Original Article

Validation of a semiquantitative food frequency questionnaire for estimation of intakes of energy, fats and cholesterol among Singaporeans

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The aim of this study was to assess the relative validity of a 159-item semiquantitative food frequency questionnaire (FFQ) for use among adult Singaporeans. This FFQ should be able to classify intakes of energy, total fat, saturated fat, polyunsaturated fat, monounsaturated fat and cholesterol into quintiles of intakes for purposes of epidemiological studies. A total of 126 subjects (84 women and 42 men) took part in the study which included an interview using the newly developed FFQ (assess past month's intake) and three 24-h (24 h) recalls (reference method, collected over a period of 1 month). Subjects also collected two 24 h urinary samples for urea from which total nitrogen excretion was assessed to validate protein intake. When compared to the reference method, the FFQ slighty overestimated the intakes of energy, total fat and types of fat as reflected by the difference in means and the ratio of FFQ to 24 h intakes. The overestimation ranged from 1 to 11% of the reference method. Dietary cholesterol was underestimated by 17% by the FFQ. These differences were however, not statistically significant. Pearson's correlation coefficients (95% confidence intervals (CI)) between intakes assessed by FFQ and reference method varied from 0.58 (0.45, 0.69) for total fat to 0.39 (0.23, 0.53) for polyunsaturated fat. Cross-classification into quintiles resulted in correct classification into the same or adjacent quintiles in 70% of subjects, with only one or two subjects being grossly misclassified. Nitrogen (N) intake from the 24 h recalls did not differ significantly from that estimated from the urinary nitrogen excretion. The mean (± SD) difference was 0.0 ± 0.4 g and the Pearson correlation coefficient (95% CI) was 0.55 (0.31, 0.72). It is concluded that the newly developed FFQ is an adequate tool for classifying individuals' intakes into quintiles for epidemiological studies among Singaporean adults.

Key words: multiple 24-h recalls, semiquantitative food frequency questionnaire, Singaporeans, urinary biomarker, validation study.

Introduction

The mortality from cardiovascular disease in Singapore is comparable to those of the West and higher than those in other parts of Asia (such as Japan and Hong Kong).[1]

From the National Health Survey in Singapore conducted in 1992[2] and studies by Hughes *et al*,[3–9] it is apparent that cardiovascular risk factors differ in the three major ethnic groups (Chinese, Malays and Indians) in Singapore. Such risk factors include obesity, abdominal fat distribution, elevated blood pressure, abnormal blood lipids, elevated blood glucose and insulin. Indians have the highest incidence of acute myocardial infarcts followed by Malays and Chinese.[2]

There is, however, no satisfactory explanation currently for the high prevalence of cardiovascular diseases in Singapore and differential rates among the ethnic groups to enable public health measures to be carried out to arrest and even reverse the trends.

The role of diet in cardiovascular diseases is well-documented.[10–14] A diet high in energy, total fat, saturated fat and cholesterol and relatively low in unsaturated fats, fruits and vegetables has been linked to the development of cardiovascular risk factors. Differences in nutrient intakes could explain part of the variation in levels of risk factors among the different ethnic groups in Singapore.

Unfortunately, there has been a paucity of studies examining the dietary intakes among Singaporeans and how these are related to cardiovascular risk factors among the different ethnic groups in Singapore.[9] One main reason is the lack of a suitable local dietary tool to be able to assess individuals' usual intake over a period of time. Some methodologies used in published studies included dietary history, multiple 24 h recalls, multiple dietary records and food frequency questionnaires (FFQ).[14] The most appropriate method is dependent on the purpose of the study. For ranking of individuals by relative levels of nutrient intake (for evaluation of aetiologic hypotheses and interactions), the common tool used is the food frequency method.[15,16] However, methodologies

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developed in other populations are not suitable for use in Singapore as a result of the large variety of local foods consumed by the different ethnic groups that differ from those consumed elsewhere. The present study, conducted in early 1998, aimed to develop a dietary tool suitable for ranking individuals into quintiles of intakes of energy, total fat, saturated fat, polyunsaturated fat, monounsaturated fat and cholesterol and correlate these with cardiovascular risk factors. The dietary tool, a semiquantitative FFQ, was to be first designed using a data-based approach. This newly developed FFQ was then validated against multiple 24 h recalls (reference dietary method). In addition urinary urea (nitrogen) was used to validate the assessed protein (nitrogen) intake from the reference method. An important consideration in the development of the FFQ was that it should be relatively simple and brief to administer (less than 30 min) to reduce the burden on both the interviewers and the respondents. The FFQ should also be capable of assessing nutrients, as well as foods or food types. This was to permit determination of food sources of nutrients being studied and enable appropriate public education to be carried out.

