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Validation and Reproducibility of a Culturally Specific Food Frequency Questionnaire (FFQ) for Malaysian Punjabis

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ABSTRACT

Introduction: Validation of a culturally specific FFQ is important in assessing habitual dietary intake of ethnic population groups. This study aimed to assess the validity and reproducibility of a FFQ developed specifically for determining the dietary intake of Malaysian Punjabis. **Methods:** Subjects were approached through voluntary participation for the development and validation phase in the Klang Valley. A list of foods consumed by participants (n=100) was documented through a 3-day dietary recall. The validation process was conducted by verifying the developed FFQ against another group of Punjabi adult volunteers (n=101) who kept a 2-day dietary record. Macronutrients, dietary fibre, fatty acids, cholesterol, three types of minerals (calcium, sodium, iron) and four vitamins (B_{12}, folate, C, A) were included in the analysis. Reproducibility was shown with intra-class correlation (ICC) values between FFQ1 *vs* FFQ2 that were administered 6 months apart among 32 participants. **Results:** In the validation study, the FFQ1 was found to have over-estimated almost all nutrients compared to those in the dietary records. The Spearman correlation coefficients for energy, carbohydrate, protein and fat intake based on the FFQ1 and 2-day dietary records were 0.54, 0.38, 0.47, and 0.31, respectively. The classification into the same and adjacent quartiles was between 61- 84% for the nutrients consumed. Bland Altman plots showed relatively good agreement (between ±2 standard deviation) for both the dietary methods used. Reproducibility analysis of ICC (FFQ1 *vs* FFQ2) was between 0.46-0.76 for macronutrients and 0.20-0.92 for micronutrients. **Conclusion:** The developed FFQ could be used as a valid tool for assessing dietary intake of Malaysian Punjabis, as it showed a moderate agreement with dietary record for intake of energy and macronutrients.

Key words: Dietary intake, Food Frequency Questionnaire, Malaysian Punjabis, reproducibility, validation

INTRODUCTION

Punjabis are known to be the second largest group of the peoples of South Asian descent and one of the most diversified ethnic groups in the world originating from India (Ishtiaq Ahmed, 2008). Genetic predisposition as well as higher abdominal fat has been linked to these individuals exposing them to higher risk of developing non-communicable diseases (Misra *et al.*, 2007). In a study conducted in the UK, migrant Punjabis were noted to have a

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higher prevalence of clustered risk factors of cardiovascular diseases and diabetes compared to other ethnic groups (Tillin *et al.,* 2005).

Early evidence validates the rapid migration of the Punjabis into Malaya in the 19th century (Gill & Gopal, 2010). The community has since been incorporating the local culture and lifestyle as part of their daily life. Acculturation has been reviewed to be one of the main factors of dietary pattern changes in a migrated community such as the Punjabis in Malaysia. The changes from the native diet to a more acculturate dietary pattern has shown the emergence of chronic diseases, particularly in this ethnic group (Gilbert & Khokhar, 2008). Based on the usual dietary pattern of Punjabis, it has been documented that the usage of ghee and butter for cooking is high in addition to the high frequency of consumption of Indian sweets (*barfi, jelebi, laddu*) (Simmons & Williams, 2007). This highlights the dietary intake to be higher in fats and sugar which is very much associated with the development of chronic diseases.

Migration of this ethnic group into Malaysia was due to occupational factors with most of them being employed in the armed forces. Punjabis who migrated to Malaysia mostly practise Sikhism (Gill & Gopal, 2010). Migration has an important role in the emergence of chronic diseases as evident in the United States where a more acculturated community has been shown to mimic the host culture in terms of their dietary intake (Kim & Chan, 2004) Dietary practices in Malaysia have been varied mainly due to it being a multi-ethnic country comprising three major ethnic groups namely Malays, Chinese and Indians. Hence, assessment of the dietary intake may appear to be challenging for this multi-cultural population.

The food frequency questionnaire (FFQ) is the most widely used inexpensive dietary tool to assess dietary intake at the population level. It is able to measure the typical dietary intake of an individual over time as compared to other measures of dietary measurement; however, one FFQ may not serve all different groups of population (Cade *et al*., 2004). In terms of measuring diet within a specific ethnic group, FFQ serves as a convenient tool as traditional foods can be incorporated making it a more sensitive tool for measuring dietary intake or pattern in a community that practices the same culture and to further associate the dietary exposure to health outcomes (Cade *et al*., 2004; Sevak *et al*., 2004). A culturally specific FFQ is needed when a minority group's dietary intake is of concern mainly because a general FFQ will not be able to capture the traditional food that is closely linked to an individual's habitual intake (Kelemen *et al*., 2003).

