of lactating mothers who consumed SSPM
Notes: SSPM, the group consuming soya bean sprout protein milk; Plac, group consuming placebo; numbers with similar letters show a non-significant difference (p>0.05)

the germination process that increased total soluble solid, thereby increasing yield. Furthermore, SSPE was rich in isoflavones (39.1ppm) compared to soya protein isolates which only had 26.7ppm. High SSPE yield, protein, and isoflavones enabled the powder to be used as a functional food ingredient. This finding revealed that SSPE obtained from germinated soya can be formulated

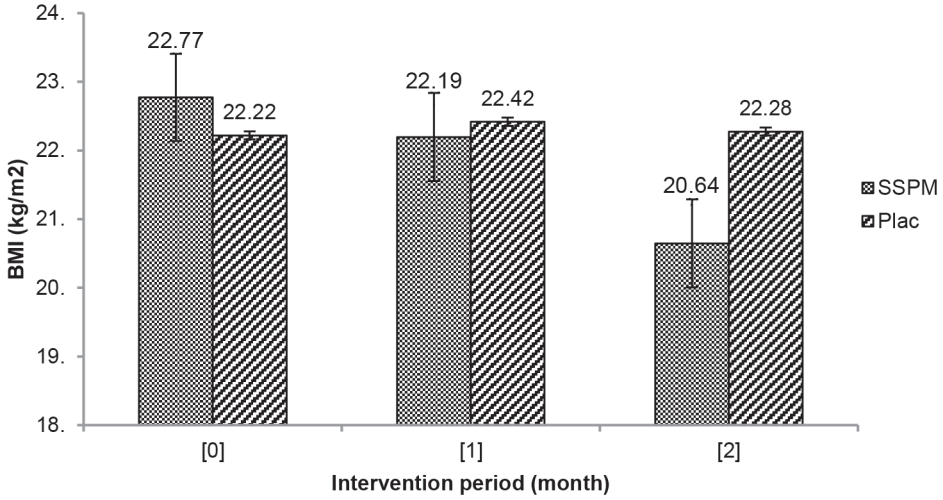

Figure 2. Effect of SSPM on BMI of lactating mothers
Notes: SSPM, group consuming soya bean sprout protein milk; Plac, group consuming placebo; 0, 1, and 2, intervention period in month; BMI, body mass index, n = 25; $P < 0.05$; numbers with similar letter show non-significant differences (p>0.05)

into functional food products. To date, SSPE has not been commercialised. This finding therefore provides an opportunity for the mass production of SSPE.

The sensory of SSPM

Regarding AF value, formulas A and B had a maximum score (100), and were therefore selected. It was likely that both formulas had an attractive colour. A nutritious and delicious food product will be less preferable if the colour is dull or deviant from the common shades. Wilson *et al.* (2017) explained that colour, among other factors such as taste, frequently serves as a main consideration and in some cases, significantly determines the selection of a product. Food or beverage colour is due to naturally formed pigments from plant or caramelisation, with dark colour due to Maillard reaction, enzyme oxidation, and additional colourant. The colour of a product is a contribution of water-soluble substances, which in SSPM were protein, carbohydrate, vitamins B1 and B2.

According to Topin *et al.* (2014), flavour is the response of our smelling sense in the nasal cavity. Flavour is among the determining properties of the deliciousness in foods. Flavour is also defined as something detected by the smelling sense, and therefore essential to determine food deliciousness. Flavour is derived from chemical reactions and interaction with other ingredients. The detectable beany flavour in SSPM product is due to the lipoxygenase enzyme in soya that can hydrolyse polyunsaturated fatty acid and produces volatile compounds (Peng *et al.*, 2016). The flavours of these products were not different among formulas (p=0.22), and all AF was 100, except for formula C (87.5), therefore the selected formulas were A, B, D, or E. It was likely that lipoxygenase activity was inhibited due to germination, milling and infusion processes, so the odd flavour was lessened and the preferable flavour released. Preference scores in all of the products across formulas were not significantly different too (p=0.25), except for formula C, while the highest AF score was found in formula B, and so it was selected.

Taste is a crucial component in food products. A food can release favourable taste depending on its substances. Food ingredients are generally composed of not one, but a combination of various tastes that generate a whole taste of food. Factors like consistency of food ingredients affect food taste. The change in flavour or taste of food ingredients is usually more complex than that in colour (Spence *et al.*, 2010). Taste is related to the response of chemical stimulation by the sense of taste (tongue) as an interaction between flavour, taste, and texture of food. Ammari & Schroen (2018) stated that taste is contributed by some factors namely chemical substances that can release different flavours. Acidic intensity depends on H+ ion production, whereby sweet flavour is due to aliphatic compound, and bitter taste is due to alkaloids. Temperature affects one's tasting ability to detect taste stimulation. Concerning concentration, each person has a lowest limit to taste a product concentration. The interaction among components that react to the primary taste component also affects the flavour of a product.

Effect of isoflavones and protein content of SSPM on IL-6 levels and BMI of breastfeeding mothers

The protein content in SSPM was 13.8±0.001%, higher than that in non-germinated soya milk (3.6±0.002%). The increase in protein content is supported by the finding of Narsih, Yunianta & Harijono (2012) on germinated sorghum. During germination, the activity of the protease enzyme (involved in the degradation of peptide component to

amino acids) increases, and the amount of protein will increase. This increase is due to the presence of protein hydrolysis, as well as the result of protease enzyme activity during germination of the seeds. In this case, protease enzymes break down the peptide bonds in proteins and produce amino acids, subsequently increasing protein content. The increase in protein content during seed germination will increase the mobilisation of nitrogen-fixing and thus improve the quality of proteins used for the development of young plants.

