Developing and validating a version of the food frequency questionnaire for young adults in a public university in Malaysia

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Running title: Food frequency questionnaire for youths

Maisarah Ghazali MD, MPH and Zaleha Md Isa PhD

Department of Public Health Medicine, Faculty of Medicine, Universiti Kebangsaan Malaysia Medical Centre, Kuala Lumpur, Malaysia

Corresponding Author: Prof. Zaleha Md Isa, Department of Public Health Medicine, Faculty of Medicine, Universiti Kebangsaan Malaysia Medical Centre, Jalan Yaacob Latif, Bandar Tun Razak, Cheras, 56000 Kuala Lumpur, Malaysia. Tel:. Email: zms@ppukm.ukm.edu.my

ABSTRACT

Background and Objectives: Epidemiological studies often use the food frequency questionnaire (FFQ) to predict the food consumption habits of a target group and subsequently promote healthy eating in the group. In the present study, a version of the FFQ for Malaysian young adults aged 18–24 years was designed and validated. **Methods and Study Design:** This study comprised development and validation phases. In the development phase, 129 young adults from a public university in Klang Valley completed a 3-day food record (3DFR), and the data were used to create a food list for the FFQ. Two weeks later, in the validation phase, another 100 participants recruited from the same university completed the 3DFR and a newly developed FFQ for assessing consumption of 38 food items. Finally, the data obtained from the FFQ and 3DFR were used to analyze the nutrient intake of each participant, and the developed FFQ was validated using Spearman correlation coefficients (r) and Bland–Altman methods. **Results:** For the development phase, 38 food items were determined to contribute to 90% of the participants' total energy and macronutrient intake, and these items were included on the FFQ. For the validation phase, the average Spearman correlation coefficient for energy and all nutrients was 0.43, which indicated good agreement between the 3DFR and FFQ. Cross-classification analysis of the 3DFR and FFQ results revealed that 79% of the young adults were classified into similar or neighboring quartiles when each set of results was used. The Bland–Altman plots revealed that the results obtained using the two methods were parallel. **Conclusions:** The FFQ is a simple and validated tool that can be self-administered to young adults to assess their energy and nutrient consumption.

Key Words: Food frequency questionnaire (FFQ), 3-day food record (3DFR), validation, young adults, Malaysia

INTRODUCTION

According to the United Nations, young adults comprise the segment of the population aged between 15 and 24 years, with young adulthood being the liminal period between the life stage of childhood, during which an individual is generally dependent, and the life stage of adulthood, during which an individual is generally independent.[1] Young adults entering the independent stage of life are prone to developing unhealthy dietary habits, which can lead to overweight or obesity.[2] Such adults tend to eat an excessive amount of fast food and snacks that are high in calories and low in nutrient density and to eat an insufficient amount of healthy foods, such as fruits and vegetables.[3,4] In addition, young adults tend to be more easily influenced by and sensitive to peer influence of pressure than other adult age groups are, particularly with respect to their health behaviors.[5] Because of their poor eating habits and higher susceptibility to the influence of peers, being able to assess the food consumption habits of young adults is crucial. Overweight and obesity have become increasingly prevalent in young adults worldwide, with this prevalence being particularly notable in college students.[6] This problem has become notable in developing countries, such as China (2.9%) and Egypt (59.4%),[6] and a study involving university students in Malaysia revealed that 14.31% of the included students had overweight and 10.13% had obesity.[7]

For programs targeting nutrition, food, and health to be effectively implemented, dietary assessment of the target population must be completed. Several tools can be used to complete a dietary assessment for a particular population within a specified period. Such tools include the FFQ, which is used to measure daily consumption of food items or food groups;[8] 24-h dietary recall; and dietary records. Dietary assessment tools are typically selected based on study objectives, participant characteristics, the respondent burden, and available resources. The FFQ is commonly used in clinical and epidemiological studies to estimate the regularity and amount of food consumption.[9] The FFQ is typically used in large-scale epidemiological research because of its practicality and cost-effectiveness.[10] This instrument can be used to capture long-term food intake within a single administration and does not require the use of highly trained interviewers. Because each population's eating habits vary with its culture, demographic characteristics, food supply, and socioeconomic factors, the FFQ should be substantiated using data from the population of interest to ensure the reliability and accuracy of study outcomes.[11]

In the present study, an FFQ was designed and verified to enable evaluation of the food consumption habits of Malaysian young adults aged 18 to 24 years of multiple ethnicities. Malaysia's population is composed of multiple ethnic groups, with the main groups being Malay, Chinese, and Indian. Each group has a unique culture and distinct set of dietary habits.[12] No FFQ has yet been established for dietary assessment of Malaysian young adults. Therefore, the present study was conducted to fill this gap in the literature. This study also details its process for developing and validating the FFQ to ensure its replicability in future large-scale and longitudinal nutritional studies.