Methods

Development of food list

The semiquantitative FFQ would comprise a food list of items commonly consumed in Singapore, to be used for assessing frequency of intakes of these food items over the past 1 month. This food list aimed to include not only foods that were rich in energy or the selected nutrient, but also foods that were important to the population's intake of the nutrient of interest. The list of foods was developed by means of a data-based approach similar to those used by Block *et al.*[15], using dietary data from a food consumption study among Singaporeans conducted in 1993.[17] This 1993 dataset consisted of intakes of 1147 foods and 22 nutrients based on 3-day weighed food records of 457 subjects. There was an over sampling of Malays and Indians, with each group making up 20% of the sample population, to ensure adequate representation. The remaining 60% comprised Chinese (the most common ethnic group in Singapore). This 1993 study was part of the National Health Survey with a population sample of some 5000 adults obtained from stratified multi-staged sampling.[2]

The dataset of 1147 foods were first grouped into 161 conceptually similar major food types (for example, plain steamed rice and rice porridge were grouped as 'white rice', and different types of noodles fried in similar manner were grouped as 'fried noodles'). The other criteria for grouping were that the foods should be similar in nutrient content per usual serving (not per 100 g) and should enable classification of individuals with respect to nutrient intake. In addition, respondents should be able to make the necessary distinctions between the food types.[15] For each food group, careful consideration was given to ensure that foods from the three ethnic groups were represented. The questionnaire was pretested among the three groups for completeness of food list.

The food composition database residing in the Ministry of Health in Singapore was used to estimate the nutrient content of the food types. The amount of energy and each of the nutrients contributed by each food item was computed, based on its nutrient composition, weight of the food item consumed and the frequency of consumption. This computation ensured that foods with lower nutrient composition, but eaten frequently, would not be overlooked.

Food items were included in the food list if they made an important contribution to the overall intakes of energy, fats and cholesterol. The percentage contribution of each of the food types to total energy and the five selected nutrients, namely total fat, saturated fat, polyunsaturated fat, monounsaturated fat and cholesterol was determined and foods were ranked in descending order of their contribution for each of the nutrients. The cumulative percentage contribution was computed and foods contributing cumulatively to 90% of the total intakes of energy or one of the five nutrients were included in the list.

To identify foods important for explaining the variance of intake between persons, a stepwise multiple regression analysis as described by Byers *et al.*[18] was performed. The regression analysis was performed separately for energy and each of the five nutrients. The contribution of each nutrient by individual food items (independent variables) was regressed on the total intake of the same nutrient (dependent variable). The fraction of the variance in the total energy/nutrient that could be progressively explained by an expanding list of food items was expressed as the cumulative r^2 as each food item was entered in a stepwise fashion into the regression model. Food items that contributed to 90% of the cumulative r^2 for energy and each of the other five nutrients were then included in the food list if they were not already in. The basic list of food items was 145 after taking into consideration their contribution to the absolute intakes and variance of intakes of energy and the five nutrients. This list was able to account for more than 99% of the intakes of energy and the five nutrients. In fact, for energy, 75 items alone were able to account for 90% of intake. Adequate capture of energy intake would enhance the capture of a wide range of nutrients.[15]

This basic food list was further enhanced to ensure that cooking methods for the different main food types were captured for better assessment of fat intake. In each of the food groups, care has been taken to take cooking methods into account. For example there are two items of chicken curry — one cooked with coconut milk and one without. This is the same for all dishes requiring coconut as an ingredient. Even for the desserts commonly consumed, such as red bean soup, there are different codes when that is consumed with coconut cream or without. Every cooked food item was coded in three different ways depending on the cooking oil/fat used during preparation (for example, predominantly polyunsaturated, monounsaturated or saturated cooking oil/fat).