To the best of our knowledge, there has been no known FFQ developed and validated specifically for the Malaysian Punjabis, and this could be the first attempt at developing such a tool for use in this community in Malaysia. Hence, it may serve as a useful tool to further evaluate the dietary intake and pattern of this ethnic group to help in chronic disease prevention.

METHODS

This study was approved by the Human Research Ethics Committee of Universiti Sains Malaysia (USM/JEPeM/281.3. (4)) and written informed consent was obtained from all participants. All participants voluntarily participated in this study and were recruited from Sikh temples in the central region of Malaysia. Due to good co-operation, participants were conveniently recruited. They were however, required to be Malaysians citizens, of Punjabi ethnicity, between the age group of 18 to 59 years old and were able to give their informed consent in order to participate in this study. The study flow is illustrated in Figure 1.

Development phase - Pilot study

Upon assessing the criteria needed, 150 individuals agreed to take part in the development study; however due to incomplete recalls, the dietary recalls of only 100 individuals were finally utilised. They were required to complete a 3-day dietary recall of their daily intake. Guided imagery of household measurements (E.g., standard bowls, cups and spoons) conducted by the researcher and trained enumerators was shown to participants of the study during the dietary recall process to help them with the recall. In addition the Malaysian Food Atlas (Suzana *et al.*, 2009) was also shown to obtain the portion sizes of the foods consumed. There were three major steps in the development phase which included constructing the food list from the diet recalls, classifying and organising the food items and finally assigning portion sizes and frequency of intake. Commonly consumed food items were compiled into a food list and the average weight of foods consumed was defined as the average portion sizes. Face and content validity was confirmed by two nutritionists who were familiar with the ethnic's dietary intake. They verified the food list and if food prominent in the diet of this population was missing, these foods were added to the list and the FFQ was then finalised. The FFQ consisted of the food items, its standard portion size and frequency of intake. Each food item was assigned a standard portion size based on the average weight gathered from the 3-day dietary recall and reviewed against

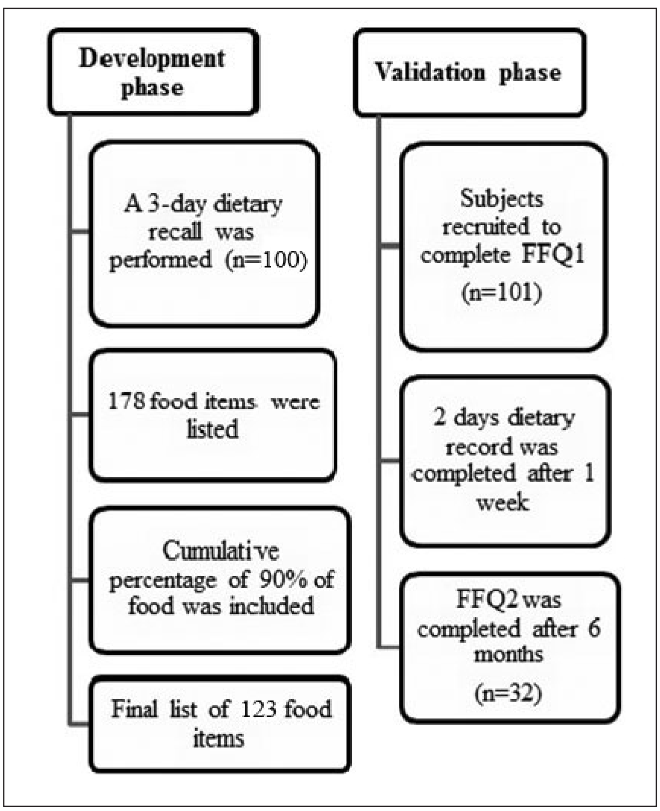

Figure 1. Flow chart to depict the development and validation phase of the FFQ.

the reported portions of the Malaysian food composition table (Tee *et al*., 1997) and atlas (Suzana *et al*., 2009). Food items were assigned to the following food groups: grains and cereals, starches, meat, legumes, pulses and nuts, milk and dairy products, vegetables, fruit, fried snacks/confectionary, spreads and pickles and beverages. The intake frequencies were kept at four open ended choices to allow participants to indicate the frequency they consumed in a day, week or month with an additional option of never or rarely. Frequencies were structured to obtain past one month intake.

Validation and reproducibility phase

Participants in the validation phase were required to complete the developed FFQ (FFQ1) and 2-day (one weekday and one weekend) dietary record. The dietary record served as the reference method for the FFQ validation process. Socio-demographic data on age, gender and education level was collected prior to dietary intake data. The FFQ was completed through self-administration after a short briefing; an average of 30 to 40 min was needed to complete it. As for the dietary record (DR), the first diet record (DR1) was conducted a day after the FFQ completion and the second DR (DR2) was done in the same week. This helped to ensure continued participation and reduce the dropout rate. The second FFQ (FFQ2) was completed after 6 months by the same participants of the FFQ1 administration for the reproducibility study. Due to a lower response rate, attributed to work and time commitment, 32% of the individuals agreed to complete the second FFQ (FFQ2).

