Short Communication

Validity and reproducibility of a food frequency questionnaire (FFQ) for dietary assessment in Malay adolescents in Malaysia

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Background: Food frequency questionnaire (FFQ) must be tailored to the target populations because dietary habits vary within the populations due to differences in cultural and lifestyles practices. Limited information is available to assess the validity of FFQ used among Malaysian adolescents. Objective: To construct the validity and reproducibility of a newly developed FFQ in assessing habitual nutrients intake over the past year of 170 Malay adolescent boys and girls in Kelantan, Malaysia. Methods: The FFQ that consisted of 124 food items was assessed, whereas three days of 24-hours dietary recalls (DR) was administered as the standard criteria method. Results: Estimated mean intake for most nutrients assessed by the FFQ were higher as compared to the three DRs (p<0.05). Pearson correlation coefficients for energy-adjusted nutrients intake between both methods were ranged from 0.22 (zinc) to 0.68 (calcium) with a median r-value of 0.43. The cross classification of quartile analysis showed that most nutrients were classified into the same or adjacent quartiles (median=52.7%). For the reproducibility of FFQ, the correlation of nutrients ranged from 0.43 for carotene to 0.86 for total fat intake (median=0.67), after adjusting for total energy intake. Conclusion: The newly developed dietary FFQ is a relatively good and valid tool in assessing habitual nutrients intake for the past year among Malay adolescents in Malaysia.

Key Words: Food frequency questionnaire (FFQ), 24-hours dietary recall, validity, reproducibility, adolescents

INTRODUCTION

It is well established that dietary factors play a pivotal role in promoting and maintaining good health and general well-being of the population. Assessment of dietary nutrient and eating pattern of children and adolescents have received greater attention due to increasing evidences showing the positive relationships between habitual dietary intakes during growing years and the risk of chronic diseases development in their current and adulthood life.[1,2] Moreover, rapid changes and alterations of eating behaviour is observed in growing years, which attributed to rapid physical growth spurts and influences from external peer and environment factors.[3,4] Therefore, such understanding of alterations in dietary nutrient patterns and behaviours in children and adolescents is of particular importance because eating pattern and behaviours established during these growing years could determine the quality of diet and health outcomes later in their life.[2,4]

Several dietary assessment methods such as weighing food record, 24-hour dietary recalls, dietary history record and food frequency questionnaire (FFQ) are used to assess dietary nutrients intake in epidemiological study settings, in which none of these methods has particularly high accuracy in assessing habitual dietary intake due to random and systematic measurement errors.[5] Although the weighed food record method has often been regarded as dietary criteria reference method for estimating the usual nutrient intakes, this methods is highly time consuming and requires high compliance from the participants, that often tends to cause under-reporting.[5,6] On the contrary, FFQ seems to be more practical to use in the epidemiological setting because it is relatively easy to use, inexpensive and able to collect reliable information on average nutrient intakes over an extended period with limited of resources.[5,7] Furthermore, formulation of the FFQ must be tailored to the target populations due to varying dietary practice habits across populations of different ethnicity, social, and cultural practices.[5,7,8] Therefore, designing of specific FFQ for target populations is particularly important in order to increase the accuracy and precision of the estimated nutrients intake over the defined study period, to assess the relationships of dietary nutrient factors on health and/or disease outcomes.[5,8] It is generally agreed that assessment of dietary nutrients intake in any population is often complicated by the difficulty of collecting accurate and reliable dietary information from participants,[8] whereby an additional dimension

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of difficulty is found in children and adolescents due to their limited cognitive and memory ability to recall the types of food consumed and the portion size served.[9]

To our best knowledge, there is no much published information pertaining to the validity and reproducibility of this FFQ method used in children and adolescents in Malaysia, despite of the two validation studies in adult and an elderly population.[10, 11] Therefore, the aim of the present study was to construct the validity and reproducibility of the newly developed dietary FFQ tool in assessing the habitual dietary intake over the past year among adolescent boys and girls of Malay origin in Kelantan, Malaysia.