MATERIALS AND METHODS

Study design and sampling

This cross-sectional study recruited Malaysian undergraduate students studying at a public university in the State of Selangor, Malaysia. The participants were aged 18 to 24 years. Convenience sampling was used to recruit students of Malay, Chinese, Indian, and other minority descent to participate in the development and validation phases of the study. This study used two means difference to calculate the required sample size,[13] with the standard deviation being determined with reference to a previous study conducted in Malaysia.[14] The results revealed that to achieve a power of 80% and a level of two-tailed significance of 0.05, at least 100 participants would be required.

This study collected data between December 2021 and February 2022. During this period, most of the students were taking online classes at home due to the COVID-19 pandemic. Online data collection was conducted because the students were physically located in different places around Malaysia. The inclusion criteria for this study were being an undergraduate student at the National University of Malaysia, being aged 18–24 years, and having Malaysian citizenship.

Ethical approval

Approval for the present study was granted by the Research and Ethics Committee of the National University of Malaysia (JEP-2020-726). Before data were collected, informed consent was obtained from the participants.

FFQ development

The FFQ development process comprised three steps: (1) establishing a food list based on data obtained from a pilot 3DFR study; (2) classifying and shortlisting the food items from the records, and (3) identifying the consumption prevalence and ratios of the foods. 3DFR was selected over 24-hour dietary recall because it is less reliant on memory. First, a Google form containing 3DFR was sent to the student or personal email accounts of 200 students. The students were asked to record their dietary consumption over 24 hours for 3 days (2 weekdays and 1 weekend day). They were asked to list all the foods and beverages they consumed on that particular day; the quantity of the foods and beverages they had consumed, with the quantity measured using common household measurements, such as a cup (250 mL), a tablespoon (15 mL), and a small bowl (250 mL); and the method that had been used to cook the food, such as frying, steaming, or grilling. They independently recorded their dietary intake and subsequently completed a Google form after they had completed a food record for 3 days. Of the 200 students who received the email, 143 submitted the Google forms. After the inclusion criteria were applied, the responses of only 129 students were retained and included in the development phase.

The students had a mean age of 23 ± 1 years; 51.9% were women, and 69.8% were of Malay ethnicity. The mean body mass index (BMI) was 22.8kg/m^2. Initially, this study identified 112 food items. The items were divided into 13 groups: (a) fruits, (b) cereals and cereal products, (c) seafood and fish, (d) fast food, (e) milk and dairy products, (f) seasonings and flavorings, (g) meats and meat products, (h) legumes and legume products, (i) eggs, (j) vegetables, (k) sweets, (l) beverages, and (m) spreads. Each food item's nutritional information was obtained, and the total energy and macronutrients were summed. Meals accounting for ≥90% of total energy and macronutrient intake were included in the FFQ.15 The frequency with which each food item was consumed was categorized as follows: (a) never, (b) one to three times per month, (c) one time per week, (d) two to four times per week, (e) five to six times per week, (f) once per day, (g) two to three times per day, and (h) four or more times per day. Additionally, this study categorized the portion size of each consumed food item by using the Malaysian Adult Nutrition Survey system of classification, with the size categorized as a cup, a slice, a piece, matchbox size, a tablespoon, and a teaspoon.16

FFQ validation

Validation was completed using two main steps: 1) 3DFR collection and 2) FFQ administration. At this phase, the 3DFR and FFQ were administered to 115 undergraduate students aged 18 to 24 years who did not participate in the development phase. First, the students recorded their dietary intake on a Google form similar to that used in the development phase. Two weeks later, they were asked to complete the newly developed FFQ, which was used to evaluate how frequently they had consumed certain foods during the previous month. They received instructions regarding how they should complete the FFQ; they were asked to evaluate their usual frequency (e.g., once per week or once per day) of consuming each food item over the previous month. They were asked to then estimate the size of the portion (e.g., 2 cups or 3 pieces) of a given food they consumed in a single meal. The 3DFR and FFQ were completed 2 weeks apart as a means of minimizing the occurrence of discrepancies in the findings regarding the students' dietary intake patterns obtained using the two methods. To ensure the validity of the collected dietary data, students who reported implausible energy intakes on the 3DFR or FFQ (i.e., <800 or $>4,000$ kcal/day for male students and <500 or >3,500 kcal/day for female students) were excluded from the study (n = 15).[9] The students' sociodemographic data, including their age, sex, and ethnicity, were obtained during 3DFR collection, and BMI was calculated using the students' self-reported body weight and height. In this phase, 22% of the included students were considered overweight or obese, 19% were considered underweight, and the rest were considered to have a normal BMI.

