Original Article

Comparative validity of a Food Frequency Questionnaire (MyUM Adolescent FFQ) to estimate the habitual dietary intake of adolescents in Malaysia

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Background and Objectives: The food frequency questionnaire (FFQ) is a dietary tool used to assess the habitual intake of the population. The goal of this study is to examine the reproducibility and validity of the FFQ that was developed for a multi-ethnic population in Malaysia. **Methods and study design:** Collective food data from MyHeARTs 2012 database were used to construct the MyUM Adolescent FFQ. Seventy-eight participants between 13 and 15 years old in 2014 were selected through convenient sampling for test – retest study. They completed the MyUM Adolescent FFQ twice, with an interval period of one week. One hundred and fifty-six MyHeARTs study participants who were 15 years old in 2014 were randomly selected for this comparative validity study. They completed a 7-day diet history (7DDH) and subsequently completed the self-administered MyUM Adolescent FFQ. **Results:** Pearson's correlations between the FFQ and 7DDH for all macronutrients were statistically significant. Energy-adjusted correlations for protein, carbohydrate, and fat were 0.54, 0.63 and 0.49 respectively. Most of the micronutrients and minerals, were statistically correlated ranging from 0.31 to 0.49 after energy adjustment. Cross-classification analyses revealed that more than 70 percent of adolescents were classified into either the same or adjacent quartile of nutrient intake when comparing data of 7DDH and FFQ. No serious systematic bias was evident in the Bland-Altman plots. **Conclusion:** The 200-item FFQ developed for Malaysian adolescents has moderate to good comparative validity for assessment of macronutrient and micronutrient intake.

Key Words: reproducibility, validity, food frequency questionnaire, adolescent, Malaysia

INTRODUCTION

The increasing incidence of obesity in children and adolescents worldwide is a public health concern. Irrespective of sex and ethnicity, this global phenomenon is seen in both developed and developing countries. The prevalence of overweight and obesity among adolescents in the United States of America increased from 10.5 percent in 1998 to 15.5 percent in 2000, and remained high in 2012.[1,2] The same trends hold in China, where 19 percent of boys and 13 percent of girls in child and adolescent population were identified as obese in 2010. There was a rapid increment in obesity among boys of approximately 9 percent per year; from 1985 to 2010.[3] Since 1990 an increasing trend of obesity among adolescents has also been observed in Malaysia.[4] The Global School-based Student Health Survey conducted in 2012 among 13 to 17 year olds showed that one in three adolescents were either overweight or obese,[5] while a study in 2014 reported a much higher prevalence of overweight and obesity among 13-year-old adolescents, which equated to 23.9 percent of that age group.[6]

Although there are many complex environmental, lifestyle, and biological factors that contribute to obesity, most studies have found that a high-calorie diet and a lack of physical activity are the main factors contributing to this global epidemic.[7,8] Globalisation, societal changes, and the increasing availability of fast food have led to fewer meals being eaten at home, shifting most of the adolescent population's diet from a high fibre and a low-fat diet to low fibre and energy dense diet.[9,10] This dietary transition is not only affecting the habitual adolescent diet; it is also increasing the risk of developing chronic diseases, as risk comorbidity is positively correlated with an increase in body mass index (BMI).[11] The Malaysian

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adolescent population is at risk of becoming an unhealthy adult population if no action is taken. Currently, 2.6 percent of adolescents, and 10 percent of overweight and obese adolescents, have already developed metabolic syndrome.[12] Thus, accurate and consistent measurement of the dietary intake of adolescents in Malaysia is essential so that effective prevention strategies and public health interventions can be planned, implemented, and evaluated.

In epidemiological studies, the Food Frequency Questionnaire (FFQ) is a commonly used method of dietary assessment. The FFQ is a viable method of assessment for the repeated measurement of a population's diet. It can identify trends over time, but most importantly, the FFQ is relatively inexpensive and easy to administer. This method is less resource intensive, so it is commonly used in large population studies to measure habitual dietary intake.[13] However, no FFQ is universal, as dietary habits differ across populations. Different FFQs are needed for different populations as preference, accessibility to food, food availability, environment, setting, ethnicity and religion vary from one population to another.[14] Thus, to produce valid and reliable data, the development of an FFQ specific to the target population is required.[15]

The FFQ was initially developed for the adult population.[16] Over the years, more FFQs were developed for the elderly, adolescents, and also children.[17,18] To the best of our knowledge, limited numbers of FFQs have been developed for Malaysia. Those FFQs that do exist are specifically mainly for adults or pregnant women.[19,20] Earlier, an FFQ for ethnic Malay adolescents mainly residing in the state of Kelantan was developed.[21] However, to date no FFQs have been developed for the three major ethnic groups in Malaysia. Therefore, this study presents the development and comparative validity of an FFQ for the multi-ethnic adolescent population in Malaysia.