Additions to each of the food items (for example, addition of sugar, creamer, different types of milk to beverages) were also included to refine the list. Fruits and vegetables were classified into different subtypes (for example, by physical characteristics and cooking methods) for future correlation with cardiovascular risk factors, when values for various antioxidants and phytochemicals would be available in the local food composition database.[19] The final food list of 159 individual items was grouped into 23 main food types and 25 subfood types. As far as possible, these were structured according to meal types (see Annex 1).

Validation of the FFQ

The final FFQ comprising the rather comprehensive list of food items was then put to the final validation testing among 180 adults. The sample size was calculated using the inter- and intra-person variation in intakes of energy and five nutrients obtained from the 1993 study. About 150 subjects would be sufficient for the detection of differences of 10% in intakes between subjects.[20]

For the validation study, a team of nutritionists and dieticians underwent a 2-day training on interviewing techniques, reviewing of questionnaire and coding of data. The training included both theory and practical sessions.

The Ministry of Health and the National Medical Research Council in Singapore approved the study protocol and all subjects gave their written consent on the actual survey day.

Subjects were recruited from a typical housing estate in Singapore through home visits. Only those between the ages of 19 and 69 were recruited. Those who agreed to participate were then invited to the community club for the interviews. Each of the subjects had to undergo four interviews, beginning with the FFQ, to be followed at least 3 weeks later by the three 24 h dietary recalls. This sequence was scheduled to reduce possible influences of learned responses when reporting intakes for the FFQ. Weight and height measurements were taken during the first interview. Bodyweight was measured to the nearest 0.1 kg in light indoor clothing without shoes, using a digital scale (Seca, Utrecht, The Netherlands). Body height was measured without shoes with Frankfurt plane horizontal, to the nearest 0.1 cm using a wall-mounted stadiometer. From the weight and height, the body mass index (BMI; kg/m^2) was calculated.

The FFQ was administered in the language (either in English, Mandarin, Malay or Tamil) that the subject was most comfortable with, with use of interpreters where necessary. The length of interview ranged from 30 min to 45 min (if interpreter was needed). The subject was asked to recall usual intakes of the foods on the food list over the past 1 month. The usual serving sizes of each food item in common household measures (for example, rice bowl, soup spoon, cups) were included in the list. Columns were provided to enable subjects to report intake as frequency per day, per week or per month. To aid the recall, life size food models, food pictures and household utensils were used. Subjects could choose to report the intake in the preferred serving sizes (this was later coded as fractions of the standard serving portions). Foods consumed less than once a month were not recorded. The first of the 24 h recalls took place at least 3 weeks after the administration of the FFQ. These 24 h recalls included two weekdays and one weekend (Sunday) and were conducted at least one week apart from each other. Only Sunday was considered as a weekend, as the normal workweek in Singapore comprised six working days. As for the FFQ, the necessary memory aids were used to facilitate recalls. During the first two interviews for 24 h recalls, subjects were also given verbal and written instructions to collect 24 h urinary samples according to the protocol described by Bingham *et al*.[21] Collection commenced on the morning after the interviews. After the collection was completed, the urinary samples were collected from the subjects and sent to the laboratory immediately for analysis of urea and creatinine. Urinary urea was determined by enzymatic method using a commercially available test kit (Boehringer Mannheim/ Hitachi 1820 206 R2, Mannheim, Germany), and urinary creatinine by a modified Jaffé method.[22] Only the data of those subjects ($n = 46$) who had completed the FFQ, at least two dietary recalls and collected two valid 24 h urinary samples were used for the validation of protein (nitrogen) intake. Samples are considered adequate and valid when the creatinine excretion was within the expected range (males between 124 and 230 mmol/kg per d and females between 97 and 177 mmol/kg per d.[23]

The relative validity of the FFQ was conducted by comparing the intakes of energy and five nutrients obtained against the weighted means from multiple (three) 24 h dietary recalls. The weighted average intake for the multiple 24 h recalls was calculated as:

$$\frac{(6 \times \text{mean weekday intakes}) + (1 \times \text{weekend intake})}{7}.$$