In this study, the highest protein content in milk enriched with SSPE was 13.8±0.001%. It is mentioned that the highest amino acid content in soya protein is glutamic acid (190.11 mg/g) (Liu, 1999). There is a possibility that glutamic acid content was also the highest in our SSPE product, although its level was not analysed in this study. Glutamic acid gives an umami taste, which is a delicious savoury taste that many like. Besides glutamic acid, soya protein also contains tryptophan. The body converts these amino acids into simple molecules called 5-hydroxytryptophan (van den Oord & van Wassenar, 1997). This molecule is an important raw material in the synthesis of serotonin, melatonin, and vitamin B6. Serotonin is a chemical that functions to send signals between nerve cells, regulates mood, and influences behaviour. Meanwhile, melatonin plays a role in regulating the sleep cycle, and vitamin B6 is needed to play a role in the formation of energy. Thus, tryptophan creates a positive mood, and makes panelists like milk enriched with SSPE.

During the germination process, all soya components including protein, carbohydrate and lipid are hydrolysed. Strong component bonds start to detach that allow digestion. Germination can also increase protein digestibility due to reserve protein degradation. Some components in germinated soya protein that play a role in decreasing sugar levels are binding amino acids and isoflavones. Three poly-chained amino acids such as leucine, valine, and isoleucine prevalent in germinated soya protein are crucial in the metabolism process (Wolfe, 2017). When consumed, these amino acids are directly detected in plasma and peripheral tissues including skeletal muscles and adipose tissues. Therefore, the increasing level of poly-chained amino acids accelerates catabolism in peripheral tissues. Poly-chained amino acid degradation in skeletal muscles is related to alanine and glutamine production that maintain glucose homeostasis.

Winarsi *et al.* (2016) stated that germinated soya protein contains amino acids that trigger higher insulin excretion than non-germinated soya protein. Amino acids triggering insulin secretion are arginine, lysine, phenylalanine, alanine, leucine, and isoleucine, which are prevalent in soya protein, including germinated soya protein. Moreover, germinated soya beans contain amino acids glycine and arginine that control insulin hormone. Accordingly, SSPM is very suitable for a diabetic person.

Soya protein diet can lower triglyceride levels mainly in the liver. Germinated soya protein is likely to lower triglycerides since its protein can block activities of the hepatic lipogenic enzyme, particularly glucose 6-phosphate dehydrogenase and synthesised fatty acids, as well as acetyl-CoA carboxylase (ACC). ACC is an enzyme that crystallizes carboxylated acetyl-CoA into malonyl-CoA. However, the inhibited activity decreases malonyl-CoA, and triglycerides are formed. The decreasing triglyceride is correlated with the increasing activities of several skeletal muscle enzymes that play a role in fatty acid oxidation including carnitine palmitoyltransferase and beta-hydroxy acyl-CoA, medium-chain acyl-CoA

oxidase and acyl-CoA dehydrogenase. Therefore, the protein-rich SSPM is expected to reduce triglycerides or liver lipids.

The fat content of SSPM was 0.9±0.001%, lower than that of soya milk (2.0±0.002%). Similar finding was reported by Narsih *et al.* (2012) on germinated sorghum, whereby during germination, lipase activity increases, thus degrading soya fat into glycerol and fatty acids. Glycerol and fatty acids are water-soluble, thereby diffused into cell tissues. Accordingly, germination increased the hydrolysis of complex organic compounds in insoluble soya bean into less complex and water-soluble organic compounds.

Ash content is the parameter of inorganic matter value in a product. The higher the level, the more inorganic matters contained in a product. The components of inorganic matter vary in type or amount. Ash content of SSPM was 0.1±0.002%, lower than that in soya milk (6.2±0.001%). A similar finding was reported by Chaudhary & Vyas (2014) that millet germination-based premixes reduced ash content, while soaking time increased the loss of minerals used for growth of the sprout fine root since ash content was depleted. Ash content can be a parameter of the nutritional value of ingredients - the lower the ash content, the lesser the minerals. Therefore, SSPM is suitable for diabetic patients who suffer from kidney disorders with limited mineral intake.

The level of carbohydrate increased in germinated soya protein milk. Carbohydrate in this research likely included fibre. Warle *et al.* (2015) stated that the increasing carbohydrate level is derived from the outer layer of soya. Crude fibre commonly decreases in soaked mung bean, but conversely, increases in rice and soya. It is made clear that the soaking stage (before germination) affects the level of crude fibre, but not carbohydrates.

Germination changes the biochemical composition of grains including carbohydrates. During germination, the activity of α-amylase and β-amylase increase. Germination is responsible to increase amylose but decreases amylopectin. The germinated cereal grains cause extensive changes in the structure and composition of macromolecule substances. High carbohydrate level as fibre in SSPM is significantly beneficial for diabetic, cardiac, and hypercholesterolemic patients (Winarsi *et al.*, 2016).

During the postpartum period, there is an increase in inflammatory responses in the serum, which reflects the activation of the inflammatory response system (Christian & Porter, 2018). This condition is related to several factors such as physiological stress, including changes in life, lack of social support, and the possibility of illness in infants. Sleeping disorders and pain are physical stress that are common among new mothers, which also increases the risk of depression. Physical and psychosocial stresses increase inflammation, which is reflected by high levels of IL-6.

In general, mothers who have new babies feel happier. However, there is a change in the quantity and quality of sleep. Disrupted sleep periods can damage physical health and adversely affect the work of the immune system (Chattu *et al.*, 2019). Sleep disturbance generally occurs in the postpartum period, thereby increasing levels of night cortisol, glucose, and insulin resistance.

During the postpartum period, mothers generally experience increased level of stress. Breastfeeding their babies make them calmer, so the response to stress is reduced. Breast milk is an ideal nutrition for infants and is sufficient for the optimal growth of babies in the first six months (Motee & Jeewon, 2014). Breastfeeding is important for

the psychological health of postpartum mothers. Several studies have shown that breastfeeding can protect the body against type 1 diabetes, multiple sclerosis, and rheumatoid arthritis. Le Doare *et al.* (2017) revealed the role of IL-6 and transforming growth factor beta (TGF-β) in the emergence of autoimmune diseases in infants because these cytokines are found in baby serum. IL-6 is a multifunctional cytokine that regulates immune responses and acute phase reactions. High levels of IL-6 indicate the pathogenesis of several degenerative diseases, even increasing the risk of myocardial infarction in future, so the levels must be suppressed.

