Short Communication

Validation of a food frequency questionnaire to assess dietary cholesterol, total fat and different types of fat intakes among Malay adults

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Background: Cardiovascular diseases are the major cause of death in Malaysia. Evidence shows that dietary fat intake is one of the important risk factors for cardiovascular disease. However, studies assessing the association of fatty acids and risk of cardiovascular diseases in Malaysia are scarce. Therefore, this study aimed to develop and validate a food frequency questionnaire (FFQ) assessing total fat and different types of fat among Malay adults in Malaysia. Methods: A 100 food item FFQ focused on dietary cholesterol, total fat, saturated fat, mono-unsaturated fat and polyunsaturated fat intake for the past one month was developed and validated against 3-day dietary record (DR) among 151 Malay participants. Validity was assessed through the reliability and agreement of two methods. Intra-class correlation (ICC) coefficients were used to assess reliability; while regression analysis and classification into categories were used to assess agreement of the two methods. Results: The mean nutrient intakes tended to be higher in FFQ compared to DR. The developed FFQ showed excellent reliability with ICC coefficients ranging from 0.92-0.98. Regression analysis demonstrated an acceptable agreement between FFQ and DR for total fat and different types of fat intakes. There were a relatively high proportion of subjects being correctly classified (into same or adjacent category) and only a small number of grossly misclassification for total energy, fat, dietary cholesterol, saturated fat and unsaturated fat occurred. Conclusion: This FFQ is valid in assessing absolute total energy, total fat and types of fat intakes among Malay adults.

Key Words: food frequency questionnaire, validation, fat, cholesterol, Malay adults

INTRODUCTION
Cardiovascular diseases have been known as the leading cause of death worldwide. Diet and nutrition are thought to exert a great influence on the risk of cardiovascular diseases.[1-2] Considerable evidence demonstrated the effects of dietary fats and different types of fat intakes on the risk of cardiovascular diseases.[3-5] The consistency of dietary fat intake recommendations to limit daily intakes of total fat,[6-7] saturated fat and dietary cholesterol while encouraging mono- and polyunsaturated fat continues to highlight the importance of dietary fat and different types of fat intake to the risk of cardiovascular diseases.

Nowadays, Malaysians' diet have shifted towards 'western' foods which are high in fat and calories.[8-10] The practice of 'western' eating habits have contributed to the rising consumption of fat and animal products.[11] There is no published validated dietary assessment tool designed to assess dietary fat intake in Malaysia. The variety of diets and food patterns consumed by our multiethnic population may be one of the obstacles in developing and validating a FFQ. The lack of appropriate dietary assessment tool to assess detailed fat intakes could be the major barrier in determining the relationship between detailed fatty acids intake and risk of cardiovascular diseases among Malaysians. Generally, FFQ is the most popular tool for dietary assessment in epidemiological studies.

Validation of a new dietary questionnaire is important because incorrect information may lead to false associations between dietary factors and diseases. The most common methodologies in published studies to validate dietary tool for assessing dietary fat intake were comparing food frequency questionnaire (FFQ) against multiple days of diet recalls or records.[12,13] Other than dietary assessment methods, some studies used biochemical markers such as lipid profile, adipose tissue and saliva as reference methods.[14-16]

Several dietary questionnaires from other countries have been developed and validated specifically to assess dietary fatty acids intake in different populations, but these questionnaires are inappropriate for Malaysians. In our study, a FFQ was developed by adaptation from a previous local FFQ.[17] The aim of this study was to validate the FFQ for assessing total fat and different types of fat among Malay adults in Malaysia.

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MATERIALS AND METHODS

Study design and sample size estimation

This study was of a cross-sectional design. Participants were enrolled from a worksite Wellness Programme in a medical centre in Kuala Lumpur. Sample size was calculated using Power and Sample Size (PS) Program.[18] With a regression coefficient for total fat assumed to be 0.27 according from an earlier study,[19] a power of 80% and a two-tailed significant level set at 0.05, a sample size of 130 subjects would be required. The participants were randomly selected from the list of participants of the Wellness program by using computer generated random numbers through a statistical software.[20] All selected participants were then contacted through phone. Those who agreed to participate were recruited and written informed consent was obtained. The study was approved by the Medical Ethics Committee of the medical centre which governed all human related studies.