MATERIALS AND METHODS

Development of MyUM Adolescent FFQ

The Malaysian Health and Adolescent Research Team's (MyHeARTs) research study is a stratified sampling, dynamic, prospective cohort study that follows up Malaysian adolescents from the age of 13 years old (form 1- 1st year of secondary school) until adulthood (27 years old).[6] An open-ended data collection approach was used, in which collective food data from the 7-day diet history (7DDH) obtained from the MyHeARTs population-based study conducted in 2012,[6] was used to construct the proposed FFQ. One thousand three hundred and sixty one items were analysed from MyHeARTs 2012 participants' food data, and 523 food items were reported as being consumed regularly. For completeness of the food list in the FFQ, the food items listed need to provide an amount of nutrients of interest cumulatively accounting for at least 90 percent of dietary intake.[22-24] Thus, from these 523 foods, 150 were identified as contributing to the intake of at least 90 percent of each of the nutrients of interest. A group discussion was also conducted, involving a public health professional and five dietitians consulted concerning the list. Modifications and additions to items in the food list were made accordingly.

The final adapted questionnaire contained a total of 200 close-ended single food items, divided into 14 categories. The categories are: (1) cereal and cereal based dishes; (2) meat and poultry; (3) seafood and shellfish; (4) milk and dairy products; (5) egg and egg dishes (6) vegetables; (7) fruits (8) seasonal fruits; (9) traditional *kuih* (cake) (10) beverages; (11) alcoholic beverages; (12) sweets and spreads; (13) processed food; and (14) fast foods and snacks. The general format of the questionnaire contains instructions on how to use the FFQ, portion size options and frequency options. The participants were also instructed to include foods consumed over the past 12 months. Frequency of food consumption was recorded in nine categories (none per month; 1 to 3 times per month; one time a week; 2 to 4 times per week; 5 to 6 times per week; one time a day; 2 to 3 times per day; 4 to 5 times per day; and six and more times per day). In each category, there are options for how frequently each food item was consumed. For example, if a food item is consumed three times per week, the participant enters 3 in the '2 to 4 times per week' category. A flip chart with colour illustrations of household measurement utensils and the portions of commonly consumed food was also developed in order to explain the portion options for the food items to the participants. The portion options were based on the *Malaysian Atlas of Food Exchanges and Portion Sizes.*[25] The questionnaire instructions, frequency options, and food list were presented in the Malay language. Face validity was then tested on 10 adolescent respondents. Participant understanding of the questions and the food items listed was obtained. Minor modifications were made to the content language to increase respondents' understanding of the questions in the FFQ. The questionnaire requires an average of 30 minutes to be completed.

Test-retest reliability of MyUM Adolescent FFQ

Using the convenience sampling method, 119 adolescents aged 13 to 15 years old who were not participants in the MyHeARTs study were invited to participate in the test-retest of the FFQ. The participants were from the Malacca, Perak, and Penang areas of peninsular Malaysia. The FFQ was administered twice, one week apart for each participant. A duration of one week was chosen to avoid true changes in the dietary habits of the adolescents, which may occur over longer periods of time.[21, 26-30]

Sample size calculation for comparative validity of MyUM Adolescent FFQ

Based on the Bland-Altman method, the sample size needed to validate the MyUM Adolescent FFQ had to consist of at least 50 participants, preferably more.[31] However, a sample size larger than 200 subjects provides little additional precision.[24]

Therefore, some correlation criteria were established in order to arrive at the sample size. Previous studies demonstrate that correlation coefficients for validation studies usually fall within the range of 0.3 to 0.7.[31-33] Thus, the hypotheses HO: r <0.3 and H_A: $r \geq 0.3$ were used to assess the correlation between the MyUM

Adolescent FFQ and the 7DDH, which gave minimal sample size of n=85; for a desired lower limit of a two-sided 95 percent confidence interval, a β of 0.2 and *r* of 0.3.[34] A total of 156 MyHeARTs participants took part in this comparative validity study, which was more than the calculated sample size.

Comparative validity of MyUM Adolescent FFQ

Comparative validity of the FFQ was performed for one hundred and fifty-six 15-year-old adolescents who were participants in the MyHeARTs 2014 study. Recruitment for the current study was conducted via schools in Perak, Selangor and Wilayah Persekutuan per the MyHeARTs study protocol.[6] Recruitment was based on the following inclusion criteria: (1) age 15 years old; (2) studying in a government school; (3) able to speak Malay; and (4) given parental consent. Data collection was conducted from April to June 2014. Participants were interviewed about their 7DDH and given the MyUM Adolescent FFQ to complete afterwards. Their MyUM Adolescent FFQ responses were then compared with their 7DDH. The calculation of the nutrient intake of the adolescents was based on frequency and portion size of the food consumed.