Epidemiological studies explain that soya isoflavones have anti-inflammatory activity in cardiovascular patients. Some researchers even reported a decrease in inflammatory cytokines by isoflavone-rich soya-based food products (Yu *et al.*, 2016; Ferguson *et al.*, 2014). Winarsi *et al.* (2010) reported that in soya bean sprouts, the content of isoflavones was higher than in non-sprout soya beans. Genistein, which is known to be excessive in soya isoflavones, is a tyrosine kinase inhibitor. This enzyme affects the signalling pathway of immune cells, both innate and adaptive immune responses. Thus, these isoflavones suppress IL-6 levels through improved immune response, so that immune cells are no longer activated to produce more cytokines. It was also reported that low-level isoflavones can bind with β-oestrogen receptors and then activate and modulate peroxisomal proliferator-activated receptor-γ (PPAR-γ) (Yu *et al.*, 2016). PPAR-γ is an inflammatory control pathway. On the other hand, it is possible that the lunasin peptide, a result of the hydrolysis of soya bean sprout proteins, is also potentially an anti-inflammatory agent. Anti-inflammation may be an important intervention strategy for the prevention and treatment of cancer (Rayburn, Ezell & Zhang, 2009). Lunasin can be an agent for cancer inhibitor and therapy. The peptide blocks or reduces the NF-kappa-B inflammatory marker, thereby reducing IL-6 levels.

IL-6 levels in breast milk initially amounted to 4.85pg/mL. IL-6 levels can increase up to three times in depressed women. In general, having a baby and breastfeeding are happy times for every family, but because almost all activities change, it could result in high levels of stress, which is reflected in high levels of IL-6. After two months of consuming SSPM, IL-6 levels in breast milk decreased from 4.89 to 1.56 pg/mL, but the decrease was not significant (p= 0.44) (Figure 1). Even so, the levels in breast milk were not different from those in plasma (p>0.05).

Germinated soya milk gives strong benefits to both lactating mothers and their babies, because breast milk is the main food compound in the early phase of a baby's life. Lactating mothers feel happy that they could provide sufficient food supply to their baby through breast milk. Factually, the baby who got SSPM slept much longer (1.85 hour) than those from the placebo group (1.25 hour). Based on these findings, it could be assumed that the treated babies got enough milk and so felt safe due to breast milk from his/her mother.

In this study, it was proven that SSPM was able to reduce BMI of breastfeeding mothers. There are several possible causes for the decline in breastfeeding mothers' BMI. SSPM, which protein is known to be rich, gives a sense of satiety, thus eliminating a sense of wanting to eat again, and suppresses subsequent energy intake. Ortinau *et al.* (2014) reported that a group on a high-protein diet produced longer satiety than those on a diet low in protein, thus suppressing following energy intakes. This occurs because the body does not store protein, so protein is immediately

metabolised to energy. The formation of energy is identical to the process of re-oxygenation, which illustrates the improved condition of hypoxia, which in turn decreases the release of IL-6 from adipose cells.

The number of lipids in women is higher than in men, because they have more subcutaneous fat than men, while men contain more abdominal fat (visceral) (Wu *et al.*, 2009). The diversity of depot fat raises the expression of different genes, for example, visceral lipid (men) produces more angiotensin, IL-6, and plasminogen activator inhibitor-1, but lesser leptin and adiponectin. The opposite is true in women who have a subcutaneous fat depot, where levels of IL-6 is lower than men. Thus, SSPM was able to suppress weight, as well as IL-6 levels of breastfeeding mothers with different mechanisms played by isoflavones, peptides, and proteins.

CONCLUSION

The preferred SSPM formula composed of 65.0% SSPE, 1.5% low-calorie sweetener, 6.0% fructose, 27.0% skim milk, and 0.5% salt. The product is thick creamy white, rich in protein (13.8±0.001%) and isoflavones (229.9±0.001 mg/g), and conversely low in fat. SSPM given to lactating mothers for two consecutive months saw a decrease in IL-6 level of the plasma by 82.5%, as well as in breast milk by 68.1%. Aside from being an anti-inflammatory, SSPM was also able to reduce the BMI of breastfeeding mothers by 9.4%, to achieve a normal BMI within two months. This product is fit to be consumed by lactating mothers since it can be used as a source of antioxidants, anti-inflammatory, weight loss, and to provide them with sufficient amount of milk for their babies. It is possible that this product can also be potentially beneficial for obese men and adolescents.

Acknowledgment

Authors would like to express their gratitude to Danone Institute Indonesia Foundation for providing funds to run the research.

Authors' contributions

HW, principal investigator, conducted the study, data analysis and interpretation, prepared the draft of the manuscript and reviewed the manuscript; AY, conceptualised and designed the study, led the data collection, advised on the data analysis and interpretation, assisted in drafting of the manuscript and reviewed the manuscript; GRR, led the data collection, advised on the data analysis and interpretation and reviewed the manuscript.

Conflict of interest

The authors report no conflict of interest to disclose in this work.

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Mal J Nutr 26(2): 303-315, 2020

The relationship between health risk and consumption of confectioneries: An instrumental variable approach

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ABSTRACT

Introduction: Consumption of confectioneries is a determinant of health risk. However, how health risk determines the intake of confectioneries remains unclear. The objective is to examine how waist circumference (WC) as a measurement of health risk influences the consumption of confectioneries among adults. The research question is that do high-risk people consume more confectioneries than low-risk people? **Methods:** A quantitative research design with a focus on establishing a correlation between the measurement of health risk and consumption of confectioneries was adopted. Secondary analysis of a nationally representative cross-sectional data was used. The population of interest was the Malaysian population, regardless of being obese or non-obese. Analyses stratified by body mass index (BMI) or WC were not conducted. An instrumental variable (IV) approach was used to estimate the regression of consumption of confectioneries. BMI was used as an IV for WC. In the first stage, we regressed WC on all exogenous variables, including BMI. Then, we replaced the original values of WC with the fitted values of WC. **Results:** BMI was an appropriate IV for WC. An additional cm of WC was associated with a 0.022 unit of reduction in the serving of confectioneries per week. The negative relationship between WC and consumption of confectioneries indicated that adults who had high health risk consumed lesser confectioneries than adults who had low health risk. **Conclusion:** Drawing from the IV regression results, the present study highlighted that people with high health risk, rather than people with low health risk, were less likely to consume confectioneries.