The validity in this study is not expected to be absolute, as no dietary survey method has been shown to be free of systematic errors in free living subjects.[20,24,25]

Intakes of energy and each of the nutrients obtained from the FFQ and multiple 24 h dietary recalls were divided into quintiles of intake. The ability of the FFQ to accurately classify individuals into the same or adjacent quintile of intake as that obtained from the reference method was tested using χ^2 test. Differences between values obtained from the FFQ and reference method were tested using paired *t*-test, and Pearson's correlation coefficients were calculated between intakes obtained from the two methods.

The ability of the multiple 24 h dietary recalls to estimate dietary intakes of the subjects was verified by the use of an additional urinary biomarker as recommended by Bingham *et al*.[21] The reported intake of nitrogen (N) from the 24 h dietary recalls was compared to intake estimated from 24 h urinary urea excretion. In a diet high in protein, 90% of urinary N consists of urea.[26] A constant fraction of 81% was used to estimate N intake from total urinary N excretion.[24] These factors were used to estimate N intake from urea excretion [Estimated N intake = (N from urea/0.9)/0.81]. Paired *t*-test of difference and Pearson's correlation analysis were performed on the dietary N intake and estimated N intake data.

All data were analysed using SPSS Version 8.0.[27] Values are given as mean ± SD. Correlation coefficients are presented as Pearson's correlation coefficients with 95% confidence intervals. Relationship of the difference between dietary N intakes and estimated N intake (from urinary N excretion) and the mean N intakes obtained from both methods is presented as a Bland and Altman plot.[28] Significance level was set at $P < 0.05$.

Results

The study population consisted of 180 subjects, with 117 women and 63 men. After eliminating incomplete records (less than two 24 h dietary recalls), 126 subjects were left (84 women and 42 men). These subjects had a mean

(± SD) age of 44.7 ± 11.1 years, height of 160.8 ± 8.7 cm, weight of 62.3 ± 12.7 kg and BMI of 24.0 ± 3.9 kg/m^2. Of the 126, only 46 subjects had valid urine samples (two samples with creatinine excretion within normal limits). These subjects were slightly older (mean age of 47.6 ± 11.6 years), but had a similar ethnic, height, weight and BMI distribution compared to those without complete urine samples.

Reported intakes of energy, total fat, saturated fat, polyunsaturated fat, monounsaturated fat, cholesterol and protein using FFQ and multiple 24 h recalls are given in Table 1. Overall, there was overreporting of intakes with the FFQ for energy, total fat and types of fat, and underreporting for cholesterol and protein as reflected by the differences in means and the percentage reference (FFQ × 100/24 h). These differences were, however, small and not significant except for polyunsaturated fat, cholesterol and protein.

In Table 2, the quintiles of intakes for energy, total fat, types of fat and cholesterol are presented. As expected, the range of intakes for males is higher than females for all nutrients. After dividing into quintiles, the expected misclassifications were calculated based on the correlation coefficients. For energy and all nutrients, the FFQ was found to be adequate for classifying subjects into the same or adjacent quintiles of intakes when compared to the multiple 24 h recalls. The observed proportions of misclassifications were not significantly different from that expected for energy and the nutrients tested (Table 3). The percentage of gross misclassifications were small (classified from one extreme category to the other extreme category), with only two (1.8%) subjects being grossly misclassified for total fat, saturated fat and protein intakes, only one subject (0.9%) for polyunsaturated fat, monounsaturated fat, cholesterol and none for energy.