MyUM Adolescent FFQ and 7-day diet history

There are several methods for obtaining data on the habitual dietary intake of an individual. It can be assessed through food weighing, diet record, or diet history to evaluate energy intake. Seven-days diet history has been shown to provide a valid estimate of energy intake among adolescents compared with other methods,[35,36] so it was also employed in the current study. All 1247 MyHeARTs participant in 2014 were interviewed about their 7DDH in a face-to-face interview with a dietitian, assisted by tools such as flip charts and household measuring utensils such as cups, bowls and spoons. After the diet history interview, and others data collection procedures such as blood sampling and physical activity as described elsewhere,[6] randomly selected participants from each school were gathered and invited to participate in the MyUM Adolescent FFQ comparative validity study. Those who agreed were given verbal and written instructions on how to complete the MyUM Adolescent FFQ by a different researcher and subsequently asked to self-complete the MyUM Adolescent FFQ in the presence of the researcher. The MyUM Adolescent FFQ was then checked for completeness. Participants were asked to clarify any unclear or missing data whenever possible.

Data entry of nutrient intake

Information obtained from the 7DDH and MyUM Adolescent FFQ was input into Nutritionist Pro^{TM} Diet Analysis (Axxya System, USA) software in order to calculate participant nutrient intake. The nutrient composition data in the Nutritionist Pro^{TM} Diet Analysis database is compiled from a variety of sources, including the Nutrient Composition of Malaysian Food, which is the standard reference adopted by the current study.[37] Average daily nutrient intakes from 7DDH were calculated as follows: (Intake of nutrient from Monday to Sunday)/7. Calculations of nutrient intake from the FFQ were based on the following formula: frequency of intake x serving size x total number of serving x weight of food in one serving. Foods taken once a week, for example, were divided with 7 days. Thus, the frequency of intake per day would be 0.14. Those foods taken once a month were divided with 30 days. Thus, frequency of intake daily would be 0.03.

Test – retest reliability of MyUM Adolescent FFQ

Using ±2 standard deviation (SD) reporting of energy intake cut off criteria, subjects with a total energy intake falling outside the range of 800 to 4000kcal per day based on the MyUM Adolescent FFQ1 and MyUM Adolescent FFQ2 (n=31) were excluded from the study.[38,39] Questionnaires with incomplete (n=4) and missing information (n=3) were also excluded (see Figure 1). The

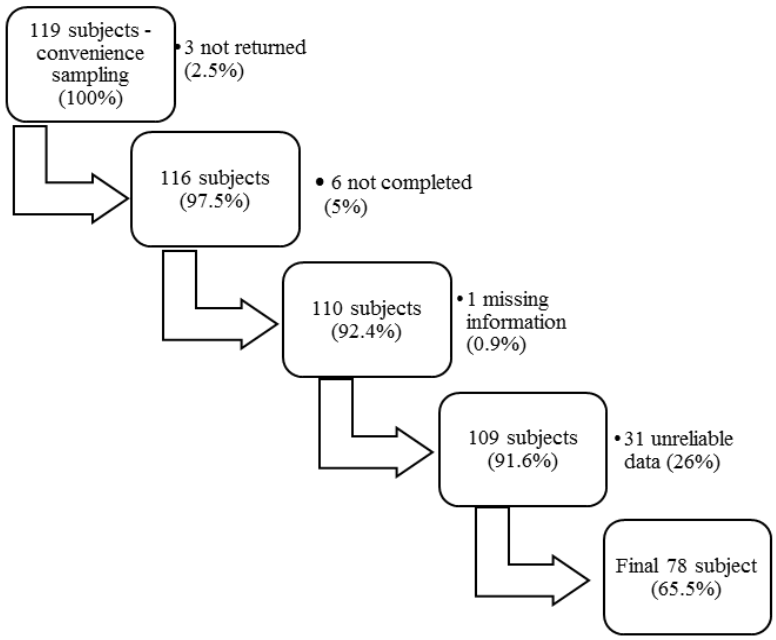

Figure 1. Flow diagram of sample selection for MyUM Adolescent FFQ reliability study