PARTICIPANTS AND METHODS

Participants and study design

A total of 170 participants were recruited by random sampling of two secondary schools located in Kelantan, where each participant was required to undergo two different phases of the study. First, participants were required to complete a self-administrated FFQ and three 24-hour dietary recalls comprising of two weekdays and one weekend day. Second, they were asked again to complete another FFQ one week after the first FFQ was administered. All dietary assessments were conducted from early February until April in 2009. The study was approved by the Human Ethics Review Committee of the Universiti Sains Malaysia (USM) for human studies and written informed consent was obtained from both participants and parents or guardians prior to the study.

Dietary assessment methods -Development of the FFQ

The FFQ was developed based on the list of foods and beverages obtained from the dietary pilot study of 100 Malay adolescent boys and girls in Kelantan, whose were interviewed in person by trained nutritionist on common foods and beverages consumed in several consecutive days, namely school days and weekends for 2 months, from early October until the end of November in 2008. The detailed food and beverage items were taken throughout the day such as foods consumed in their school canteen, and outside from home were obtained. Moreover, additional information of typical foods consumed during snacking was also gathered, since snacking is commonly found practiced by adolescents in Malaysia.[12] All food items gathered from all participants were then categorised into 15 common food pattern groups namely, rice and noodle dishes, cereal and wheat-based food, meat and poultry, seafood and shellfish, milk and dairy products, egg, nut and legume, tuber, vegetables, fruits, local deserts *(kuih-muih)*, fast food, snack foods, spread and sauce, and beverages. In addition, some seasonal local fruits those are common, such as: durian, rambutan, mangosteen and mango were also included. At the end of the pilot study, a total of 124 food items were identified and included into the newly developed FFQ, which covers the most common foods consumed throughout the year due to its availability and accessibility all year round in Malaysia, except for some seasonal local fruits.

Participants were asked to recall the foods they consumed and then recorded their usual frequency of intake, as well as portion size served for each food items listed in the FFQ based on specific food item groups. During dietary assessment, a comprehensive list of food photos model and common household measures (plates, bowls and spoons of serving size) were used to help participants to quantify food items with the assistance of trained interviewers. A completed FFQ was then re-checked by the trained nutritionist for completeness and accuracy. Additional information were further obtained from participants to ensure that each participant understood each food items in the FFQ.

Three days of the 24-hour dietary recalls assessments

The 24-hours dietary recall method (DR) was used as a criteria reference method since it is considered as one of the best self-reported dietary assessment methods available in children and adolescents[13] and also because of its simplicity, and ease of administration compared to a weighed food record method for multiple days.[5,7] The DR method was administered for 3 days, consisted of two weekdays and one weekend day in order to minimise the day-to-day variability of an individual's dietary intake during school days and the weekend. Each participant was required to report detailed descriptions of any food and beverages consumed in the assigned day. Any incomplete or missing information was further verified and obtained from the participants by the interviewer.

Statistical analysis

The energy and all nutrients were calculated using the Nutrient Composition of Malaysian Foods.[14] Since there are several micronutrients that are unavailable in the Malaysian nutrient composition database; such as cholesterol, vitamin D, vitamin K, magnesium, zinc and folate, the content of these nutrients value were obtained from the USDA food composition database.[15] All the variables were tested for normality by the Kolmogorov-Smirnov test and test of homogeneity of variance before any statistical comparisons were made. Since almost all nutrient intakes were not normally distributed, all nutrients were then log transformed prior to further statistical analyses. Descriptive statistics of daily nutrients calculated from the FFQ and three DRs were presented as mean values ± SD, and any differences as mean ± SEM for all variables, unless otherwise indicated. Ratio of the FFQ to the three DRs was calculated as each nutrient derived from FFQ divided by each nutrient estimated from the three DRs. A bivariate analysis of the paired *t*-test was used to examine the differences of nutrient intakes estimated from both FFQ and the three DRs. The crude *Pearson* correlation coefficients test was used to determine the validity of this newly developed FFQ against the three DRs as criteria reference method, and correlation coefficients, adjusted for total energy intake by residual method,[5] was also computed. A cross-classification of quartiles analysis was used to determine the percentage of participants correctly classified in terms of nutrients intake into quartile categories, based on the distribution data for both newly developed FFQ and the three DR. Extreme quartile was defined as when the mean nutrient intake was categorised into opposite quartiles by the two methods (ie difference within more than two quartiles). All Statistical analysis was performed using the SPSS for windows version 18.0

and statistical significance for all the tests was defined at *p*-value <0.05.