Keywords: Body mass index, confectionery, health risk, obesity, waist circumference

INTRODUCTION

Waist circumference (WC) is considered a measurement of health risk. Health risk is defined as an individual's probability of developing a disease. Large WC is related to various non-communicable diseases

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doi: https://doi.org/10.31246/mjn-2019-0076

(NCDs), most notably cardiovascular disease, stroke and diabetes, accounting for greater mortalities than small WC (WHO, 2018). Individuals who are in the upper quantile of WC have about 137-216% higher odds of developing hypercholesterolemia, hypertension and diabetes compared with individuals who are in the lower quantile of WC (Zhu *et al.*, 2002). An increase of 1 cm in WC raises the odds of being diagnosed with high triglycerides and metabolic syndrome by 6-7% (Janssen, Katzmarzyk & Ross, 2004). Men and women who have large WC are two times more likely to suffer from colon cancer than their counterparts having small WC (Moore *et al.*, 2004). It is apparent that large WC indicates higher health risk, while small WC denotes lower health risk.

The increase in the prevalence of NCDs has become a serious global public health concern, notably in developing countries, including Malaysia (Lum, 2018; WHO, 2018). From 2006 to 2015, the prevalences of obesity, diabetes and hypercholesterolemia in Malaysia increased from 14.0%, 11.5% and 20.7% to 17.7%, 17.5% and 47.7%, respectively (IPH, 2008; Wan Mohamud *et al.*, 2011; IPH, 2015). There are numerous factors that elevate health risk or increase WC. One of the factors is the excessive consumption of added sugar, including confectioneries (Hu, 2013; Stem *et al.*, 2017). Added sugar is sugar that is added to foods and beverages, whilst confectionery is a type of food that consists of added sugar. Therefore, the greater the consumption of confectioneries, the greater the intake of added sugar. There is evidence suggesting that an additional serving of added sugar per day increases WC by 1 cm (Stem *et al.*, 2017). On average, a Malaysian adult consumes about 5.2 servings of confectioneries per week (IPH, 2014). This amount is significantly high, especially given that carbohydrate-rich foods are the staples of the Malaysian people.

Although the effects of added sugar consumption on WC have been well-documented, how WC as a measurement of health risk determines confectioneries consumption behaviour is unclear. A research question arises: are high-risk people or people with large WC more likely to consume confectioneries than low-risk people or people with small WC? Having a better understanding of confectioneries consumption behaviour among people is important for policy makers if the goal is to lower the risk of disease via a reduction in the consumption of confectioneries. If high-risk people, rather than low-risk people, consume less confectioneries, then anti-confectioneries policy that focuses mainly on high-risk people may be less optimal.

In general, WC can influence confectioneries consumption in two different ways. Firstly, people with high risk of disease, i.e., those who have large WC, tend to have a higher rate of time preference, that is that they are more present oriented than people with low risk of disease, i.e., those who have small WC (Komlos, Smith & Bogin, 2004; Smith, Bogin & Bishai, 2005). Since consumption of confectioneries is an unhealthy behaviour, high-risk people are hypothesised to consume more confectioneries than low-risk people. This is our first hypothesis. Secondly, high-risk people are more aware of various diseases compared with low-risk people, and consequently are less likely to consume confectioneries (Lin *et al.*, 2016; Park *et al.*, 2016). Hence, a negative relationship between having a large WC and consumption of confectioneries is hypothesised. This is our second hypothesis. With that, the objective of the present study is to examine the influence of WC, i.e., a measurement of health risk, on the consumption of confectioneries.

The relationship between health risk and intake of added sugar has been

examined in previous studies (Rehm *et al.*, 2008; Bleich & Wang, 2011; Zytnick *et al.*, 2015; Park *et al.*, 2016; Pollard *et al.*, 2016; Xu, Park & Siegel, 2018). Although previous findings are interesting, they have some limitations. Firstly, body mass index (BMI) was used to measure health risk. This may result in measurement error as BMI cannot measure fat, body image and health condition accurately. As numerous studies have indicated, BMI is not a good measure for health risk because it does not differentiate between weight from fat and weight from muscle and bone (Burkhauser & Cawley, 2008; Kinge, 2017). This means that muscular people or people with a large bone structure, but having low body fat can be miscategorised as having high risk if their BMI is more than 29kg/m^2. For instance, O'Neill (2015) found that nearly 50% of high-risk women were misclassified as being low-risk, if BMI was used. In addition, Kragelund & Omland (2005), Yusuf *et al.* (2005) and Bozeman *et al.* (2012) pointed out that BMI was a weaker predictor of illnesses as compared with other measures, such as WC and waist-to-hip ratio. Secondly, even if BMI is a good measure for health risk, it causes simultaneity issue when it is included as an independent variable in the regression for added sugar intake. Since excessive consumption of added sugar can increase body weight, there is a two-way causation between added sugar consumption and BMI. Thus, it can be concluded that BMI is an endogenous variable, which can cause endogeneity problem, that is, a problem that leads to biased and inconsistent estimates if the regressions are not estimated using an instrumental variable (IV) approach.

Owing to these weaknesses, the present study attempts to contribute to the literature in several ways. Firstly, unlike previous studies, the interest of this study is in a rapidly-growing developing country like Malaysia, with a high prevalence of health risk and where empirical studies related to health risk and added sugar consumption are lacking. Moreover, the obesity rate in Malaysia is quite high (17.7%). Hence, it can be useful for policy makers to examine how food consumption behaviour is affected by health risk. Furthermore, as pointed out by Kleiman, Ng & Popkin (2012), the majority of the sales of sugary foods across the globe is in developing countries, making the prevalence of diseases worse-off. In this context, it justifies paying more attention to a developing country than a developed country.