Statistical analysis

The 3DFR and FFQ data were used to determine the students' energy intake and intake of protein, carbohydrates, fat, vitamin C, dietary fiber, iron, sodium, vitamin B-2, calcium, potassium, phosphorus, vitamin B-1, niacin, retinol, cholesterol, trans fat, sugar, and zinc. Nutrient values were obtained from the Malaysian Food Composition Database and were analyzed using Nutritionist Pro software from Axxya Systems (Stafford, TX, USA).[17] The students' daily consumption was calculated using data from the FFQ by applying the following equation: intake frequency (conversion factor) × serving size × total number of servings × weight of food per serving. Table 1 presents the conversion factors used to predict dietary consumption with the amount of food intake. Nutrient consumption calculated using the FFQ was compared with the data of the 3DFR to assess the validity of the FFQ.

The normality of the data was assessed using the Kolmogorov–Smirnov test, with the results used to select a suitable method for analysis. Because the data for most nutrients did not have a normal distribution, the validity assessment was completed using Spearman's correlation coefficients. In addition, this study compared the predictions of the participants' nutrient intake obtained using the FFQ and 3DFR by applying the Wilcoxon signed-rank test. Subsequently, a cross-classification analysis was performed to assess the level of agreement between the FFQ and 3DFR results and the accuracy of student classification based on food consumption. First, information derived from the FFQ and 3DFR regarding energy, macronutrient, and micronutrient intake were categorized into quartiles. The results obtained using the FFQ and 3DFR data were then divided into the following categories: 1) same quartile, 2) adjacent (± 1) quartile, or 3) misclassified. Average correlation coefficients were calculated for energy, macronutrients, and micronutrients; energy and macronutrients; and micronutrients by using the sum of the correlation coefficients divided by the number of items (energy and nutrients).

Last, the agreement level between the FFQ and 3DFR results across nutrient intakes was determined using Bland–Altman analysis by considering the mean difference and a limit of

95%. The Bland–Altman plots were interpreted in accordance with the recommendation of Tang:[18] 1) good agreement means the difference in values between the test and reference measurements is ±1 SD of the average nutrient intake determined using the reference method; 2) fairly good agreement means the difference between the test and reference measurements is ±2 SDs of the average nutrient intake determined using the reference method; and 3) poor agreement means the difference between the test and reference measurements is ±3 SDs of the average nutrient intake determined using the reference method. According to the Bland–Altman plots of this study, the measurements for all nutrients exhibited fairly good agreement, and the nutrient intake plots were consistent with the energy intake plot. SPSS (version 22; IBM, Armonk, NY, USA) was used to complete all statistical analyses.

RESULTS

The results reveal that 23 of the food items that were included on the FFQ contributed up to 90% of total energy; furthermore, 17, 20, and 19 food items respectively contributed up to 90% of the carbohydrate, fat, and protein (Table 2).

Table 3 presents the descriptive data from the validation study (N = 100). Most students in the study were women (53%), and the mean age was 23 ± 1 years. Most students were of Malay descent (67%), followed by Chinese (25%); Indian (5%); and Bumiputra, an ethnic group from Sabah and Sarawak (3%). The ratio for ethnicity was imbalanced because most of the students that attend the university are of Malay descent. The students' mean BMI was 22.4 ± 5.0 kg/m^2 (Table 3). According to the data presented in Table 4, when the FFQ data were used, 14 out of 18 nutrient median intake values were overestimated, whereas the median energy and intake values for four nutrients (i.e., total fat, dietary fiber, calcium, and sodium) were underestimated. Furthermore, regarding the correlations between the FFQ and 3DFR results, the energy intake results were significantly correlated with the macronutrient and micronutrient results, excluding those for vitamin C and trans-fat. The correlation was strongest for total energy (r = 0.94), total carbohydrates (r = 0.76), total fat (r = 0.76), and total protein (r = 0.64).

The results of a cross-classification analysis of FFQ and 3DFR are presented in Table 5. The results of 79% of the students were classified into similar or neighboring quartiles; 40% were classified into the same quartile, whereas 5.3% were placed in opposite quartiles, with opposite quartile referring to the students' results being classified into the highest quartile when the FFQ results were used (Q4) and the lowest quartile (Q1) when the 3DFR results were used, or vice versa.

Figure 1 presents an example of a Bland–Altman plot for energy intake. The plot illustrates the level of agreement between the results obtained using the FFQ and those obtained using the 3DFR, with individual differences in the results plotted against mean values for the selected parameters. The differences in the total consumption of energy and nutrients between the methods were similar and distributed equally. Moreover, the plotted points were concentrated within the 95% limit of agreement. In the plots, values that are positive and negative respectively indicate overreporting and underreporting of the FFQ.

DISCUSSION

At the time of writing, no study has developed a version of the FFQ suitable for assessing dietary intake among Malaysian young adults, including undergraduate students, although several versions of the FFQ have been developed to evaluate the food consumption trends among children,[14] adolescents,[19] multi-ethnic working adults,[12] and pregnant women.[20] Thus, the FFQ developed in the present study could enable future researchers to conduct dietary assessments for multi-ethnic young adults, particularly undergraduate students, in Malaysia.