RESULTS

Nutrients intake from the FFQ and three DRs

A total of 170 Malay adolescents, comprising of 85 boys and 85 girls completed both the FFQ and the three DRs. Table 1 shows the estimated nutrients intake accessed by both FFQ and DRs. In general, nutrient intake estimated by the FFQ showed slightly higher values than that from the three DRs, ratio of the FFQ to DRs were almost similar for total energy, carbohydrates, fat, iron, magnesium, potassium, sodium, retinol, vitamin A, niacin, vitamin C and folate. Crude correlation coefficients values for macronutrients ranged from 0.46 for protein to 0.64 for fat, and for micronutrient were ranged from 0.17 for zinc to 0.67 for calcium, with a median *r*-value of 0.38 (Table 2). However, the *r*-values of the correlation coefficients for most nutrient intakes between the methods slightly improved to an overall median *r*-value of 0.43, when energy-adjusted correlation analysis of nutrients was computed. In general, agreement between all macronutrients based on the *Pearson* correlation coefficients was relatively good with all *r*-values of >0.50; and for the micronutrients, a relatively moderate to good estimates of micronutrients assessed (energy-adjusted *r*-value >0.35), was obtained for the FFQ when compared to the reference dietary method, except for zinc, niacin, folate and fibre. Quartile categorisation of nutrient distribution used to examine the agreement of all nutrients intake in the cross-classification of participants between the FFQ and DRs are presented in Table 3. On average, the exact agreement for the macronutrients ranged from 51.1% to 75.3%, and that for micronutrients ranged from 48.3% to 69.4%, with the median percentage of 52.7%. On the contrary, misclassifications in opposite extreme quartiles were found to be high in phosphorus, zinc, vitamins B-1, B-2, niacin, folate and fibre, ranging from 4.7% to 10.4%.

The reproducibility of the newly developed FFQ tool was assessed using the *Pearson* correlation coefficient after an one-week interval The crude *Pearson* correlation coefficients values for macronutrients ranged from 0.59 for protein to 0.85 for fat; and for micronutrients, it ranged from 0.40 for carotene to 0.79 for magnesium, with an overall median *r*-value of 0.64. However, the correlation coefficients *r*-values improved significantly for both macronutrients and micronutrients intake when these nutrients were adjusted for total energy intake (*r*-value 0.63 for protein to 0.86 for fat, and from 0.43 for β-carotene to 0.83 for magnesium, respectively). In general, the agreement between all nutrients estimated by both FFQ administered 1-week apart showed a satisfactory agreement with the correlation *r*-value for all nutrients found to be more than 0.30.

Table 1. Estimated daily nutrients intake assessed by food frequency questionnaire (FFQ) and 3 days 24-hour dietary recalls (DRs) among Malay school-aged adolescents in Kelantan