Secondly, the present study replaces BMI with WC and examines how it affects confectioneries consumption. WC has been proven to be a better measure and predictor of health risk than BMI (Kragelund & Omland, 2005; Yusuf *et al.*, 2005; Bozeman *et al.*, 2012; Zhu *et al.*, 2014). By using WC, low-risk people are unlikely to be misclassified as high-risk people and vice versa (O'Neill, 2015). It is well-documented that where fat is located in a person's body is significant. Fat accumulated in the abdomen is more dangerous than in the hips or in other parts of the body (Burkhauser & Cawley, 2008). Hence, measurement error can be avoided if WC is used.

Thirdly, although WC is better than BMI, WC is also an endogenous variable due to simultaneity. Hence, in order to overcome the endogeneity issue, IV approach is used to estimate the regression. A quantitative research method with a focus on IV regression is the design of the present study and is considered as the uniqueness of this research. Our estimated results will be unbiased and consistent, thereby able to provide better statistical inferences. If our model is estimated using non-IV methods, such as ordinary least square (OLS), imprecise and biased estimates will be obtained because of the two-way causal relationship between confectioneries consumption and WC. Therefore, it will lead to wrong conclusions and provide policy

makers with inaccurate information. Using an appropriate IV regression can ensure that this problem will not occur, especially when IV is correctly identified.

MATERIALS AND METHODS

Data

Secondary data from the Malaysian Adult Nutrition Survey (MANS) 2014 were used in the present study (IPH, 2014). It was a nationwide survey conducted by the Ministry of Health Malaysia. A multi-stage random sampling was used. In the first stage, the entire country was divided into several enumeration blocks (EBs), i.e., geographical areas with boundaries. Overall, there were about 75,000 EBs. Approximately 49,000 were in urban areas and 26,000 in rural areas. EBs were selected in accordance with the population size of each state. A total of 187 urban EBs and 150 rural EBs were selected. In the second stage, living quarters (LQs) in each EB were randomly selected. Each EB consisted of 80-120 LQs, and each LQ comprised of 500-600 in population. A total of twelve LQs were selected from each EB. In the third stage, individuals aged 18-59 years and who resided in the selected LQs were randomly selected. The exclusion criteria were those who were pregnant or breastfeeding, as well as those who followed a special diet. Since the scope of the present study was the entire Malaysian population, regardless obese or non-obese, and analyses were not stratified by BMI or WC, MANS 2014 was appropriate. Additional information about the sampling are provided elsewhere (IPH, 2014).

Multilingual structured questionnaires were used by trained staffs to conduct face-to-face interviews. These were questions in the questionnaire of the MANS 2014. Signed consent forms were taken from every respondent. A total of 3,000 respondents completed the questionnaire. However, due to missing information, only 2,696 were used for analyses. Despite some observations being deleted, the sample was still nationally representative. Ethical approval of MANS 2014 was given by the Medical Research and Ethics Committee, Ministry of Health Malaysia (NMRR-12-815-13100).

Measurements

The dependent variable was the consumption of confectioneries. The independent variables were WC, age, income, education, gender, marital status, ethnicity, employment status and household location. BMI was used as an IV. Confectioneries referred to sugar added foods such as cakes, ice-cream and snacks. Consumption of confectioneries is the total servings of confectioneries consumed by the respondents in a week. It was obtained by asking the respondents 'Normally, how many days in a week do you take confectionery?' and 'Usually on the day you eat confectionery, how many servings do you take?'. Since face-to-face interview was conducted, respondents were provided with detailed explanations. The interviewers ensured that the respondents fully understood the definition of confectionery. Consumption of sugar-sweetened beverages, such as soft drink, sports drink and energy drink was often examined in previous studies (Park *et al.*, 2016; Rehm *et al.*, 2008; Bleich & Wang, 2011; Zytnick *et al.*, 2015; Pollard *et al.*, 2016; Xu *et al.*, 2018). Different from past researches, consumption of confectioneries was analysed in this study because it had not been examined in great detail and is highly linked to obesity-related illnesses (Naughton, McCarthy & McCarthy, 2017).

Demographic variables were selected in light of the findings of previous studies (Park *et al.*, 2016; Rehm *et al.*, 2008; Bleich & Wang, 2011; Friis *et al.*, 2014; Zytnick *et al.*, 2015; Pollard *et al.*, 2016; Xu *et al.*, 2018; Cheah *et al.*, 2019a). Previous studies found

that older individuals were less likely to consume added sugar than younger individuals because older individuals were more concerned about their health (Rehm *et al.*, 2008; Park *et al.*, 2016; Xu *et al.*, 2018). Consumption of added sugar varied across income as high income people tended to have better health awareness (Rehm *et al.*, 2008; Bleich & Wang, 2011). Men were more likely to consume added sugar relative to women because they have a higher tendency to adopt an unhealthy lifestyle (Bleich & Wang, 2011; Friis *et al.*, 2014; Zytnick *et al.*, 2015; Pollard *et al.*, 2016; Xu *et al.*, 2018). Being married reduced the consumption of added sugar (Xu *et al.*, 2018) and this was because of an increase in household commitment. Owing to cultural and religious factors, there was an ethnic variation in health behaviour (Cheah *et al.*, 2019b; Cheah *et al.*, 2020). Relative to unemployed individuals, employed individuals consumed more added sugar as they had a better financial capability (Cheah *et al.*, 2019a). Given the geographical differences in the supply of foods, urban and rural dwellers displayed different odds of consuming added-sugar (Park *et al.*, 2016; Cheah *et al.*, 2019a). Given these findings, we expected that demographic factors could affect the consumption of confectioneries.

During the survey, the respondents' height [meter (m)] and weight [kilogram (kg)] were measured using SECA Stadiometer 217 and Tanita Personal Scale HD 319. These information were then used to calculate BMI (kg/m^2). In addition, SECA 201 tape was used to measure the respondents' WC in cm. BMI and WC were formatted as continuous variables, instead of categorical variables, to facilitate IV regression. Nevertheless, in an effort to understand how many percent of the respondents were obese or non-obese, we categorised BMI into obese (BMI $25kg/m^2$) and non-obese (BMI $<25kg/m^2$) categories for descriptive statistics purpose.