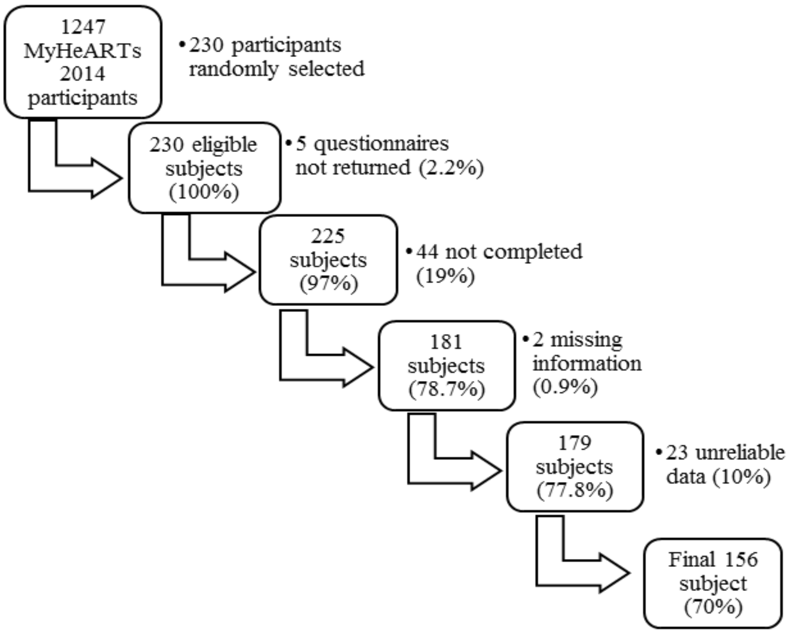

Figure 2. Flow diagram of sample selection for MyUM Adolescent FFQ comparative validity study

mean, SD, and *t*-test of energy and nutrients assessed by the MyUM Adolescent FFQ1 (1st week administration) and MyUM Adolescent FFQ2 (2nd week administration) were calculated. Intra-class correlation (ICC) was also used to estimate the nutrient value relationship between the MyUM Adolescent FFQ1 and MyUM Adolescent FFQ2. Correlation values less than 0.4 were interpreted as poor; 0.4 to 0.59 as fair; 0.60 to 0.74 as good; and nutrients with ICC more than 0.75 as excellent.[40]

The agreement between the means of energy and nutrient intake of MyUM Adolescent FFQ1 and MyUM Adolescent FFQ2 was further assessed using the Bland-Altman method. The differences between the intake of the two methods (MyUM Adolescent FFQ1 – MyUM Adolescent FFQ2) against the mean intake of the two studied measurement instruments ([MyUM Adolescent FFQ + MyUM Adolescent FFQ2]/2) were plotted.[41] The limit of agreement (mean±1.96 SD) was used to assess the agreement between the two instruments.[42]

Comparative validity of the study

Subjects with a total energy intake that fell outside the range of 800 to 4000kcal per day based on the MyUM Adolescent FFQ and 7DDH (n=23) were excluded from the study.[38,39] In addition, participants whose questionnaires had missing information (n=2) or who did not complete the questionnaire (n=44) were also excluded (Figure 2). The mean and standard deviations of nutrient intake assessed by the 7DDH and MyUM Adolescent FFQ were calculated. For the purpose of the current study, nutrient intake data derived from the 7DDH and MyUM Adolescent FFQ were compared using a signed-ranks test. Pearson correlation coefficients were used to estimate the nutrient value relationship of the 7DDH and MyUM Adolescent FFQ, where r <0.3 indicates low correlation; r >0.3-0.5 moderate correlation; and r >0.5 good correlation.[24] Nutrient intakes were adjusted for total energy with regression analysis per Willet's method.[24]

Distributions of energy and nutrient were also categorised into quartiles. The percentage of participants were classified by both methods (MyUM Adolescent FFQ and 7DDH) into 'same quartile', 'adjacent quartile', 'one quartile apart', and 'grossly misclassified' – in order to assess agreement using cross-classification of nutrient intake.[32] The agreement between the means of energy and nutrient intake of the 7DDH and MyUM Adolescent FFQ was assessed using the Bland-Altman method. The differences between the intake of the two methods (MyUM Adolescent FFQ – 7DDH) against the mean intake of the two studied measurement instruments ([MyUM Adolescent FFQ + 7DDH] / 2) were plotted.[41] The limits of agreement (mean ± 1.96 SD) were used to assess the agreement between these two methods.[42] All statistical analyses in the current study were done using the statistical package SPSS for Windows 20.0 (SPSS Inc. USA).

This study was approved by University Malaya ethics committee [MEC Ref. No: 896.34] and Ministry of Education Malaysia. Written and verbal informed consent was obtained from all participants and their guardians.

RESULTS

Test –retest reliability (MyUM Adolescent FFQ1 vs MyUM Adolescent FFQ2)

Table 1 shows demographic characteristics of seventy-eight convenience sample of non – MyHeARTs participants, who completed the questionnaire. In terms of ethnicity, the adolescents were 81 percent Malay, 14 percent Chinese and 5 percent Indian. There were more girls (60 percent) than boys.

Mean energy and nutrients intake from FFQ1 and FFQ2 are reported in Table 2. Intake of total fat, vitamin B-6, and sodium were significantly higher in FFQ1 compared to FFQ2, while others showed no significant difference.

Intra-class correlations for the two administrations of

Table 1. Participant's demographic characteristics of MyUM Adolescent FFQ test re-test reliability study (n=78)

Demographic characteristics		n	Percentage
Sex	Male	31	39.7
	Female	47	60.3
Ethnicity	Malay	63	80.8
	Chinese	11	14.1
	Indian	4	5.1

Mean age 14.4±0.77.