	FFQ		3 days DR		FFQ/3 days DR ratio
	Mean±SD[†]	Median (95% CI)[‡]	Mean±SD	Median (95% CI)	Mean±SD
Energy (kcal)[§]	1964±442	1926 (1005-2774)	1930±428	1944 (1019-2718)[*]	1.0±0.1
CHO (g)[§]	220±59	217 (102-348)	216±71	219 (110-348)[*]	1.1±0.3
Protein (g)[§]	72.9±20.8	74.0 (32.3-107)	71.8±17.3	71.7 (23.8-105)	2.7±7.6
Fat (g)[§]	99.7±15.2	97.2 (70.0-121)	97.0±13.4	99.5 (70.2-120)[*]	1.0±0.3
Ca (mg)[§]	379±131	380 (118-597)	268±131	233 (102-590)[*]	1.6±0.7
Fe (mg)[§]	15.0±2.6	15.2 (10.2-19.6)	14.9±2.6	14.9 (10.0-20.9)	1.0±0.2
Mg (mg)[††]	241±89	240 (100-390)	219±75	235 (101-378)[*]	1.1±0.2
Phosphorus (mg)[§]	450±244	415 (104-890)	526±240	521 (111-983)[*]	1.1±0.9
Potassium (mg)[§]	390±192	377 (102-790)	470±243	454 (102-991)[*]	1.1±0.9
Na (mg)[§]	414±207	368 (110-882)	478±247	417 (100-992)[*]	1.1±0.9
Zn (mg)[††]	6.9±4.3	5.7 (1.0-19.7)	3.6±2.5	2.8 (0.75-8.8)[*]	3.2±3.3
Cu (mg)[††]	0.5±0.3	0.4 (0.1-1.4)	0.3±0.2	0.2 (0.01-1.0)[*]	3.4±3.0
Retinol (μg)[§]	1547±336	1483 (1016-2176)	1426±358	1398 (699-2149)[*]	1.1±0.3
Carotene (μg)[§]	1547±332	1515 (1011-2186)	1221±394	1193 (623-2186)[*]	1.4±0.5
RE (μg)[§]	1675±324	1620 (1186-2326)	1528±362	1503 (793-2326)[*]	1.2±0.3
Vitamin B-1 (mg)[§]	1.0±0.7	0.9 (0.2-4.9)	0.3±0.3	0.2 (0.1-0.9)[*]	7.3±11.2
Vitamin B-2 (mg)[§]	1.4±0.7	1.2 (0.3-3.4)	0.4±0.3	0.3 (0.01-1.6)[*]	7.0±9.3
Niacin (mg)[§]	15.9±3.3	16.0 (10.1-22.9)	12.6±1.8	12.0 (10.1-18.3)[*]	1.3±0.3
Vitamin C (mg)[§]	101±59	87 (24-242)	76±26	75 (30-119)[*]	1.4±0.9
Folate (μg)[††]	147±77	126 (50-343)	128±59	113 (50-219)[*]	1.4±1.1
Vitamin D (μg)[††]	0.5±0.4	0.3 (0.1-3.2)	0.3±0.3	0.2 (0.0-1.0)[*]	1.6±1.3
Vitamin K (μg)[††]	4.2±2.5	3.6 (0.1-9.8)	3.2±2.3	2.7 (0.0-9.9)[*]	1.7±1.4
Fibre (g)[§]	3.8±2.4	3.0 (1.0-9.7)	3.4±2.3	2.8 (0.0-11.9)	2.7±7.6
Cholesterol (mg)[††]	231±75	220 (104-398)	201±69	199 (109-359)[*]	1.2±0.4

[†]SD - standard deviations [‡]CI - confidence interval
[§]Nutrient intake was analysed by Malaysian nutrient composition database
[††]Nutrient intake was analysed by USDA food database
[*]Significantly different from the value of the FFQ: Paired t-test on log transformed values, $p<0.05$

Table 2. Validity and reproducibility of food frequency questionnaire (FFQ) by Pearson correlation coefficients in Malay school-aged adolescents in Kelantan[†]

	FFQ *vs.* three 24-hour dietary recalls		1st FFQ *vs.* 2nd FFQ	
	r		*r*	
	Unadjusted	Energy-adjusted	Unadjusted	Energy-adjusted
Energy (kcal)	0.50**	-	0.70**	-
CHO (g)	0.54**	0.58**	0.77**	0.79**
Protein (g)	0.46**	0.49**	0.59**	0.63**
Fat (g)	0.64**	0.64**	0.85**	0.86**
Ca (mg)	0.67**	0.68**	0.67**	0.79**
Fe (mg)	0.62**	0.65**	0.65**	0.65**
Mg (mg)	0.66**	0.66**	0.79**	0.83**
Phosphorus (mg)	0.33**	0.36**	0.74**	0.74**
Potassium (mg)	0.38**	0.40**	0.66**	0.67**
Na (mg)	0.37**	0.43**	0.46**	0.54**
Zn (mg)	0.17	0.22**	0.71**	0.71**
Cu (mg)	0.35**	0.40**	0.59**	0.61**
Retinol (µg)	0.34**	0.37**	0.44**	0.46**
Carotene (µg)	0.35**	0.45**	0.40**	0.43**
RE (µg)	0.34**	0.35**	0.44**	0.44**
Vitamin B-1 (mg)	0.23**	0.35**	0.75**	0.79**
Vitamin B-2 (mg)	0.22**	0.35**	0.59**	0.59**
Niacin (mg)	0.18**	0.27**	0.64**	0.64**
Vitamin C (mg)	0.39**	0.47**	0.59**	0.69**
Folate (µg)	0.19	0.27**	0.55**	0.56**
Vitamin D (µg)	0.49**	0.54**	0.64**	0.71**
Vitamin K (µg)	0.47**	0.49**	0.61**	0.69**
Fibre (g)	0.18	0.29**	0.60**	0.67**
Cholesterol (mg)	0.51**	0.51**	0.79**	0.79**
Median	0.38	0.43	0.64	0.67