Research design

The present study used a quantitative research design, particularly the correlational research design, to understand the correlation between the measurement of health risk and consumption of confectioneries. Quantitative research is a method of collecting quantifiable data and carrying out statistical tests, whilst correlational research is a method of identifying the association between two variables. In the present study, secondary analysis of survey data was conducted. The survey gathered measurable information on health risk and confectioneries consumption. The quantitative research approach was suitable for the present study because it could establish a relationship between the measurement of health risk and consumption of confectioneries by using available survey data. In addition, the present study attempted to deal with statistical issue, thus quantitative method was considered appropriate.

WC was an endogenous variable resulted from simultaneity as it could be jointly determined with the consumption of confectioneries. While WC may affect the decisions of people in the amount of confectioneries to consume, indeed, consuming too much confectioneries may increase WC. As such, using OLS or other non-IV methods to estimate the regression of consumption of confectioneries, that included WC as an independent variable, was likely to generate biased and inconsistent results. This was the problem of endogeneity. In order to overcome this problem, IV approach must be adopted.

Kinge (2017) used family members' WC as an IV for WC. However, because of data limitation, we did not have information on this variable. Instead, we used BMI as an IV for WC given that it satisfied these two main criteria (Wooldridge, 2013; Mehta, 2015). Firstly, BMI was highly correlated with WC. The covariance between these two variables

was not zero. People with high BMI was likely to have large WC. As pointed out by Bozeman *et al.* (2012), BMI was able to predict WC. Secondly, we assumed that WC, instead of BMI, had a direct effect on the consumption of confectioneries, because WC was a better measurement of health risk. People who had high BMI did not necessarily have high body fat or poor health conditions. They may be muscular or have a larger bone structure and lean body mass.

Two stage least square (2SLS), i.e., a method of IV, was used to estimate the regression. Since BMI appeared in the regression of WC, but not the others, the regression of consumption of confectioneries could be identified. In the first stage, we regressed WC on all the exogenous variables and BMI. This regression was known as a reduced form equation. The fitted values of WC were then used in the second stage. They replaced the original values of WC. Moreover, we used gender as an additional IV for WC in an effort to compare whether BMI was a better IV than demographic variables. We expected that gender would be highly correlated with WC. In the second stage, we regressed the consumption of confectioneries on all independent variables and the fitted values of WC. This regression was a structural equation, which was the model of primary interest of the present study. For comparison purpose, we also estimated the main regression using OLS. Because the fitted values of WC had lesser variations and were highly correlated with other exogenous variables, the standard errors of the IV estimates tended to be larger than those of the OLS estimates. Hence, robust standard errors of the IV estimates were calculated.

In spite of the assumption stating that BMI was an appropriate IV, we conducted a statistical test to confirm if this was true. We used OLS to estimate a multiple regression of WC on BMI and other exogenous variables. If the estimate of BMI was significant, BMI was considered to be an appropriate IV and the equation for the consumption of confectioneries could be identified. IV approach had been previously used to study the relationship between obesity and medical costs (Cawley & Meyerhoefer, 2012), and demand for cigarettes (Kenkel, Schmeiser & Urban, 2014).

RESULTS

The majority of the respondents were aged 30-39 years (27.3%), followed by those aged ≤29 years (26.2%), 40-49 years (26.0%) and ≥50 years (20.6%). Approximately 52.3%, 21.3%, 9.9%, 7.1% and 9.6% of the respondents had a monthly income of ≤ Ringgit Malaysia (RM) 999, RM1000-1999, RM2000-2999, RM3000-3999 and ≥ RM4000, respectively. A large proportion of the respondents had secondary level education (64.3%), followed by those who had primary level (20.8%), tertiary level (10.1%) and no formal education (4.8%). Slightly more than half of the respondents were females (53.5%). Nearly two-third of the respondents were married (68.8%), while only 24.7% and 6.5% were single and widowed/divorced, respectively. The ethnic breakdown consisted of 72.4% Bumiputera, 17.1% Chinese, 4.5% Indians and 6.1% individuals from other ethnic backgrounds. Of the total respondents, the majority were employed (74.3%) and resided in urban areas (52.7%) (Table 1).

On average, the respondents consumed about 4.190 servings of confectioneries (e.g. cakes, ice-cream, snacks etc.) per week. This amount of serving was slightly lesser than the amount reported in MANS 2014, i.e., 5.2 servings, because of the different calculation formulas employed (IPH, 2014). Our calculation included the respondents who reported zero intake of confectioneries, thus the mean value of confectioneries intake (i.e.,

Table 1. Variables and correlates of BMI and other exogenous variables to WC (N=2696)

Variables	*Mean (standard deviation)*	*Frequency (percentage)*	*Estimates*	*Standard errors*	*p-value*
Constant	–	–	44.682	1.009	<0.001
Confectioneries	4.19 (5.84)	–	–	–	–
WC (cm)	84.58 (13.21)	–	–	–	–
BMI (kg/m^2)	25.99 (6.68)	–	1.470	0.025	<0.001
BMI					
Obese	–	1394 (51.7)	–	–	–
Non-obese	–	1302 (48.3)	–	–	–
Age					
≤ 29 years	–	707 (26.2)	–	–	–
30-39 years	–	737 (27.3)	0.029	0.519	0.956
40-49 years	–	700 (26.0)	-0.311	0.553	0.574
≥ 50 years	–	554 (20.6)	0.709	0.599	0.237
Income					
≤ RM999	–	1409 (52.3)	–	–	–
RM1000-1999	–	573 (21.3)	0.084	0.487	0.862
RM2000-2999	–	266 (9.9)	0.835	0.652	0.200
RM3000-3999	–	190 (7.1)	0.182	0.748	0.808
≥ RM4000	–	258 (9.6)	-0.008	0.742	0.991
Education					
Tertiary	–	272 (10.1)	–	–	–
Secondary	–	1734 (64.3)	-0.508	0.650	0.434
Primary	–	560 (20.8)	0.080	0.776	0.918
No formal	–	130 (4.8)	0.847	1.045	0.417
Gender					
Male	–	1255 (46.6)	1.833	0.376	<0.001
Female	–	1441 (53.5)	–	–	–
Marital status					
Married	–	1855 (68.8)	0.468	0.486	0.335
Single	–	665 (24.7)	–	–	–
Widow/divorce	–	176 (6.5)	1.235	0.825	0.134
Ethnicity					
Bumiputera	–	1953 (72.4)	–	–	–
Chinese	–	460 (17.1)	0.808	0.493	0.102
Indian	–	120 (4.5)	2.046	0.839	0.015
Others	–	163 (6.1)	0.153	0.738	0.836
Employment					
Employed	–	2003 (74.3)	-0.161	0.460	0.726
Unemployed	–	693 (25.7)	–	–	–
Location					
Urban	–	1420 (52.7)	0.789	0.375	0.035
Rural	–	1276 (47.3)	–	–	–