Development of dietary questionnaires

The FFQ was developed from an existing questionnaire by Wai that evaluated the intakes of total fat and dietary cholesterol over the past month among Malaysian adults-consisting of Malays, Chinese and Indians.[17] Wai's questionnaire was developed from 24-hour dietary recalls among 100 adults in Malaysia. Food items with 95% of cumulative contribution to the total fat and cholesterol intake were included in the food list. In addition, the basic list was extended with food items which were high in fat and cholesterol. Food items that reported more than 20 times in the recalls and contributed to fat or cholesterol intake were also included to improve the comprehensiveness of the questionnaire. Finally, an 89-item FFQ was developed and validated against interview-administered seven-day dietary recall.[17] We modified Wai's FFQ by excluding non-halal food and food items which were not frequently consumed by the Malay population. On the other hand, popular food items with contribution to important fatty acids intakes among Malay population were added into the food list. Food items were further categorised into different methods of cooking such as deep fried, stir-fried, steam, etc to improve the assessment of fatty acids contents. Additional information such as types of milk, consumption of poultry skin, addition of gravy, creamer, sugar and coconut milk were also included. This new food list was categorized into 18 different food groups and frequency of intakes was recorded as times per day, week, month and less than once a month. Food pictures were used to assist participants. Common household measurement tools such as bowls, cups, match box, plates and etc. were used to illustrate portion size. The final FFQ (Appendix A) was then pilot-tested among ten Malay adults for further refining.

The FFQ was administered through a face-to-face interview by the first author in Malay language, and the duration of each interview took about 20 to 25 minutes. All dietary data was computed by multiplying the consumption frequency of each food item by the different fatty acids content of the assigned portion sizes. After completion of the FFQ, each participant was supplied with a blank dietary record and asked to record the name and portion size of all food items and drinks they con-sumed over a three-day period (two weekdays and one weekend). Dietary record (DR) was used as reference method on assessing the validity of the FFQ. Although dietary reference methods are not necessarily more accurate, the measurement errors between a test and reference method should be independent.[21] In this case, the measurement errors of FFQ and DR are independent as FFQ is dependent on memory while DR requires the participants to record the food items consumed on the same day. Detailed verbal instructions and written examples were given to the participants to ensure completeness of the dietary records. Completed dietary records were collected and incomplete information was verified by the researcher immediately upon collection. The participants were requested to fill in the FFQ again at this point to test for its reliability.

Nutrient composition of Malaysian foods and energy was used to compute the detailed macronutrients such as energy, protein, fat and carbohydrate, different types of fat (saturated fatty acids, mono unsaturated and polyunsaturated fatty acids).[21] However this database did not provide complete information on fat composition for all food items. Only selected items had the information on fat composition. Therefore, the food database from Singapore was used to supplement the incompleteness of the Malaysian data base.[22]

Statistical analysis

Mean and standard deviation were calculated for nutrient intakes estimated from both the FFQ and DR. Independent t-test was performed to compare the mean nutrient intakes estimated by FFQ and DR. Spearman correlation coefficients were computed to assess the association between two dietary tools. Partial correlation coefficients were also computed to assess the correlation for nutrient intakes after being energy-adjusted. The validation of the FFQ was assessed using the methods of reliability and agreement. Reliability of the FFQ was assessed using Intra-class correlation (ICC) coefficient. There are many methods for assessing agreement; however there is no single method that is perfect. For this study, we will report the agreement between FFQ and DR using linear regression analyses and classification into consumption of intakes. All data was analyzed using SPSS 15.0. Statistical significance was preset at $p<0.05$.

RESULTS

A total of 151 subjects (37.6% males and 62.4% females) completed both the FFQ and DR. Mean age of the participants was 49.8±4.1 years old, and the majority of them were married and had at least secondary education. According to the WHO BMI cut-off values, most of the participants were overweight with the mean BMI of 27.3±4.3 kg/m^2 (Table 1).