Table 2. Comparison of average mean daily nutrient intake and correlations between the FFQ1 and FFQ2 (n=78)

Nutrient	Mean (SD)		
	FFQ1	FFQ2	*p*-value
Total energy (Kcal)	2001.9 (714.6)	1911.4 (731.4)	NS
Total carbohydrate (g)	304.7 (109.1)	296.8 (106.3)	NS
Protein (g)	68 (34.3)	63.6 (34.1)	NS
Total fat (g)	56.3 (32.4)	51.1 (31.3)	<0.05*
Cholesterol (mg)	239.1 (188.3)	254.5 (209.9)	NS
Crude dietary fibre (g)	4.0 (2.9)	3.9 (3.8)	NS
Total sugar (g)	56.8 (51.9)	50.9 (48.7)	NS
Vitamin A (IU)	530.7 (390.0)	467.5 (371.5)	NS
Beta-carotene (μg)	360.4 (498.4)	322.1 (548.9)	NS
Vitamin C (mg)	61.8 (73.1)	57.8 (73.3)	NS
Vitamin E (IU)	2.2 (1.9)	2.1 (1.4)	NS
Thiamin, B-1 (mg)	0.5 (0.3)	0.5 (0.4)	NS
Riboflavin, B-2 (mg)	0.7 (0.8)	0.6 (0.5)	NS
Niacin (mg)	5.7 (4.1)	4.9 (3.5)	NS
Pyridoxine, B-6 (mg)	0.5 (0.4)	0.4 (0.3)	<0.05*
Folate (μg)	36.4 (28.6)	33.1 (24.8)	NS
Vitamin B-12 (μg)	0.8 (1.0)	0.7 (0.8)	NS
Sodium (mg)	2792.8 (1721.7)	2450.6 (1641.0)	<0.05*
Potassium (mg)	1087.1 (580.7)	990.1 (569.3)	NS
Calcium (mg)	522.7 (366.5)	478.7 (347.3)	NS
Iron (mg)	18.4 (33.2)	13.9 (7.6)	NS
Phosphorus (mg)	654.8 (435.7)	581.2 (400.1)	NS
Magnesium (mg)	105.7 (63.2)	99.3 (74.0)	NS
Zinc (mg)	2.2 (1.8)	2.1 (1.7)	NS

FFQ1: MyUM Adolescent Food Frequency Questionnaire 1st administration; FFQ2: MyUM Adolescent FFQ 2nd administration.
*Statistically significant at <0.05 (paired sample *t*-test), NS: Not significant

the MyUM Adolescent FFQ ranged from 0.67 for vitamin E (good correlation) to 0.88 (excellent correlation) for total energy intake (Table 3). All macronutrient measurements gave intra-class correlations of more than 0.7, and all micronutrient measurements gave correlations of more than 0.6. This indicates that the proposed MyUM Adolescent FFQ had good to excellent reliability and reproducibility for macronutrients, and good reliability and reproducibility for micronutrients.

Moreover, the Bland-Altman plot indicates that there is no serious systematic bias between the MyUM Adolescent FFQ1 and MyUM Adolescent FFQ2 range of mean nutrient intake.

Comparative validation

From an original sample of 230 adolescents recruited from among MyHeARTs participants, five (2.2 percent) did not return the questionnaire and 44 (19 percent) did not complete the questionnaire. After excluding the questionnaires that contained unreliable data (n=23) and had missing information (n=2), a total of 156 subjects were included in the analysis (Figure 1). The demographic and physical characteristics of the subjects of the validation study are shown in Table 4 and Table 5.

Table 6 presents the comparison of the means and standard deviation for macronutrients and micronutrients of MyUM Adolescent FFQ and 7DDH. Some of the macro and micro-nutrients estimated from the MyUM Adolescent FFQ were significantly different compared to 7DDH. Total energy, protein, cholesterol, vitamin E, niacin, vitamin B-12, sodium, potassium, calcium, iron, phosphorus, magnesium, and zinc, however, show no significant difference.

Pearson's correlations for nutrient intake derived from the MyUM Adolescent FFQ and from the 7DDH are shown in Table 7. The correlation coefficients for unadjusted data varied from 0.178 (total sugar) to 0.641 (carbohydrate) for macronutrients, and from 0.070 (beta-carotene) to 0.474 (iron) for micronutrients and minerals. After adjusting for total energy intake, the correlations between some nutrients and minerals, such as protein, total fat, crude dietary fibre, total sugar, vitamin A, thiamin, riboflavin, niacin, pyridoxine, folate, sodium, potassium, iron, phosphorus and zinc were improved. All correlations for macronutrients were statistically significant with a *p*-value of <0.05. Except for beta-carotene, vitamin C and cobalamin, micronutrients and minerals also showed a statistically significant correlation with a

Table 3. Intra class correlation and 95% confidence interval between the 1st and 2nd administration of MyUM Adolescent FFQ (n=78)*