[†]All data based on log-transformed values
** Correlation is significant at the 0.01 level (2-tailed)

Table 3. Cross classification of quartiles by 124 food items listed food frequency questionnaire (FFQ) and three 24-hour dietary recalls (DRs) in Malay school-aged adolescents in Kelantan[†]

	FFQ/ DRs		
	% in the same quartile[‡]	% in adjacent quartiles[§]	% in extreme quartiles[††]
Energy (kcal)	68.3	31.1	0.6
CHO (g)	51.1	47.9	1.0
Protein (g)	59.2	38.0	2.8
Fat (g)	75.3	24.6	0.1
Ca (mg)	52.4	44.7	2.9
Fe (mg)	68.2	28.1	3.7
Mg (mg)	56.4	42.4	1.2
Phosphorus (mg)	69.4	25.9	4.7
Potassium (mg)	64.1	32.9	3.0
Na (mg)	48.8	48.3	2.9
Zn (mg)	60.0	29.4	10.4
Cu (mg)	49.3	47.0	3.7
Retinol (µg)	51.2	44.8	4.0
Carotene (µg)	52.9	43.0	4.1
RE (µg)	50.1	46.5	3.4
Vitamin B-1 (mg)	50.8	44.7	4.5
Vitamin B-2 (mg)	48.5	47.0	4.5
Niacin (mg)	48.8	43.0	8.2
Vitamin C (mg)	57.3	39.2	3.5
Folate (µg)	50.6	40.2	9.2
Vitamin D (µg)	48.3	49.3	2.4
Vitamin K (µg)	51.7	45.6	2.8
Fibre (g)	67.0	23.0	10.0
Cholesterol (mg)	60.0	37.4	3.7
Median	52.7	42.7	3.6

[†]All data based on log-transformed, unadjusted intake values
[‡]The two methods categorised nutrient intake into the same quartile
[§]The two methods categorised nutrient intake into adjacent quartiles (difference within two quartiles)
[††]T he two methods categorised nutrient intake into extreme quartiles (difference within more than two quartiles)

DISCUSSION

A FFQ for adolescents, which compromised of 124 food items have been developed as a dietary tool to estimate the habitual dietary intake over the past year. When comparing individual nutrients intake, the mean nutrient values from this newly developed FFQ was slightly higher than that obtained with the three DRs. The correlation coefficients between the newly developed FFQ and the DRs varied considerably between nutrients after adjusted for total energy intake, which ranged from 0.49 to 0.64 for macronutrients and 0.22 to 0.68 for micronutrients. In addition, reasonably good agreement was found between test-retest of the newly developed FFQ tool, which ranged between 0.63 to 0.86 for macronutrients, and between 0.43 to 0.83 for vitamins and minerals.

The present study showed that nutrients intake estimated from the FFQ was slightly higher than that from the three DRs, which is in line with other studies carried-out in adolescents of similar age, irrespective of the days of assessment.[16,17] The mean ratio of FFQ to the DRs for most nutrients intake ranged from 1.0 for energy to 7.3 for vitamin B-1, suggesting that the difference of most nutrient calculated from both dietary methods were small. The validity of the newly developed FFQ was further examined by comparing the estimated intake values of all nutrients from the FFQ against the three DRs. Significant correlations for all macronutrients such as total energy (r=0.50), carbohydrate (r=0.54), protein (r=0.46) and fat (r=0.64) were found, suggesting that the FFQ provides good estimates of macronutrients as compared with the dietary reference method used. These associations are consistent with several studies carried-out in adolescent populations.[18-21] In terms of micronutrients intake, the correlation values between both dietary methods were found to be moderate to good ($r \geq 0.35$), when energy-adjusted nutrients value were computed, which ranges from 0.35 to 0.68. In contrast, low correlation was found for zinc, niacin, folate and fibre. Such low correlation coefficient values of these micronutrients are also comparable with two studies carried-out among Australian and Japanese adolescents,[23] but the present findings were lower than that of several studies reported in adolescents.[16,18,19] Low correlation found in the present study for these micronutrients could be due to low intakes of vegetables and fruits in the present population, as both food groups are regarded as major contributing sources of folate and fibre. Another possible explanation of such discrepancy is differences in the dietary food assessment methods used, population characteristics and dietary food characteristics included in the FFQ. On the other hand, calcium was found to have the highest correlation r-value (0.68) compared with other micronutrients. Higher correlation values found in the present study for macronutrients and most micronutrients could be the result of the comprehensive list of food items used in this FFQ that took into account the seasonal food availability and festival seasons throughout the year, as well as the use of food models and standard household measures.[24] Cross-classification of nutrients into quartiles showed on average, 56.7% of the participants were classified correctly into same quartiles, whereas only 4.1% of participants were misclassified at the extreme quartiles, suggesting that the newly developed FFQ is considerably acceptable due to its ability to rank participants according to the macronutrients and micronutrients intake.