Source: MANS 2014 (IPH, 2014)

unconditional mean) was somewhat smaller. The average units for WC and BMI of the total respondents were 84.6 cm and 26.0kg/m^2, respectively. Of all the respondents, 51.7% were obese and 48.3% were non-obese. BMI seemed to be significantly associated with WC, and so was gender. Holding other factors constant, on average, an increase of one unit of BMI increased WC by 1.5 cm, and males' WC was 1.8 cm larger than females' WC.

Using BMI as an IV, the results of 2SLS regression showed that an additional cm of WC was associated with a 0.022 unit reduction in the serving of confectioneries per week, if the values of other variables were held fixed. This meant that for every 20 cm increase in WC, the weekly intake of confectioneries was lower by 0.500 serving. These results supported our second hypothesis that having a large WC was negatively related to the consumption of confectioneries. However, when gender was used as an IV, the relationship between WC and confectioneries consumption became insignificant, implying that demographic variables may not be a better IV for WC compared with BMI. Considering the OLS estimates, for every one unit increase in WC, the consumption of confectioneries reduced by only 0.018 serving (Table 2).

DISCUSSION

Considering the two-way causal relationship between health risk and confectioneries consumption, the present study examined the influence of WC, i.e., a measurement of health risk, on consumption of confectioneries among adults. Owing to the fact that WC was an endogenous variable, IV approach was utilised to estimate the regression of confectioneries consumption. BMI was used as an IV for WC. Our findings suggested that BMI was an appropriate IV for WC as there was a significant association between these two variables, although it may not be the best IV. In addition, our findings showed that WC was negatively associated with the consumption of confectioneries, which indicated that adults who had high risk of disease consumed lesser added sugar than adults who had low risk of disease. However, we were unable to identify whether high-risk people consumed more or lesser fat and energy-dense foods than low-risk people because of data limitation. Moreover, the IV estimate of WC was found to be larger and more statistically significant than the OLS estimate. This implied that if non-IV method was used, the effect of WC on confectioneries consumption would be underestimated and may consequently be neglected by researchers and policy makers. The outcome could result in an inappropriate conclusion with dire consequences on public policy development.

A similar relationship between BMI and WC was evidenced in previous studies (Chinedu *et al.*, 2013; Gierach *et al.*, 2014), particularly in studies that used various statistical approaches and found a strong positive correlation between BMI and WC. Given that the effect of WC on confectioneries consumption had not been examined in previous studies, our literature review was based on studies pertaining to the relationship between BMI and consumption of added sugar. Similar to WC, high-risk people referred to those with high BMI, while low-risk people referred to those with low BMI. The relationship between BMI and consumption of added sugar found in previous studies appeared to be mixed. Using data from the National Health Interview Survey, Park *et al.* (2016) found that high-risk men were less likely to consume added sugar compared to low-risk men. They claimed that people who had high risk had a higher tendency to reduce their sugar intake in an effort to reduce their risks of suffering from diseases than their low-risk counterparts. Similar findings were evidenced by Zytnick *et al.* (2015),

Table 2. Correlates of WC and demographic factors to consumption of confectioneries, N=2696

Variables	*OLS*	*2SLS*[a]	*2SLS*[b]
Constant	5.934*	6.313*	20.764*
	(0.861)	(0.909)	(10.013)
WC (cm)	-0.018*	-0.022*	-0.198
	(0.008)	(0.009)	(0.121)
Age			
≤ 29 years	–	–	–
30-39 years	0.094	0.095	0.158
	(0.341)	(0.378)	(0.403)
40-49 years	-0.146	-0.150	-0.327
	(0.363)	(0.429)	(0.457)
≥ 50 years	-0.368	-0.361	-0.206
	(0.394)	(0.405)	(0.449)
Income			
≤ RM999	–	–	–
RM1000-1999	0.371	0.377	0.418
	(0.319)	(0.336)	(0.366)
RM2000-2999	-0.442	-0.440	-0.336
	(0.428)	(0.402)	(0.440)
RM3000-3999	0.333	0.341	0.561
	(0.491)	(0.578)	(0.642)
≥ RM4000	0.555	0.557	0.644
	(0.487)	(0.478)	(0.523)
Education			
Tertiary	–	–	–
Secondary	0.464	0.461	0.425
	(0.426)	(0.398)	(0.429)
Primary	-0.492	-0.487	-0.392
	(0.509)	(0.449)	(0.498)
No formal	-1.118	-1.116	-0.991
	(0.686)	(0.583)	(0.648)
Gender			
Male	-0.393	-0.382	–
	(0.247)	(0.246)	
Female	–	–	–
Marital status			
Married	-0.127	-0.118	0.178
	(0.319)	(0.369)	(0.405)
Single	–	–	–
Widow/divorce	-0.083	-0.074	0.332
	(0.542)	(0.482)	(0.527)

Table 2. Correlates of WC and demographic factors to consumption of confectioneries, N=2696 *[cont'd]*