The comparison between reported dietary intakes of N (from reference dietary method) and estimated N intakes (from urinary N excretion) is found in Table 4. The mean N

Table 1. Comparison of intakes between multiple 24-hour dietary recalls (24 h) and food frequency questionnaire (FFQ) in Singaporean adults

Food component	24 h*	FFQ**	Difference	% reference***	Correlation coefficient§
Energy (kcal)	1893(520)	1961(605)	–68(–162,26)	104	0.56 (0.43, 0.67)
Fat (g)					
Total	63.1(22.4)	64.8(27.9)	–1.7(–5.9,2.5)	103	0.58 (0.45, 0.69)
Saturated	23.0(8.8)	23.5(11. 1)	–0.5(–2.3,1.3)	102	0.51 (0.37, 0.63)
Polyunsaturated	13.8(6.2)	15.3(7.9)	–1.4(–2.8,–0.1)	111	0.39 (0.23, 0.53)
Monounsaturated	21.4(8.6)	21.6(10.9)	–0.2(–2.0, 1.5)	101	0.50 (0.36, 0.62)
Cholesterol (mg)	271(170)	226(120)	45(18,71)	83	0.51 (0.37, 0.63)
Protein (g)	75.4(26.5)	69.7(24.0)	5.7(1.1, 10.4)	92	0.46 (0.31, 0.59)

n = 126, *mean ± SD, ** calculated as 24 h–FFQ mean paired difference, (95%CI), ***(FFQ/24 h) × 100, §Pearson's product-moment correlation coefficient, *r* (95% CI).

Table 2. Quintiles of intakes of energy, total fat, types of fat and cholesterol by sex

	n	Food component	Upper limits for first four quintiles			
			1st	2nd	3rd	4th
Female	84	Energy (kcal)	1328	1598	1914	2277
		Fat (g)				
		Total	39.5	48.2	64.0	81.7
		Saturated	12.9	16.8	23.3	29.6
		Polyunsaturated	8.2	10.8	15.4	20.7
		Monounsaturated	12.0	16.4	21.1	27.5
		Cholesterol (mg)	115	160	213	284
Male	42	Energy (kcal)	1730	1987	2398	2785
		Fat (g)				
		Total	45.1	60.3	79.2	97.2
		Saturated	17.1	20.2	28.6	38.1
		Polyunsaturated	10.2	12.9	17.3	27.6
		Monounsaturated	13.9	19.8	22.6	33.0
		Cholesterol (mg)	144	195	271	372
All	126	Energy (kcal)	1373	1724	2040	2455
		Fat (g)				
		Total	41.9	53.1	67.7	84.9
		Saturated	13.4	18.2	24.1	31.3
		Polyunsaturated	9.0	11.2	15.6	21.6
		Monounsaturated	12.4	16.7	21.6	29.8
		Cholesterol (mg)	120	170	237	326

intake of 10.2 ± 2.6 g was the same as that estimated from urinary N. The mean difference between actual and estimated dietary N intake was 0.0 ± 0.4 g. The Pearson's product correlation coefficient between dietary N and estimated N intake was 0.55 (0.31, 0.72).

The Bland and Altman plot of difference in dietary and estimated N intakes against the mean of dietary and estimated N intakes (Fig. 1) showed that the differences were not significantly correlated to the level of N intakes ($r = 0$).

Discussion

The sample population of 180 was selected from a typical housing estate with different flat-types in Singapore. This study did not require a representative sample as a result of the nature of the methodology employed. The proportion of residents of different ethnic groups in this housing estate was, however, similar to the ethnic distribution in Singapore, majority being Chinese, with 14% Malays and 7% Indian. The other ethnic groups which made up about 3% of the population were not included in the sample. The low number of respondents ($n = 46$) who collected both urinary samples satisfactorily was because of the difficulties presented by the hot humid weather, which made it rather unpleasant to collect and store the urine for 24 h. This was especially so for workers who need to bring the containers to work, as not all workplaces are air-conditioned. However, the characteristics of these 46 subjects are comparable to the total number of subjects.

The FFQ was chosen as the possible tool for detection of 'usual' intakes of energy, total fat, saturated fat, polyunsaturated fat, monounsaturated fat and cholesterol as it has a low respondent burden and high response rate compared to other methods such as the dietary history and repeated weighed food records. As the purpose for its development is to classify subjects into quintiles of intake and not to measure the individual's absolute intake, it is considered an adequate tool despite its limitations.[29] While many researchers have developed FFQ for studies on diet-disease relationship, these FFQs could not be easily adapted for use in the local context for various reasons. The most important limitation in using FFQ developed in other populations is the food list. The food list to be used in Singapore has to include foods commonly consumed by the population, which are important contributors to the dietary intakes of the foods/nutrients being studied. Such foods should also be able to account for variation in intakes of the nutrients concerned. Many foods and their cooking methods are unique to the local context and nutrient data are often not available from other commonly used databases. As such, much work has been put in by the Ministry of Health in Singapore to systematically analyse the nutrient composition of foods commonly eaten in Singapore, both by direct laboratory analysis and indirect analysis using a computer program developed specially for this purpose. The availability of these food composition tables, together with the 1993 dataset on foods consumed by the population (obtained from 3-day weighed food records) made it possible to develop a FFQ for the local population.