Variables†	ICC	(95% CI)
Total energy (Kcal)	0.88	(0.80-0.92)
Protein (g)	0.87	(0.79-0.92)
Carbohydrate (g)	0.84	(0.76-0.90)
Total fat (g)	0.83	(0.73-0.89
Cholesterol (mg)	0.71	(0.55-0.82)
Crude dietary fibre (g)	0.80	(0.69-0.88)
Total sugar (g)	0.79	(0.67-0.87)
Vitamin A (IU)	0.72	(0.56-0.82)
Beta-carotene (μg)	0.73	(0.57-0.83)
Vitamin C (mg)	0.78	(0.65-0.86)
Vitamin E (IU)	0.67	(0.47-0.79)
Thiamin, B-1 (mg)	0.75	(0.61-0.84)
Riboflavin, B-2 (mg)	0.78	(0.63-0.86)
Niacin (mg)	0.77	(0.71-0.88)
Pyridoxine, B-6 (mg)	0.72	(0.56-0.83)
Folate (μg)	0.72	(0.56-0.82)
Vitamin B-12 (μg)	0.72	(0.55-0.82)
Sodium (mg)	0.85	(0.75-0.91)
Potassium (mg)	0.82	(0.71-0.88)
Calcium (mg)	0.83	(0.74-0.89)
Iron (mg)	0.68	(0.50-0.80)
Phosphorus (mg)	0.73	(0.57-0.83)
Magnesium (mg)	0.71	(0.54-0.82)
Zinc (mg)	0.75	(0.60-0.84)

ICC: intra class correlation; CI: confidence interval.
†All variables were log-transformed before analysis to improved normality, *All nutrients were statistically significant with *p*-value less than 0.05.

Table 4. Demographic characteristics of the subjects in the validation study (156 MyHeARTs participants)

Characteristics		n	Percentage
Sex	Male	78	50.0
	Female	78	50.0
Ethnicity	Malay	102	65.8
	Chinese	24	15.5
	Indian	25	16.1
	Others	4	2.6
Residence	Urban	100	64.1
	Rural	56	35.9

n=156.

p-value of <0.05.

Data on the nutrient intake estimated from the MyUM Adolescent FFQ and 7DDH were distributed into intake quartiles. These were then cross-classified. A subject would be correctly classified using one assessment tool if the nutrient intake of that particular subject were ranked into the same or adjacent quartile in the other assessment tool. Table 8 presents a summary of cross-classification analysis. The classification of the subjects into the same and adjacent quartiles ranged from 70.5 percent for crude dietary fibre to 88.5 percent for carbohydrate in the case of macronutrients. For micronutrients, classification ranged from 65.7 percent for beta-carotene to 80.2 percent for magnesium.

Moreover, the Bland-Altman plot indicates no serious systematic bias between the MyUM Adolescent FFQ and 7DDH range of mean nutrient intake.

DISCUSSION

The results demonstrated that the 200-item self-administered MyUM Adolescent FFQ proposed in the current study is a relatively valid tool for dietary assessment among the adolescent population in Malaysia. Statistical tests and analysis showed that the MyUM Adolescent FFQ has moderate to good reproducibility and strength in terms of diet estimation.

In the current study, based on analysis using intra-class correlation, reliability and reproducibility between the first and second MyUM Adolescent FFQs (FFQ1 and FFQ2) in 78 participants showed a higher correlation (0.67 to 0.88) than that reported in other previous studies with correlation of 0.53 to 0.65 and 0.31 to 0.73 respectively.[43,44] The test-retest study duration, however, was longer compared to the MyUM Adolescent FFQ test-retest study.

The mean nutrient intake value derived from the MyUM Adolescent FFQ noted to be higher than that from the 7DDH. This was expected as this is a common issue that has also been reported by other studies; adolescents tend to overestimate the nutrient intake in their recall for a FFQ compared to their recall for multiple 24-hour diet record.[24,33] The signed-ranks test showed no significant difference in most macronutrients, micronutrients and minerals, indicating there is agreement between the two methods of diet estimation investigated in the current study.

The comparative validity of this newly developed FFQ was further examined by correlation coefficient analysis, where the 7DDH was used as a reference. A significantly moderate to high correlation for macronutrients such as total energy, protein, carbohydrate and total fat, proved good evaluation of the macronutrient intake compared to the reference method. This was also the case for micronutrients, because the correlation for most of the micronutrients was found to be moderate. This is consistent with other studies on adolescent populations.[21,45,46]

Table 5. Physical characteristics of the subjects in validation study (156 MyHeARTs participants)