Generally, there was over reporting of intakes in FFQ for all nutrient components except percent energy from fat. However, the mean differences for all nutrient components between FFQ and DR were within 20%. Total energy, total fat, unsaturated fat and percent energy derived from unsaturated fat showed significant differences between the two methods ($p<0.05$). Spearman correlation coefficients between FFQ and DR ranged from 0.08 for

Table 1. Demographic characteristic of study subjects

Characteristics (n=151)	n (%)
Age (years), mean ± SD	49.9 ± 4.1
Gender	
Male	39 (25.8%)
Female	112 (74.2%)
Marital status	
Bachelor	8 (5.3%)
Married	129 (85.4%)
Widowed	10 (6.6%)
Divorced	4 (2.6%)
Educational level	
Primary	3 (2.0%)
Secondary	107 (70.9%)
Diploma	32 (21.2%)
Tertiary	9 (6.0%)
Body Mass Index	
Underweight/normal (<25.0 kg/m^2)	46 (30.5%)
Overweight (25.00 to 29.9 kg/m^2)	73 (48.3%)
Obese ($\geq$30.0 kg/m^2)	32 (21.2%)

calculated as [weight in kg/(height in meter)^2]

percent energy from PUFA to 0.64 for total energy. Total energy (r=0.64, *p*<0.01) and fat (r=0.47, *p*<0.01) intakes estimated from FFQ and DR showed moderate and significant correlations while percent energy from fat and fatty acids intakes showed weak but significant correlations between FFQ and DR (r<0.4, *p*<0.05). Correlation coefficients for dietary cholesterol as well as percent energy from SFA, MUFA and PUFA were low and not statistically significant (r<0.07). After energy adjustment, the correlation coefficients for total fat, SFA, MUFA and PUFA intake slightly decreased. On the other hand, the correlation coefficients for energy-adjusted dietary cholesterol and percent energy from PUFA intakes increased, however their correlation coefficients remained statistically insignificant. After energy-adjustment, the correlation coefficient of percent energy from MUFA intake between FFQ and DR had decreased and was no longer significant (r=0.04) (Table 2).

Reliability is the degree of consistency of a questionnaire when retested on the same individual on two different occasions and is important to assess the validity of a questionnaire.[23,24] A valid questionnaire should agree well with the reference method and able to produce reliable test-retest estimates. The reliability of our FFQ is excellent with ICC coefficients ranging from 0.92 to 0.98 (Table 3).

As shown in Table 3, the regression coefficients of total energy (r=0.56, *p*<0.05) and total fat intakes (r=0.46, *p*<0.05) derived from both dietary tools showed moderate agreement. Percent energy from fat, SFA, MUFA and

Table 2. Relationship of nutrient intakes assessed by FFQ and DR

Nutrient	Mean intake±SD	Mean difference±SD	Difference (%)†	*p*-value	Spearman Correlation Coefficient, r	
					Unadjusted	Energy-adjusted
Energy, kcal/d					0.64**	-
DR	1827±344	-195±275	-10.7	<0.001		
FFQ	2023±299					
Total fat, g/d					0.47**	0.37**
DR	66.8±16.9	-5.84±15.9	-8.75	<0.001		
FFQ	72.6±15.1					
% energy from fat, %/d					0.21**	0.27**
DR	32.8±5.20	0.43±6.13	1.31	0.388		
FFQ	32.3±4.79					
Cholesterol, mg/d					0.09	0.12
DR	256±141	-0.52±156	-0.20	0.968		
FFQ	256±92.1					
SFA fat, g/d					0.34**	0.19*
DR	22.7±7.04	-1.09±7.32	-4.81	0.068		
FFQ	23.7±5.81					
% energy from SFA fat, %/d					0.13	0.11
DR	10.1±2.91	-0.48±3.40	-4.31	0.086		
FFQ	10.6±2.05					
MUFA, g/d					0.30**	0.18*
DR	19.1±5.51	-1.82±6.56	-9.53	0.001		
FFQ	20.9±5.48					
% energy from MUFA, %/d					0.30*	0.04
DR	8.52±2.27	-0.79±3.07	-8.40	0.002		
FFQ	9.31±2.04					
PUFA, g/d					0.27**	0.18*
DR	12.0±4.46	-2.19±5.32	-18.3	<0.001		
FFQ	14.2±4.36					
% energy from PUFA, %/d					0.08	0.13
DR	5.34±1.97	-0.95±2.40	-16.2	<0.001		
FFQ	6.29±1.60					

† Calculated as [(mean DR – mean FFQ)/mean DR] x 100
* Significant at the 0.05 level (2-tailed)
** Significant at the 0.01 level (2-tailed)