Data analysis

The Malaysia Food Composition Database (Tee *et al.*, 1997) was used to calculate the energy intake and all nutrients. However, only Malaysian foods were able to be computed using this database. Punjabi foods (E.g.: *paneer, alooghobi, jelebi*) were gathered mainly from the Indian and Pakistan food database (Gopalan *et al.*, 1989; Hussain *et al.* 2001)and it was added into the Nutritionist Pro™software (Axxya Systems LLC., USA) to analyse the nutrient intakes. Energy and dietary fibre intakes were included in the analysis. In addition, nutrients analysed comprised all macronutrients, fatty acids, cholesterol, vitamins (A, B12, folate, C) and minerals (calcium, iron, sodium). Mixed dishes that were not available in the databases were added into the software by including the standard recipes of the foods.

Data was presented in median and interquartile range due to abnormality in distribution. Nutrient intake values were adjusted using the residual method whereby nutrient intake was regressed on total energy intake. The adjustment is generally done to correct the attenuation caused by intra-individual day-to-day variation. Correlation coefficient between both methods (FFQ *vs* DR) was de-attenuated by considering the within to between individual variation. Wilcoxon Rank test was performed to determine the differences between the FFQ and the DRs and Spearman correlation analysis was conducted to validate the FFQ against the DR method, as it serves as a reference method.

Cross-classification of quartiles (5^{th}, 50^{th} and 95^{th} percentiles) analysis was performed to determine correctly classified individuals in terms of their nutrient intakes from data of the FFQ and two DR. This was conducted through the ability of both dietary methods to be correctly classified in the same quartile, ± one quartile or grossly misclassified. Bland Altman plots were constructed to ensure the level of agreement between both methods. Reproducibility of the FFQs was determined using the Intra Class Correlation (ICC) analysis that was performed on FFQ1 and FFQ2. ICC is a measurement of agreement between two methods whereby comparison is done using ANOVA model to ascertain the between and within group variability. Values close to 1 represent good agreement, and closer to 0 is viewed as lesser agreement between the methods. The interpretation of agreement can be further explained as follows: 0.0-2 as poor; 0.3-0.4 as fair; 0.5-0.6 as moderate; 0.7-0.8 as strong and finally >0.8 as almost perfect agreement (Portney & Watkins, 2000). SPSS Version 20 was used for all data analysis and a p value of <0.05 was used for all analysis.

RESULTS

Participants in this validation study (n=101) were mainly from the central region of Peninsular Malaysia particularly from Kuala Lumpur and Selangor. More females participated (58.4%) in the study. Their mean age was 31.4 ± 11 years and most had tertiary education (81%). The FFQ which has been developed through the food list initially had a list of 178 food items. Food items were then arranged in descending order based on contribution of the highest to lowest percentage of energy (calories). The cumulative percentage of food items, contributing to 95% of total energy intake, was then included into the food list of the FFQ. In addition, common Punjabi foods that were missed through the recall were also included into the list (E.g., cow's milk, *jelebi)*. A final total of 123 food items was then generated and divided into the respective food groups.

Table 1 shows the median nutrient intake based on the multiple 24-h dietary records and FFQ developed. The FFQ had significantly higher estimates of nutrient intakes except for fat, saturated fat, cholesterol, PUFA, iron, folate and sodium. However, despite being insignificant, all nutrients were found to be higher in FFQ as compared to the dietary records except for sodium. Average relative difference of both methods was 20% with the highest for vitamin C (92%) and lowest for sodium (0.9%). Percentage of energy from macronutrients intake did not differ significantly between FFQ and dietary records.

Spearman correlation coefficient of both the methods were found to be significantly correlated with the macronutrients (energy 0.54, carbohydrate 0.47, protein 0.38, fat 0.31) but not for some micronutrients (calcium, iron, sodium, folate, vitamin A) (Table 2). Energy adjustment reduced the correlation for almost all nutrients (0.34 to 0.01). Classification into the same and adjacent quartiles was highest in energy (84%) and lowest in cholesterol (62%). Macronutrients were classified correctly by 82% for carbohydrate, 77% for fat and 76% for protein. Misclassification appeared to be low as there were only 3 nutrients with more than 10% gross classification (cholesterol 11%, iron 11%, and sodium 12%). Mean of gross classification derived from both methods was 8%.

The Bland Altman plot generated shows the level of agreement between the FFQ and 2-day dietary records (Figure 2). These plots were generated to observe differences between FFQ and DR and the 95% level of agreement was computed. From the analysis, the level of agreement between both methods was deemed to be acceptable as the scatter plot was mostly between the dotted lines (Mean ±2SD).