Characteristics	Mean (SD)		Total
	Male, n=78	Female, n=78	
Weight (kg)	56.3 (17.1)*	51.2 (11.6)	53.9 (14.8)
Height (cm)	163.4 (7.3)*	154.6 (5.3)	159.2 (7.6)
Body mass index (kg/m^2)	21.0 (5.8)	21.4 (4.7)	21.2 (5.3)
Waist circumference (cm)	73.4 (14.0)*	70.2 (9.5)	71.8 (12.1)
Hip circumference (cm)	89.6 (10.9)	92.6 (8.7)	91.1 (10.0)

n=156.
*Independent sample *t*-test shows significant difference between the sexes with *p*-value <0.05

Table 6. Comparison of nutrient intakes per day by MyUM Adolescent FFQ and 7DDH (n=156)

Nutrient	FFQ	7DDH	p-value†
	Mean (SD)	Mean (SD)	
Energy (Kcal)	1965.4 (565.7)	1897.9 (558.1)	NS
Protein (g)	72.1 (27.5)	72.4 (22.2)	NS
Carbohydrate (g)	283.4 (85.9)	257.1 (80.2)	<0.05*
Total fat (g)	60.4 (25.1)	64.4 (22.6)	<0.05*
Cholesterol (mg)	258.9 (163.1)	249.4 (120.0)	NS
Crude dietary fibre (g)	4.4 (3.0)	3.7 (2.0)	<0.05*
Total sugar (g)	44.5 (30.4)	38.0 (22.4)	<0.05*
Vitamin A (IU)	541.0 (302.5)	439.9 (319.9)	<0.05*
Beta-carotene (μg)	485.7 (720.5)	169.4 (267.9)	<0.05*
Vitamin C (mg)	72.1 (58.6)	59.8 (37.7)	<0.05*
Vitamin E (IU)	2.7 (1.7)	2.3 (1.5)	NS
Thiamin, B-1 (mg)	0.5 (0.3)	0.4 (0.2)	<0.05*
Riboflavin, B2 (mg)	0.7 (0.5)	0.4 (0.2)	<0.05*
Niacin (mg)	6.0 (3.1)	5.1 (3.2)	<0.05*
Pyridoxine, B-6 (mg)	0.5 (0.3)	0.3 (0.2)	<0.05*
Folate (μg)	40.4 (22.2)	27.9 (19.9)	<0.05*
Cobalamin, B-12 (μg)	0.8 (0.8)	0.8 (0.9)	NS
Sodium (mg)	2747.9 (1381.0)	2664.5 (1018.7)	NS
Potassium (mg)	1218.7 (505.7)	1146.8 (403.8)	NS
Calcium (mg)	498.6 (277.4)	485.7 (244.4)	NS
Iron (mg)	16.2 (7.6)	15.3 (7.4)	NS
Phosphorus (mg)	629.9 (313.4)	587.5 (360.5)	NS
Magnesium (mg)	115.5 (52.1)	115.8 (47.3)	NS
Zinc (mg)	1.2 (1.2)	2.0 (1.3)	NS

FFQ: MyUM Adolescent Food Frequency Questionnaire; 7DDH: Seven Days Diet History.
†Sign-rank test.
*Statistically significant at p-value <0.05, NS: Not significant

Table 7. Pearson's correlation for MyUM Adolescent FFQ estimates and 7DDH estimates (n=156)

Nutrient†	Unadjusted correlations	p-value	Energy-adjusted correlation‡	p-value
Energy (Kcal)	0.719	<0.05*	-	-
Protein (g)	0.490	<0.05*	0.535	<0.05*
Carbohydrate (g)	0.641	<0.05*	0.628	<0.05*
Total fat (g)	0.480	<0.05*	0.486	<0.05*
Cholesterol (mg)	0.340	<0.05*	0.260	<0.05*
Crude dietary fibre (g)	0.187	<0.05*	0.247	<0.05*
Total sugar (g)	0.178	<0.05*	0.210	<0.05*
Vitamin A (IU)	0.181	<0.05*	0.403	<0.05*
Beta-carotene (μg)	0.070	NS	0.013	NS
Vitamin C (mg)	0.256	<0.05*	0.110	NS
Vitamin E (IU)	0.226	<0.05*	0.220	<0.05*
Thiamin, B-1 (mg)	0.402	<0.05*	0.430	<0.05*
Riboflavin, B-2 (mg)	0.273	<0.05*	0.368	<0.05*
Niacin (mg)	0.363	<0.05*	0.397	<0.05*
Pyridoxine, B-6 (mg)	0.237	<0.05*	0.337	<0.05*
Folate (μg)	0.088	NS	0.255	<0.05*
Cobalamin, B-12 (μg)	0.077	NS	0.131	NS
Sodium (mg)	0.257	<0.05*	0.332	<0.05*
Potassium (mg)	0.352	<0.05*	0.413	<0.05*
Calcium (mg)	0.425	<0.05*	0.337	<0.05*
Iron (mg)	0.474	<0.05*	0.489	<0.05*
Phosphorus (mg)	0.367	<0.05*	0.499	<0.05*
Magnesium (mg)	0.394	<0.05*	0.314	<0.05*
Zinc (mg)	0.280	<0.05*	0.386	<0.05*