In the development of the FFQ, certain issues were considered to ensure its applicability in Singapore. By using a data-based approach, it was ensured that the food list would include foods that are commonly consumed by the adult population in Singapore. The portion sizes used in the food list are in common household measures for ease of estimation of portion eaten. Foods were grouped in a manner to allow for estimation of fat and types of fat. Thus, food items which were conceptually similar were further grouped by cooking methods and also by the form commonly eaten by the sub-

Table 3. Cross-classification of dietary intakes in Singaporean adults into quintiles by food frequency questionnaire (total number of subjects = 126) and 24-h recalls

Food component	Same or adjacent category (n)	Gross misclassification (n)**	P*
Energy (kcal)	88	0	0.65
Fat (g)			
Total	85	2	0.29
Saturated	91	2	0.54
Polyunsaturated	76	1	0.29
Monounsaturated	89	1	0.77
Cholesterol (mg)	89	1	0.77
Protein (g)	71	2	0.57

*χ^2 to test observed misclassifications from expected, ** being classified from one extreme category to the other extreme category.

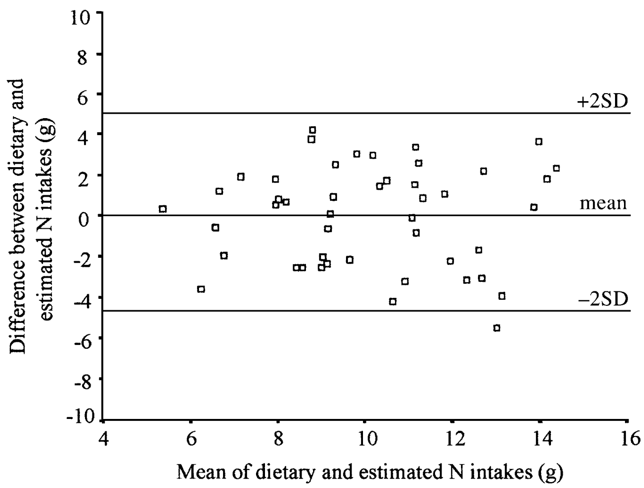

Figure 1. Plot of difference in dietary N intakes (from multiple 24-h recalls) and estimated N intakes (from urinary N excretion) against mean of dietary and estimated N intakes.

Table 4. Comparison of 24-h dietary N intake and estimated N intake from urinary urea excretion ($n = 46$) in Singaporean adults

N intake (g/day)		Estimated N intake (g/day)*		Difference (intake – estimated)		Correlation coefficient**	
Mean	SD	Mean	SD	Mean	95% CI	r	95% CI
10.2	2.6	10.2	2.6	–0.0	(–0.7, 0.7)	0.55	(0.31, 0.72)

*Calculated as (N excretion from urea/0. 9)/0.8 11, ** Pearson's product-moment correlation coefficient ($P < 0.05$).

jects (for example, poultry with skin, poultry without skin were in different main food types). The food items in each group had similar energy, fat and cholesterol content per serving. There is a fairly extensive intermingling of all races in Singaporeans, resulting in diets comprising foods originating from different ethnic backgrounds. For example, in the hawker centres or food courts (a collection of food stalls selling ready-to-eat foods) patronized by almost all, one can find Chinese, Indian and Malay foods sold side by side and it is not uncommon for patrons to buy from more than one stall. More recently halal Chinese foods are also available locally. Thus, it was necessary that the types of foods included in the list covered those consumed by all three ethnic groups, making this questionnaire valid for all three ethnic groups.