The final FFQ in this study can be used to assesses consumption of 38 items of food classified into 11 groups. The number of items included on the FFQ of this study is much lower than that of those on versions of the FFQ developed for young adult or adult populations in other countries, which include between 135 and 195 items.[21,22,23] The number of participants involved in the FFQ development process in previous studies has generally ranged from 95 to 120,[21,22] which is comparable to the number included in the present study. The considerable difference in the number of included food items may be attributable to the method of food categorization that was employed. This study categorized foods based on the Malaysian Adult Nutrition Survey,[16] which mostly includes raw foods.

Regarding the validation phase of this study, the newly developed FFQ overestimated 14 out of 18 nutrients. A similar result was obtained in a previous study including female undergraduate students with the mean age of 20.1 years; the study results revealed that the developed FFQ overestimated 14 out of 24 nutrients when the results were compared with those obtained using 5-day food records.[21] Underreporting in food records and overreporting on the FFQ are common.[12,20] With respect to dietary variation that may have led to underestimation or overestimation of energy or nutrient intake, the food consumption habits of Malaysian people generally do not exhibit seasonal variation. Although Malaysian people consume several seasonal foods during festivals, these foods are not part of a typical Malaysian diet.[12] The present study results regarding the average correlation coefficient for all nutrients and energy intake (r = 0.43) was consistent with those of earlier studies.[24,25,26] The results revealed that the mean correlation coefficient for macronutrients (r = 0.50) was higher than that for micronutrients (r = 0.39), which is likely due to vitamin C having low correlation coefficients. Previous studies have reported that macronutrient correlation coefficients tend to be higher than those of certain micronutrients.[26,27]

According to the cross-classification analysis of this study, the FFQ accurately classified 56% (trans-fat) to 97% (energy) of the students' nutrient intake into the same or adjacent quartiles as the 3DFR did. The FFQ and 3DFR accurately classified an average of 40% of the students' nutrient intake into the same quartile, which is comparable to the 34% accuracy reported in another study.[21] By contrast, the FFQ misclassified between 0% (energy and carbohydrates) and 22% (trans fat) of the students' intake. The FFQ also generally correctly classified the students' intake into similar or neighboring quartiles, with <6% being misclassified. These results indicate that the FFQ and 3DR had good agreement.

Validation studies often use both correlation coefficients and Bland–Altman analysis, and such analysis is recommended for assessing the FFQ's absolute validity.[28] In the current study, all 19 Bland–Altman plots for energy and nutrients revealed no notable systematic bias in the mean intake results of the FFQ and 3DFR. At least 92% of the data points fell within ±2 SDs. The nutrients with the most data points falling outside of ±2 SDs, that is, with 8 points each falling outside, were vitamin C and niacin. Overall, the Bland–Alman plots indicated that the FFQ and 3DFR had good agreement.[23]

This study has several limitations. First, the Malaysian Food Composition Database that was used as a reference in this study does not contain up-to-date or complete information for some micronutrients, such as trans-fat. This may have led to errors in the FFQ and 3DFR measurements. When data on certain nutrients were not available on the Malaysian Food Composition Database, the Energy and Nutrient Composition Database of Singapore was used.[29] Second, the students of this study may not be representative of the general young adult population in Malaysia because of their educational background and high motivation to complete the 3DFR and FFQ. Future studies might include young adult populations from different sociodemographic backgrounds to ensure their results can be generalized to the general Malaysian young adult population. Finally, 3DFR data is self-reported; because of problems such as inaccurate reporting of serving sizes or food items not being declared, such data are often unreported. In the present study, to overcome this limitation, the students were provided with clear and specific instructions when they were given the 3DFR form. The present study also has a key strength: this study used 3DFR rather than 24-hour diet recall as a reference method. Because the 3DFR can be used to directly predict meal sizes and does not rely on memory, this study was able to minimize recall bias in its validation of the FFQ.[19]

Conclusion

The FFQ that was developed and validated in this study may be useful for predicting relative energy, macronutrient, and micronutrient intake among Malaysian young adults, particularly university students. This tool is efficient, economical, and has a small respondent burden, which makes it suitable for the target population. This FFQ can be used to track the dietary intake and patterns of food consumption among young adults and can serve as a guide for establishing effective, evidence-based public health strategies to combat cardiovascular disease and obesity. Nevertheless, further studies should be conducted to investigate whether the FFQ developed in this study can be used on a larger scale and applied for the overall young adult population in Malaysia.

CONFLICT OF INTEREST AND FUNDING DISCLOSURE

The authors declare no conflict of interest.