†All variables were log-transformed before analysis to improved normality.
‡Nutrients intake were adjusted for total energy intake by residual method.
*Correlation is significant at <0.05 (2-tailed), NS: Not significant

Although there was a decrease in correlation after energy adjustment in carbohydrate, vitamin C, vitamin E, calcium and magnesium, which may indicate a systematic error of overestimation or underestimation,[47] most of the nutrients, such as protein, cholesterol, crude dietary fibre, and other micronutrients improved correlation with energy adjustment. This may be due to the wide-range of food items listed in the MyUM Adolescent FFQ, taking into account multi-ethnic common food consumption and seasonal fruits as well as the use of household measure-

Table 8. Cross-classification of nutrient intake between MyUM Adolescent FFQ and 7DDH (n=156)

Nutrient	Same quartile (%)	Adjacent quartile (%)	One quartile apart (%)	Grossly misclassified (%)
Total energy (Kcal)	54.5	37.8	5.8	1.9
Protein (g)	43.6	41.0	12.8	2.6
Carbohydrate (g)	50.0	38.5	10.3	1.2
Total fat (g)	39.1	41.7	16.0	3.2
Cholesterol (mg)	32.0	43.6	15.4	9.0
Crude dietary fibre (g)	32.0	38.5	21.8	7.7
Total sugar (g)	33.3	39.1	17.9	9.6
Vitamin A (IU)	36.3	39.0	17.1	7.5
Beta-carotene (μg)	26.0	39.7	23.3	11.0
Vitamin C (mg)	26.2	42.1	24.1	7.6
Vitamin E (IU)	32.2	35.6	25.3	6.8
Thiamin, B-1 (mg)	30.1	47.3	19.2	3.4
Riboflavin, B-2 (mg)	32.2	40.4	22.6	4.8
Niacin (mg)	34.9	40.4	19.9	4.8
Pyridoxine, B-6 (mg)	30.1	42.5	19.2	8.2
Folate (μg)	26.0	40.4	24.7	8.9
Cobalamin, B-12 (μg)	28.1	39.0	21.2	11.6
Sodium (mg)	37.2	32.7	24.4	5.8
Potassium (mg)	32.1	42.9	19.2	5.8
Calcium (mg)	36.5	39.7	18.6	5.1
Iron (mg)	35.3	43.6	17.3	3.8
Phosphorus (mg)	35.3	42.3	17.3	5.1
Magnesium (mg)	35.3	44.9	15.4	4.5
Zinc (mg)	31.5	45.9	16.4	6.2

FFQ: MyUM Adolescent Food Frequency Questionnaire; 7DDH: Seven Days Diet History.
[†]All data based on unadjusted values.

ment utensils, frequency, and serving size options in the MyUM Adolescent FFQ. These enabled the near-precise estimation of nutrient intake among adolescents.[25]

The use of correlation analysis in assessing the validity of a questionnaire is often questioned because it measures the strength of association rather than agreement.[31,42] Hence, multiple statistical analysis (Bland-Altman plot and cross-classification) were used in the current study to show the strength of agreement of the proposed FFQ rather than using correlation analysis alone. The used of cross-classification and Bland-Altman plots showed that there was minimal systematic bias for most of the macro and micronutrient, which indicates good agreement, and shows that the MyUM Adolescent FFQ is comparable with other FFQs.[21,45,48,49]

It should be noted that the current study has some limitations. First, a general limitation that needs to be acknowledged is that tools of dietary assessment that rely on recall, such as MyUM Adolescent FFQ and 7DDH, may be subject to bias due to over- and underestimation. However, the 7DDH is one tool that can be used in the population studies to captured the foods that commonly consumed by Malaysian teenagers.[50] Based on this, the MyUM Adolescent FFQ was constructed. Furthermore, this limitation was minimised in the current study by the use of face-to-face interviews conducted by dietitians, assisted by colourful flip charts and household measurement utensils to overcome bias.[51] Additionally, to capture more representative data on nutrient intake, the allocation of greater number of days for diet recall or a diet record would be required, especially for micronutrients. A longer period of assessment is required for micronutrients because some of them are only present in certain food.[52] However, an FFQ can be used as a complementary dietary assessment tool and is able to capture the micronutrient intake and day-to-day variation, while reducing burdens on the subjects.[53] Thus, the MyUM Adolescent FFQ is a suitable tool to use to capture not only the habitual diet of Malaysian adolescents, but also to assess their micronutrient intake, which usually takes a greater number of days when using traditional diet record or diet recall methods.

In conclusion, this 200-item FFQ developed specifically for the Malaysian adolescent population demonstrates moderate to good comparative validity and therefore can be used to assess the diet of multi-ethnic adolescents in Malaysia. It can also be used to examine the diet – disease relationship in future epidemiological studies.

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