During the validation study, the choice of reference method was made to enable ranking of individuals into quintiles rather than to estimate actual individual intake. Multiple 24 h recalls would enable this without imposing too high a respondent burden (compared to food records or dietary history). This was the method thought to be most appropriate for population groups where there is a possibility of variation in the quality of food-record data.[30] The estimated N intake from the urinary biomarker correlated well with the dietary N intake data for this reference method. This, together with the mean difference between the estimated and dietary N intakes of 0.0 ± 0.4 g, supports the suitability of the multiple 24 h recalls as a reference method in this study. The use of the additional biochemical marker has the advantage in that the potential sources of random error occurring with the urinary marker are different from those of the questionnaire measurement (in this case, the FFQ). In addition, these errors are also unlikely to be correlated with those of daily intake measurements (the reference method). Kaaks,[31] therefore advocated the use of the additional biochemical marker in validation studies to make it more likely that criteria of independent errors are met.

The deviation of the intake data obtained from the newly developed FFQ as compared to the reference method is within the limits reported in other studies. For fat intake (a major concern in this study), studies conducted by various research groups reported an overestimation with FFQ in the range of between 1 and 55% of the reference method.[32–36] The overestimation found in this study is 3% of the reference. The Pearson correlation coefficient of 0.58 between fat intake from FFQ and reference method in this study is also consistent with those reported in other studies. For example, most studies in America reported correlation coefficients of between 0.4 and 0.7, both in minority and non-minority groups,[30] while a study in the Netherlands reported a fairly high correlation coefficient of 0.78.[37] This correlation appeared to be inversely proportionate to the time interval between the administrations of the different methodologies. All the intakes obtained from this newly developed FFQ are significantly correlated to those obtained from the reference method, ranging from 0.56 for energy to 0.39 for polyunsaturated fat.

The main purpose of this validation study was to determine the ability of the newly developed FFQ to classify individuals into the respective quintiles of intake when compared to multiple 24 h recalls over a reference period of one month. Cross-classification resulted in correct classification into the same or adjacent quintile for 70% of cases for energy and the five nutrients, with a minimum of gross misclassifications. Statistical testing showed that the proportion of misclassification was not significantly more than that expected, on the basis of the correlation coefficients.

In conclusion, the newly developed FFQ has been found to be an adequate tool for the assessment of dietary intakes of energy, total fat, saturated fat, polyunsaturated fat, monounsaturated fat and cholesterol among adult Singaporeans. The FFQ can be used as a dietary tool to classify individuals into quintiles of intake for purposes of evaluating aetiologic hypotheses and interactions between dietary intakes and disease risk factors.

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Annex 1. Food groups and subgroups in FFQ

Food group	No. items	Subgroups	No. items
1. Bread	7		
2. Bread spreads	5		
3. Cereals	2		
4. Rice**	2		
5. Flavoured rice**	7		
6. Flavoured porridge**	1		
7. Noodles**	12	Noodles in soup	2
		Dry noodles	2
		Fried noodles	4
		Noodles in lemak (creamy) gravy	3
		Others	1
8. Vegetables**	28	Pale green leafy	5
		Dark green leafy	5
		Tomatoes, carrots, red/yellow peppers	4
		Fresh legumes and pulses	5
		Mixed vegetables	5
		Potatoes	1
		Others (roots/stems)	3
9. Tofu/beancurd**	2		
10. Salad dressings	3		
11. Fruits	5		
12. Poultry**	12	Poultry without skin	6
		Poultry with skin	6
13. Meat**	19	Meat - lean	7
		Meat - lean and fat	7
		Meat - preserved/cured	5
14. Fish/seafood**	14	Fish	7
		Other seafood	7
15. Eggs**	2		
16. Desserts/local snacks**	8	Desserts in soup	2
		Kueh kueh - steamed	2
		Others	4
17. Biscuits, pastries and cakes**	6		
18. Fast foods and soft drinks**	5		
19. Nuts	2		
20. Tidbits and snacks	3		
21. Hot beverages*	3		
22. Milk and dairy products	7	Milk	3
		Yoghurt	2
		Cheese	2
23. Alcoholic beverages	4		

*A choice of seven additions could be made, **for cooked items with added fat or oils, a choice of eight types could be made.