REFERENCES

1. 1. Definition of Youth: United Nations Department of Economic and Social Affairs (UNDESA); [Available from: https://www.un.org/en/global-issues/youth.
2. Poobalan A, Aucott L. Obesity Among Young Adults in Developing Countries: A Systematic Overview. Curr Obes Rep. 2016;5(1):2-13.
3. Bauer KW, Larson NI, Nelson MC, Story M, Neumark-Sztainer D. Fast food intake among adolescents: Secular and longitudinal trends from 1999 to 2004. Preventive Medicine. 2009;48(3):284–7.
4. Larson NI, Neumark-Sztainer D, Hannan PJ, Story M. Trends in adolescent fruit and vegetable consumption, 1999–2004. American Journal of Preventive Medicine. 2007;32(2):147–50.
5. Rivis A, Sheeran P. Descriptive norms as an additional predictor in the theory of planned behaviour: A metaanalysis. Current Psychology. 2003(22):218–33.
6. Peltzer K, Pengpid S, Samuels TA, Özcan NK, Mantilla C, Rahamefy OH, et al. Prevalence of Overweight/Obesity and Its Associated Factors among University Students from 22 Countries. International Journal of Environmental Research and Public Health. 2014;11:7425-41.
7. Pitil PP, Ghazali SR. Overweight and obesity: a study among university students in Sarawak, Malaysia. International Journal of Health Promotion and Education. 2022.
8. Gibson RS. Validity in dietary assessment methods. Principles of Nutritional Assessment. 2nd ed. New York: Oxford University Press; 2005.

9. Willett W. Nutritional epidemiology. 3rd ed. Oxford, UK: Oxford University Press; 2012.
10. Willett W, Stampfer MJ. Total energy intake: implications for epidemiologic analyses. American Journal of Epidemiology. 1986;124(1):17-27.
11. Cade J, Thompson R, Burley V, Warm D. Development, validation and utilisation of food-frequency questionnaires – a review. Public Health Nutrition. 2002;5(4):567–87.
12. Moy FM, Eng JY, Lew TSY, Rampal S, Zainuddin AA, Bueno-de-Mesquita HBa. Relative Validity of a Food Frequency Questionnaire among Multi-ethnic Working Population in Malaysia. ASM Science Journal. 2020;13(5):30-8.
13. Faul F, Erdfelder E, Lang A-G, Buchner A. G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behavior Research Methods. 2007;39(2):175-91.
14. Fatihah F, Ng BK, Hazwanie H, Norimah AK, Shanita SN, Ruzita AT, et al. Development and validation of a food frequency questionnaire for dietary intake assessment among multi-ethnic primary school-aged children. Singapore Med J. 2015;56(12):687-94.
15. Karim NA, Margetts B. Calibration of a food frequency questionnaire developed for the South Asian community in the United Kingdom. Malaysian Journal of Nutrition. 1997;3:49-60.
16. (IPH) IfPH. National Health and Morbidity Survey 2014 : Malaysian Adult Nutrition Survey. 2014;1.
17. Siong TE, Noor MI, Azudin MN, Idris K. Nutrient Composition of Malaysian Foods. 4th ed. Kuala Lumpur: Malaysian Food Composition Database Programme, Institute for Medical Research; 1997.
18. Tang HK. Diet, physical activity, environments and their relationship to the emergence of adolescent overweight and obesity in Ho Chi Minh City, Vietnam (dissertation): Newcastle, NSW: University of Newcastle; 2005.
19. Mohamed K, Tin TS, Jalaludin MY, Al-Sadat N, Majid HA. Comparative validity of a Food Frequency Questionnaire (MyUM Adolescent FFQ) to estimate the habitual dietary intake of adolescents in Malaysia. Asia Pac J Clin Nutr. 2018;27(4):898-907.
20. Loy S, Mohamad M, Yaacob NA, JM HJ. Development, validity and reproducibility of a food frequency questionnaire in pregnancy for the Universiti Sains Malaysia Birth Cohort Study. Malays J Nutr. 2011;17(1):1-18.
21. Georgea GC, Milania TJ, Hanss-Nussa H, Kimb M, Freeland-Gravesa JH. Development and validation of a semi-quantitative food frequency questionnaire for young adult women in the southwestern United States. Nutrition Research 2004;24:29–43.
22. Henn RL, Fuchs SC, Moreira LB, Fuchs FD. Development and validation of a food frequency questionnaire (FFQ-Porto Alegre) for adolescent, adult and elderly populations from Southern Brazil. SciELO Public Health. 2010;26(11):2068-79.
23. Harmouche-Karaki M, Mahfouz M, Obeyd J, Salameh P, Mahfouz Y, Helou K. Development and validation of a quantitative food frequency questionnaire to assess dietary intake among Lebanese adults. Nutrition Journal 2020;19(65).
24. Thompson FE, Subar AF. Dietary assessment methodology. In: A C, C B, M F, L D, editors. Nutrition in the prevention and treatment of disease. Amsterdam, The Netherlands: Elsevier; 2017. p. 5-48.