Variables	*OLS*	*2SLS*[a]	*2SLS*[b]
Ethnicity			
Bumiputera	–	–	–
Chinese	-2.372*	-2.372*	-2.299*
	(0.324)	(0.315)	(0.354)
Indian	-1.757*	-1.749*	-1.337*
	(0.551)	(0.423)	(0.594)
Others	-0.975*	-0.987	-1.315*
	(0.484)	(0.541)	(0.627)
Employment			
Employed	0.573	0.570	0.446
	(0.302)	(0.305)	(0.320)
Unemployed	–	–	–
Location			
Urban	-0.043	-0.036	0.083
	(0.246)	(0.241)	(0.271)
Rural	–	–	–

Note: [a]BMI is used as an IV. [b]gender is used as an IV. Standard errors in parentheses
*p<0.05
Source: MANS 2014 (IPH, 2014)

who used a different dataset. Their findings showed that high-risk adults consumed lesser sports drinks than low-risk adults. On the other hand, Pollard *et al.* (2016), who investigated the intake of added sugar among Australians, found that high-risk women consumed more added sugar than low-risk women. They argued that the reverse causation between health risk and added sugar consumption was the reason. Xu *et al.* (2018) in examining the consumption of added sugar among adults with and without diabetes, also found that high-risk adults were more likely to consume added sugar than low-risk adults. Our findings confirmed our second hypothesis that high-risk people were more likely to take care of their health by avoiding confectioneries, as well as the findings of Park *et al.* (2016) and Zytnick *et al.* (2015) that being high-risk was inversely related to added sugar intake. Since Park *et al.* (2016) and Zytnick *et al.* (2015) used logistic regressions, the magnitude of WC evidenced in the present study could not be directly compared with their estimates.

Because individuals who have an unhealthy body weight usually have a large WC, except those with high lean body mass, there exists a significant positive relationship between WC and BMI. Even though WC is a more accurate determinant of the consumption of confectioneries compared with BMI as it predicts obesity-related diseases and mortality better than BMI (Kragelund & Omland, 2005; Yusuf *et al.*, 2005; Bozeman *et al.*, 2012; Zhu *et al.*, 2014), WC and BMI are closely related. It appears, therefore, that BMI is an appropriate IV for WC. Given that consumption of confectioneries is an unhealthy behaviour, people often believe that high-risk people are associated with high consumption of confectioneries. However, findings of the present study

indicated that this was not necessarily the case. In fact, high-risk people are more aware of their health than low-risk people, and thus have a lower likelihood of consuming confectioneries (Lin *et al.*, 2016; Park *et al.*, 2016).

Given the findings of the present study, we suggest that an intervention measure directed towards reducing the consumption of confectioneries among low-risk people or people with small WC should be adopted and emphasised in order to prevent further increases in the prevalence of diseases. More attention should be paid to this group of population than high-risk people or people with large WC. Unfortunately, analysis stratified by WC was not conducted in the present study, therefore we were unable to identify factors other than risk that determined confectioneries consumption among high- and low-risk people. This could be a direction for future research. Also, the cost-effectiveness of policies was not analysed in our study, thus we avoided providing any unverified extrapolations to possible anti-confectioneries policies.

While the present study had significantly illustrated the effect of WC on consumption of confectioneries, it had some limitations. For instance, all the information, except for BMI and WC, were self-reported by the respondents. Hence, minor reporting errors may have existed as high-risk people may have underestimated or underreported their consumption of confectioneries. However, this error was not as serious as what had been found by Ali Zainuddin *et al.* (2019). The authors calculated the respondents' energy intake-basal metabolic rate ratio and found high prevalence of underreporting of energy intake in MANS 2014. This should not be an issue in the present study because in MANS 2014, the questions used to obtain data on confectioneries intake were not related to the questions used to calculate energy intake. This meant that even though the information on energy intake lacked reliability, the data on confectioneries consumption were still reliable and useful for research.

Another limitation was that the data on confectioneries consumption were not obtained from very thorough dietary assessment techniques, such as 24-hour diet recall, and there was no information on total sugar intake per respondent. Next, given that cross-sectional data were used, the causality between WC and confectioneries intake could not be well identified. Finally, some people consumed confectioneries infrequently, therefore, asking if a respondent consumed confectioneries weekly may have caused a lack of variation in the data. Notwithstanding, future research with data availability would facilitate in a better IV for WC, such as WC of the respondents' siblings or parents. In addition, other types of measurement of health risk, such as waist-to-hip ratio and body fat percentage could be considered in the analysis. Moreover, data with a larger sample size, if available, should be utilised in order to generate more efficient estimates.

CONCLUSION

The present study found that BMI was positively associated with WC, indicating that obese people were likely to have large WC. In addition, there was a strong evidence suggesting that individuals who had large WC were less likely to consume confectioneries compared to individuals who had small WC. This implied that high-risk people were more aware of their health than low-risk people, and consequently had a lower tendency to consume confectioneries. In terms of policy implications, an intervention strategy directed towards reducing the intake of confectioneries among low-risk people or people who have small WC may yield promising results. Policy makers are suggested to make a concerted effort to improve health awareness among this group of population by providing

them with adequate knowledge about the negative consequences of excessive consumption of confectioneries.

Acknowledgement

The authors would like to thank the Director General of Health, Malaysia for his permission to use the data from the Malaysian Adult Nutrition Survey (MANS) 2014 and to publish this paper. The authors would also like to thank Jianfei Cao for his feedback and comments. This research received funding from the Fundamental Research Grant Scheme (FRGS) (KOD SO 14218), which is sponsored by the Ministry of Education Malaysia.

Authors' contributions

CYK, conceptualised the study, contributed in the funding acquisition, methodology, validation, formal analysis, investigation, drafting of original manuscript, reviewing and editing of the manuscript, visualisation and supervision of the study; MA, contributed in the methodology and validation of the study; NSMN, contributed in the methodology and validation of the study; PSN, contributed in the drafting, reviewing and editing of the manuscript; NHAM, contributed in the reviewing and editing of the manuscript.

Conflict of interest

The authors have no competing interests to declare.

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