In adolescents, long time intervals may results in changes in dietary habits, short time intervals may influence the responses by repeating same answer from the questionnaire. In this study, an one-week interval was chosen and the correlation coefficients ranged from 0.43 for carotene to 0.86 for fat. The present findings were comparable to the study by Vereecken and colleagues[21] using the same time interval and a study by Hong and his-coworkers[19] at a longer time interval of 6 months.

Limitations of this present dietary validation study need to be acknowledged. Firstly, we used the Malaysia Nutrient Composition database for most nutrients calculations; however, due to limited information on certain micronutrients of interests, we used the USDA food composition database for these specific micronutrients. This may cause over and/ or under-estimating for these micronutrients values. However, in order to avoid the variations due to the differences in nutrients value from both food composition databases, calculation of nutrients for food items for most mixed dishes were based on the ingredients used in the food recipe. Secondly, the present dietary validation study was examined in Malay adolescents, therefore, the present findings can not be generalise to adolescents of a different ethnicity in Malaysia. On the contrary, the present study has several strengths, which include a comprehensive food item list obtained from the dietary pilot study that took into account several factors such as common food items consumed based on seasonal availability and festival seasons throughout the year. In addition, food items consumed during other times, such as snacking and eating out from home were also included. Secondly, the use of food model photographs and common household measures for each food items would help to improve the accuracy of the participants' recall, because it is generally agreed that children and adolescents tend to be limited in estimating the type and amount of food consumed.[26] Lastly, the present validation study had a large sample size. In conclusion, the newly developed FFQ provides a considerably good and valid estimate of habitual nutrients intake for the past year among Malay adolescent boys and girls in Kelantan, Malaysia.

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AUTHORS DISCLOSURE

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Short Communication

Validity and reproducibility of a Food Frequency Questionnaire (FFQ) for dietary assessment in Malay adolescents in Malaysia

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馬來西亞的馬來青少年膳食評估的飲食頻率問卷效度及信度

背景：由於文化及生活習慣的差異，使得族群間的飲食習慣多樣化，因此飲食頻率問卷必須設計至適用於目標族群。很少研究評估馬來西亞青少年的飲食頻率問卷之效度。目的：以新發展的飲食頻率問卷評估 170 名馬來西亞吉蘭丹州(Kelantan)的馬來青少年過去一年的慣常營養素攝取量，並建構其效度及信度。方法：評估由 124 個食物項目組成的飲食頻率問卷，並以三天 24 小時飲食紀錄當作黃金標準。結果：以飲食頻率問卷估算的大部分營養素平均攝取量高於三天的飲食紀錄(p<0.05)。兩者的熱量校正營養素攝取量，皮爾森積差相關係數範圍從 0.22(鋅)到 0.68(鈣)，中位數 r 值為 0.43。以四分位分組分析顯示，大部分的營養素被分類到同一組或相鄰組別(中位數=52.7%)。飲食頻率問卷的信度，在校正總熱量攝取量後，營養素相關性範圍從胡蘿蔔素的 0.43 到總脂肪攝取的 0.86(中位數=0.67)。總結：評估馬來西亞的馬來青少年過去一年的日常營養素攝取量，這個新發展的飲食頻率問卷是一個相當良好且有效的工具。

關鍵字：飲食頻率問卷(FFQ)、24 小時飲食紀錄、效度、信度、青少年