25. Morel S, Portolese O, Chertouk Y, Leahy J, Bertout L, Laverdière C, et al. Development and relative validation of a food frequency questionnaire for FrenchCanadian adolescent and young adult survivors of acute lymphoblastic leukemia. Nutrition Journal. 2018;17(1).
26. Khalesi S, Doshi D, Buys N, Sun J. Validation of a short food frequency questionnaire in Australian adults. International Journal of Food Sciences and Nutrition 2017;68(3).
27. Rodriguez CA, Smith ER, Villamor E, Zavaleta N, Respicio-Torres G, Contreras C, et al. Development and Validation of a Food Frequency Questionnaire to Estimate Intake among Children and Adolescents in Urban Peru. Nutrients 2017;9(10):1121-31.
28. Tabacchi G, Filippi AR, Amodio E, Jemni M, Bianco A, Firenze A, et al. A meta-analysis of the validity of FFQ targeted to adolescents. Public Health Nutrition. 2016;19(7):1168–83.
29. Singapore HPB. Energy and Nutrient Composition Singapore: Health Promotion Board; 2003.

Table 1. Conversion factors for food intake frequencies from the FFQ

Food intake frequency	Conversion factor (formula)
Daily	
1	1.00 (1.0/1)
2 - 3	2.50 (2.5/1)
≥ 4	4.00 (4.0/1)
Weekly	
1	0.14 (1.0/7)
2 - 4	0.43 (3.0/7)
5 - 6	0.79 (5.5/7)
Monthly	
1 - 3	0.07 (2.0/30)
Never	
0	0

Table 2. Food items contributing up to 90% of total energy, carbohydrate, fat, and protein

Variable	Food item	Contribution to energy or macronutrient intakes (%)	Cumulative (%)
Energy			
1	White rice	35.5	35.5
2	Chicken	13.6	49.1
3	Noodles	7.5	56.6
4	Flavoured rice	7.0	63.6
5	Local *kuih*	3.7	67.3
6	Sugar	2.9	70.2
7	Malted drink	2.2	72.4
8	Vermicelli	1.7	74.1
9	Marine fish	1.5	75.6
10	Condensed milk	1.5	77.1
11	Pasta	1.5	78.6
12	Ice cream	1.2	79.8
13	Tea	1.2	81.0
14	Flattened bread	1.1	82.1
15	Commercial milk	1.0	83.1
16	Hen eggs	1.0	84.1
17	Pizza	1.0	85.1
18	Snacks/ crackers	0.9	86.0
19	Meat	0.9	86.9
20	Bread	0.9	87.8
21	French fries	0.9	88.7
22	Cereal grains	0.7	89.4
23	Condiment	0.7	90.1
Carbohydrate			
1	White rice	53.7	53.7
2	Flavoured rice	6.4	60.1
3	Noodles	4.9	65.0
4	Sugar	4.9	69.9
5	Local *kuih*	4.4	74.3
6	Chicken	3.2	77.5
7	Vermicelli	2.5	80
8	Condensed milk	1.5	81.5
9	Tea	1.4	82.9
10	Ice cream	1.3	84.2
11	Bread	1.2	85.4
12	Flattened bread	1.1	86.5
13	Fruit juice	1.0	87.5
14	Cereal grains	0.9	88.4
15	Snacks/ crackers	0.8	89.2
16	Malted drink	0.7	89.9
17	Legumes	0.7	90.6
Protein			
1	Chicken	33.2	33.2
2	White rice	16.9	50.1
3	Pasta	6.6	56.7
4	Noodles	6.4	63.1
5	Meat	4.4	67.5
6	Flavoured rice	4.1	71.6
7	Marine fish	4.1	75.7
8	Local *kuih*	2.1	77.8
9	Burger	1.5	79.3
10	Condiment	1.4	80.7
11	Vermicelli	1.3	82.0
12	Squid	1.3	83.3
13	Pizza	1.2	84.5
14	Commercial milk	1.2	85.7
15	Malted drink	1.0	86.7
16	Freshwater fish	0.9	87.6
17	Condensed milk	0.9	88.5
18	Ice cream	0.8	89.3
19	Bread	0.7	90.0

Table 2. Food items contributing up to 90% of total energy, carbohydrate, fat, and protein (cont.)