Table 3. Reliability of FFQ and agreement between DR and FFQ

| Nutrient | Reliability | Agreement | | | | |
| | Intra-class correlation (ICC) | Regression coefficient | | Comparison by quartile (%) | | |
		Unadjusted	Energy-adjusted	Same quartile	Adjacent quartile	Grossly misclassified[¥]
Energy, kcal/d	0.92 (0.86, 0.95)	0.56*	-	37.8	40.4	1.99
Total fat, g/d	0.94 (0.91, 0.97)	0.46**	0.47**	33.8	48.3	3.97
% energy from fat, %/d	0.98 (0.97, 0.99)	0.23**	0.25**	34.4	39.1	9.93
Cholesterol, mg/d	0.96 (0.94, 0.98)	0.10	0.08	29.1	35.1	7.95
SFA fat, g/d	0.95 (0.91, 0.97)	0.30**	0.19*	37.1	44.4	5.96
% energy from SFA fat, %/d	0.96 (0.93, 0.98)	0.08	0.08	24.5	47.0	6.62
MUFA, g/d	0.95 (0.92, 0.97)	0.29**	0.21*	31.8	41.7	8.61
% energy from MUFA, %/d	0.98 (0.96, 0.99)	0.06	0.03	27.2	35.1	12.6
PUFA, g/d	0.93 (0.88, 0.96)	0.27**	0.19*	28.5	47.7	9.27
% energy from PUFA, %/d	0.95 (0.92, 0.97)	0.13	0.11	27.2	39.1	11.3

*   Significant at the 0.05 level
** Significant at the 0.01 level
¥   Being classified from one extreme category to other extreme category

PUFA intakes showed weak but significant regression coefficients (r<0.40, *p*<0.05). On the other hand, dietary cholesterol and percent energy from SFA, MUFA and PUFA intakes assessed by two dietary methods showed poor regression coefficients (r<0.12) and were not statistically significant.

Similar with few previous validation studies,[12,25,26] our FFQ shows relatively high proportion of subjects being correctly classified (into same or adjacent category) and only small number of grossly misclassification (less than 10%) in terms of total energy, fat, dietary cholesterol, saturated fat and unsaturated fat. This illustrated that our FFQ was capable of ranking individual's intakes according to DR for all nutrient components except percent energy derived from unsaturated fat which exceeded 10% (Table 3).

DISCUSSION
With the increased rates of morbidity and mortality from cardiovascular diseases among Malaysians, there is a need for a rapid screening instrument to identify an individual's dietary fat intake. This paper describes the validation of a food frequency questionnaire for assessing dietary cholesterol, total fat, saturated, monounsaturated and polyunsaturated fat intake among Malay adults.

Generally, overestimation of FFQ on total energy, total fat and unsaturated fatty acids were reported in our study as well as other previous studies.[12,25,27] Although some of the nutrient components showed significant differences between FFQ and DR, the mean differences were within 20%, indicating that the nutrient intakes estimated from two methods were comparable and acceptable.[28] The correlation coefficients for total energy, fat, saturated and unsaturated fatty acids were within the observed range of correlations from previous studies.[29,30] However, dietary cholesterol show lower correlation coefficient compared to previous studies.[13,25-26] Improvements on the correlation coefficients after adjustment for total energy for percent energy from fat, dietary cholesterol and percent energy from PUFA indicated that the variability of these nutrient intakes were related to energy intake. Lower cor-

relation coefficients for energy-adjusted total fat, saturated fat, percent energy from saturated fat, MUFA, percent energy from MUFA and PUFA may be partly due to reduction of the measurement errors of dietary methods and extraneous variation which tended to decrease the correlation coefficients of the nutrient estimations between two measures.[31,32] Low correlation coefficients for nutrient data are common in dietary survey due to the effect measurement error.[26,33] For example, under or over-report in one of the dietary method will lead to low correlation coefficients between methods. Besides, Cardoso and colleagues demonstrated that within-person variability in dietary records tended to decrease the correlation between two variables.[34]

The reliability of our FFQ was excellent with higher ICC compared to other studies.[24,33,35] This could be due to the method of administration of our FFQ. Interview-administered questionnaire as ours provided higher correlations compared to self–administered questionnaire.[36] In addition, the use of food pictures may also contribute to higher correlation as shown by other study.[37]