Variable	Food item	Contribution to energy or macronutrient intakes (%)	Cumulative (%)
Fat			
1	Chicken	27.0	27.0
2	Noodles	15.4	42.4
3	Flavoured rice	11.2	53.6
4	Malted drink	7.0	60.6
5	Marine fish	3.3	63.9
6	Local *kuih*	3.1	67.0
7	Condensed milk	2.1	69.1
8	Condiment	2.1	71.2
9	White rice	2.1	73.3
10	Pizza	2.0	75.0
11	Commercial milk	1.9	76.9
12	French fries	1.9	78.8
13	Snacks/ crackers	1.8	80.6
14	Burger	1.6	82.2
15	Ice cream	1.5	83.7
16	Nugget	1.5	85.2
17	Flattened bread	1.5	86.7
18	Tea	1.4	88.1
19	Fried chicken	1.1	89.2
20	Chocolate bar	0.8	90.0

Table 3. Sociodemographic of students in the validation study (N = 100)

Characteristics	**N (%)**
Age in years (mean ± SD)	22.8 ± 0.9
Gender	
Male	47 (47%)
Female	53 (53%)
Ethnicity	
Malay	67 (67%)
Chinese	25 (25%)
Indian	5 (5%)
Others	3 (3%)
BMI in kg/m^2 (mean ± SD)	22.4 ± 5.0

Table 4. Students' daily nutrient intake according to the FFQ and 3DFR (N = 100)

Nutrients and energy	3DFR		FFQ		Wilcoxon	Correlation coefficient (r)
	Median	Range	Median	Range	z	
Energy (kcal)	1285.7	566.1-2668.1	1277.3	590.6-2959	-1.5	0.94**
Protein (g)	50.1	23-107.4	60.2	12.3-173.7	-4.2**	0.64**
Fat (g)	52.9	13.3-129	43.3	4.9-125.2	-5.4**	0.76**
Carbohydrate (g)	151.2	50.9-369.8	172.4	82.5-394.9	-4.3**	0.76**
Dietary fiber (g)	4.1	0.5-24.9	1.2	0.15-3.9	-8.4**	0.38**
Calcium (mg)	347.3	107.3-1394.4	332.8	58.1-935.5	-1.6	0.45**
Iron (mg)	8.6	2.9-32	11	2.3-47.1	-3.2**	0.47**
Phosphorus (mg)	720.5	191.4-1866	859.3	156.9-2331.7	-3.7**	0.40**
Potassium (mg)	813.3	222.7-2080.5	1105.8	208.9-2763.2	-6.6**	0.47**
Sodium (mg)	1875.6	609.3-4421.3	842.1	131.8-3022.7	-8.2**	0.45**
Vitamin C (mg)	20.5	0.6-204.7	34.6	1.8-193.9	-3.8**	0.14
Vitamin B1 (mg)	0.5	0.1-1.4	0.7	0.2-1.7	-5.5**	0.34**
Vitamin B2 (mg)	0.7	0.2-3	1.2	0.2-2.9	-7.3**	0.39**
Niacin (mg)	6.9	1.7-24.2	10.1	0.6-25.5	-5.8**	0.43**
Retinol (µg)	419.5	60-1530.1	422.1	50.7-1763.6	-1.1	0.30**
Cholesterol (mg)	176.8	28.6-1914.5	201.9	28.1-618.3	-1.6	0.43**
Trans-fat (g)	0	0-21	0.2	0-0.4	-6**	-0.16
Sugar (g)	18.3	1.4-315.3	43.2	7.2-151	-6.5**	0.26*
Zinc (mg)	3.7	0.5-47.5	6.4	2.1-13.2	-7.1**	0.39**
Average of correlation coefficients (energy & all nutrients)						0.43
Average of correlation coefficients (energy & macronutrients)						0.50
Average of correlation coefficients (micronutrients)						0.39

*$p < 0.05$, **$p < 0.01$

Table 5. Cross-classification of results of the FFQ and 3DFR regarding nutrients (N = 100)

Nutrients (per day)	Same quartile (%)	Adjacent quartile (± 1) (%)	Opposite quartile (± 3) (%)	Same and adjacent quartile (%)
Energy (kcal)	85	12	0	97
Protein (g)	47	43	3	90
Fat (g)	53	41	1	94
Carbohydrate (g)	56	38	0	94
Dietary fiber (g)	32	44	3	76
Calcium (mg)	37	39	5	76
Iron (mg)	40	40	2	80
Phosphorus (mg)	41	38	8	79
Potassium (mg)	37	48	6	85
Sodium (mg)	41	39	5	80
Vitamin C (mg)	28	38	9	66
Vitamin B1 (mg)	38	37	2	75
Vitamin B2 (mg)	33	40	4	73
Niacin (mg)	37	40	6	77
Retinol (µg)	35	36	6	71
Cholesterol (mg)	36	43	3	79
Trans-fat (g)	18	38	22	56
Sugar (g)	32	43	11	75
Zinc (mg)	40	37	5	77

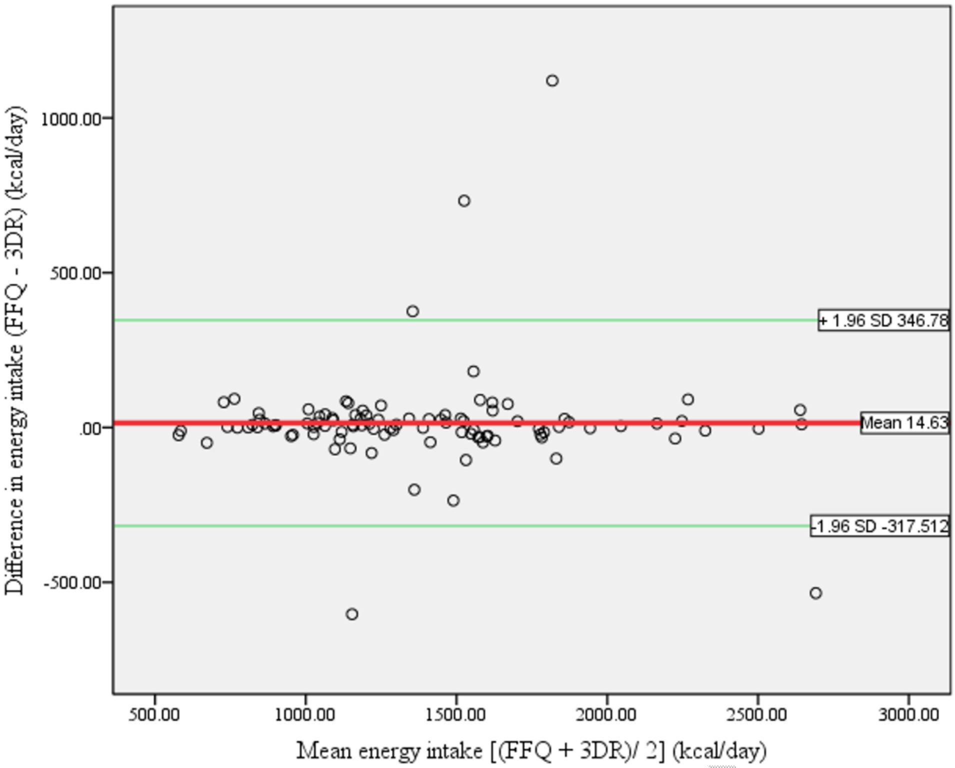
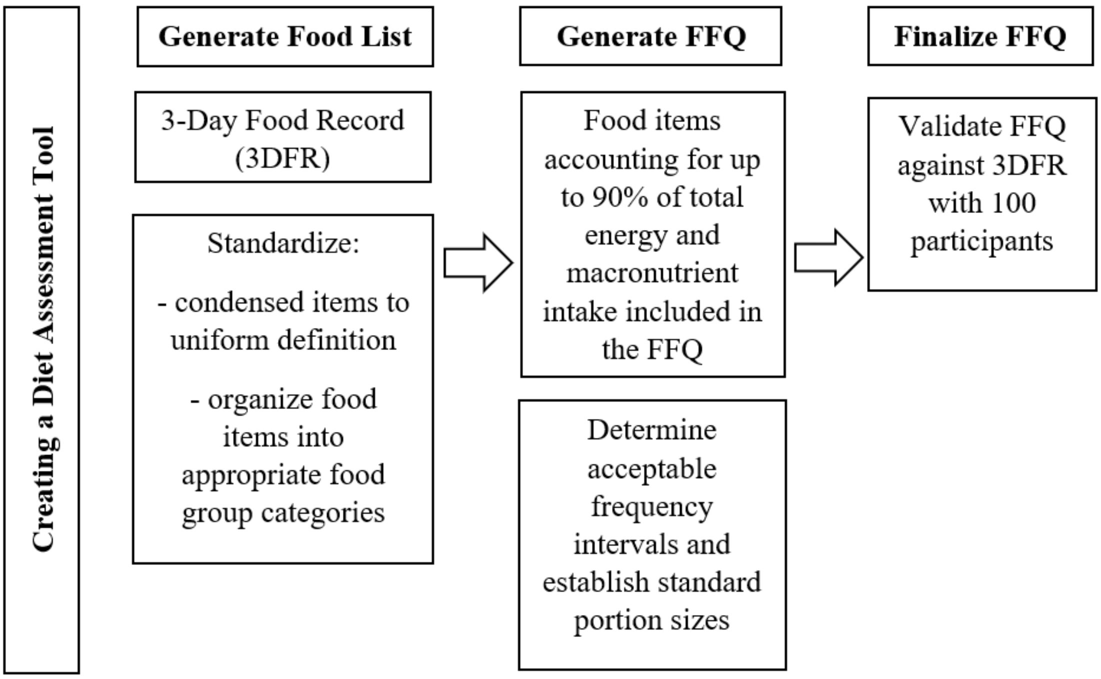


Figure 1. Bland–Altman revealing the results of the FFQ and 3DFR for energy intake (kcal) are in agreement. The thick line indicates the mean difference in absolute consumption between the methods, whereas the thin line represents the agreement limits (±2 standard deviations)



Graphical abstract