Regression analysis can be used to assess validity between two methods, but is not commonly practiced in nutritional studies. To date, only two published studies were found to examine agreement between methods using regression analysis.[19,25] Generally, a regression coefficient close to or greater than 0.50 was considered as showing good agreement.[38] Our results show significant and moderate agreement between two methods for absolute and energy-adjusted nutrients, except dietary cholesterol and percent energy from fatty acids. Although the regression coefficients for total energy, fat and MUFA were comparable to those reported in other populations,[19] lower regression coefficients for dietary cholesterol, saturated fat and polyunsaturated fat were observed compared to a previous study.[25] This may be partly due to lower numbers of food records collected in our study which tended to increase the intra-individual variation and thus lower the regression coefficient with FFQ. Future validation studies should consider at least 7 day dietary records for better agreement between methods.

In our study, the relatively high proportion of participants being classified into same or adjacent quartiles and, the small number of gross misclassification illustrated that our FFQ was capable to rank an individual's absolute nutrient intakes according to DR. Unfortunately, estimates of percent energy from unsaturated fatty acids between two measures had more than 10% of the individuals grossly misclassified. Higher percentages of gross misclassification for percent energy from unsaturated fat could be explained by large within- and between-person variation of total energy intake among the study population.

Since no universally accepted method was available to assess the validity of a questionnaire, more than one statistical method was usually used to assess the validity of a questionnaire.[38] Our results demonstrated good agreement between two dietary methods for total fat, percent energy from fat, absolute intake of MUFA and PUFA. Besides, saturated fat intake estimated by FFQ and DR showed moderate agreement while total energy, percent energy from saturated and monounsaturated fat estimates showed fair agreement between methods. However, the agreement for dietary cholesterol and percent energy from PUFA between two dietary tools were less satisfactory.

Several limitations of this study must be considered. First, the study population was Malay adults from a public university which may not be generalisable to the general Malay population. Thus, further work need to be done to validate this FFQ in a larger randomly selected Malay population in Malaysia. Furthermore, lack of local nutrient composition database on detailed fatty acids components for all food items may affect the accuracy of assessment on nutrient intakes. Hence, it is important to expand the nutrient composition database of Malaysia by including information of detailed fatty acids content on each and every food item. The three day dietary record may not be adequate as other studies showed better agreement with increased number of days for dietary records or recalls. On the other hand, this validated FFQ probably was the first that was validated and could be further expanded to other races (Chinese and Indians) of the country, as all three races of the country were consuming food items cross culturally.

In conclusion, this new FFQ can be used in nutritional studies in assessing absolute intakes of total fat as well as detail fatty acids among Malay adults in Malaysia. Besides, this FFQ is capable of classifying an individual's intake into quartiles of intakes which is useful in assessing the interaction between dietary fat intake and risk of diseases.

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評估馬來人飲食中膽固醇、總脂肪以及不同形式的脂肪攝取之食物頻率問卷的效度研究

背景：在馬來西亞，心血管疾病為主要的死因。證據顯示，飲食中脂肪的攝取量為導致心血管疾病的一重要危險因子。然而，在馬來西亞，評估脂肪酸與心血管疾病罹患風險的相關研究仍非常稀少。因此，本篇研究的目的為開發評估馬來西亞的馬來人總脂肪和不同形式的脂肪攝取的食物頻率問卷（FFQ）及其效度。方法：該FFQ含100種食物項目，針對過去一個月內飲食膽固醇、總脂肪、飽和脂肪、單元不飽和脂肪、多元不飽和脂肪的攝取，並藉由151位馬來參與者三天的飲食紀錄進行效度評估。效度的評估是透過信度以及頻率問卷及飲食紀錄兩種方式的一致性。信度用組內相關係數來評估；兩種方法的一致性以迴歸分析和類別資料分析來評估。結果：相較DR，FFQ有較高的平均營養攝取量。這個FFQ有極佳的信度，其組內相關係數範圍為0.92-0.98。迴歸分析指出FFQ和DR兩者在總脂肪以及不同形式的的脂肪攝取，具有可接受的一致性。相對較高比例的參與者被正確分類(相同或相近的類別)，只有少數在總能量攝取、脂肪、膳食膽固醇、飽和脂肪和非飽和脂肪被嚴重的錯誤分類。結論：這個FFQ能有效地評估馬來人飲食中總能量攝取、總脂肪和不同形式脂肪攝取量。

關鍵字：食物頻率問卷、效度、脂肪、膽固醇、馬來人