Reproducibility of the FFQ was tested using Intra Class Correlation (ICC) analysis and cross-classification to ascertain the ability of the FFQ to assess nutrient intake one year apart (Table 3). Macronutrients showed relatively moderate to strong agreement between both FFQs with a range of 0.46 (protein) to 0.73 (fat). ICC for micronutrients ranged from 0.25 (Vitamin C) to 0.92 (iron) between FFQ1 and FFQ2. Classification into the same and adjacent quartile varied from 53% (sodium) to 91% (fat). Mean gross misclassification between both FFQs was 3.9%.

DISCUSSION

This study examined the validity and

Table 1. Median daily intake of nutrient, relative difference and mean of nutrient densities between FFQ and 2 day diet records (DR) in the study population (n=101)

Nutrient	*FFQ Median (P_5, P_{95})*	*24-hour DR Median (P_5, P_{95})*	*Relative difference (%)*
Energy (kcal/d)	1940 (1263, 2809)	1826** (1261, 2580)	9.7
Protein (g/d)	77.4 (38.3, 148)	69.8** (38.8,118)	11.2
Carbohydrate (g/d)	265 (167,441.1)	243.9** (164.7, 356.2)	10.6
Fat (g/d)	66.2 (33.7,107.6)	61.48 (34.1, 93.2)	9.3
Saturated fat (g/d)	15.6 (6.1,30.1)	14.6 (6.2, 32)	1.4
Cholesterol (mg/d)	160 (41.2,410.1)	148 (31.2, 491.1)	-1.1
MUFA (g/d)	12.4 (5.4,32.3)	11* (3.3, 21.9)	27.1
PUFA (g/d)	7.5 (3.4,18.8)	7.5 (1.7, 15.1)	8.1
Calcium (mg/d)	864.6 (456.9,1731.6)	679.6** (351.7, 1177.4)	30
Iron (mg/d)	16.3 (9.8,35.4)	15.7 (9.1, 32.9)	1.4
Sodium (mg/d)	2011.3 (959.1, 4591.4)	2145.1 (984, 3764)	0.9
Dietary Fiber (g/d)	10.4 (4,28.7)	9.7* (3.5, 22.2)	15.7
Vitamin C (mg/d)	120 (45.3, 473.6)	52.5** (8.3, 205.2)	92.9
Folate (mg/d)	150 (76.2,441.6)	159.6 (48.7, 479.2)	-2.3
Vitamin B12 (mg/d)	6.2 (0.3,30)	1.2** (0.18, 24)	63
Vitamin A (mg/d)	920.9 (471, 2036)	663** (275.8, 1871.6)	42

Nutrient densities	FFQ		2-day DR	
	Mean	SD	Mean	SD
% energy from fat	30.0	9.3	30.3	5.9
% energy from protein	16.3	4.8	16.2	5.2
% energy from carbohydrates	55.0	10.3	54.6	7.2

* Significantly different at *p*-value <0.05
** Significantly different at *p*-value <0.01

reproducibility of the specific FFQ developed for the Malaysian Punjabis mainly to determine the energy and macronutrients intake. The main objective of this study was to develop a precise tool to measure dietary intake among adults of this population and the FFQ has been deemed to be the most suitable for this purpose in a large epidemiological study. The 123 food items in this FFQ have been relatively similar and comparable to those used in larger studies among the South

Table 2. Spearman correlation coefficient and cross-classification for the comparison between FFQ and 2-day diet records (DR) (n=101)

Nutrient	*Spearman correlation*		*Cross-classification into quartiles (%)*	
	Unadjusted	*Energy-adjusted*	*Correctly classified*	*Grossly misclassified*
Energy (kcal/d)	0.54**	-	84	3
Protein (g/d)	0.38**	0.27**	76	4
Carbohydrate (g/d)	0.47**	0.34**	82	8
Fat (g/d)	0.31*	0.20	77	6
Saturated fat (g/d)	0.33**	0.27**	76	8
Cholesterol (mg/d)	0.14	0.14	62	11
MUFA (g/d)	0.21*	0.12	74	10
PUFA (g/d)	0.12	0.11	69	10
Calcium (mg/d)	0.10	0.05	63	10
Iron (mg/d)	0.16	0.03	71	11
Sodium (mg/d)	0.15	0.01	69	12
Dietary fibre(g/d)	0.31**	0.25*	73	7
Vitamin C (mg/d)	0.22*	0.19	70	8
Folate (mg/d)	0.12	0.11	65	9
Vit B12 (mg/d)	0.32**	0.33**	74	5
Vitamin A (mg/d)	0.16	0.07	65	7

* Significantly different at *p*-value <0.05
** Significantly different at *p*-value <0.01

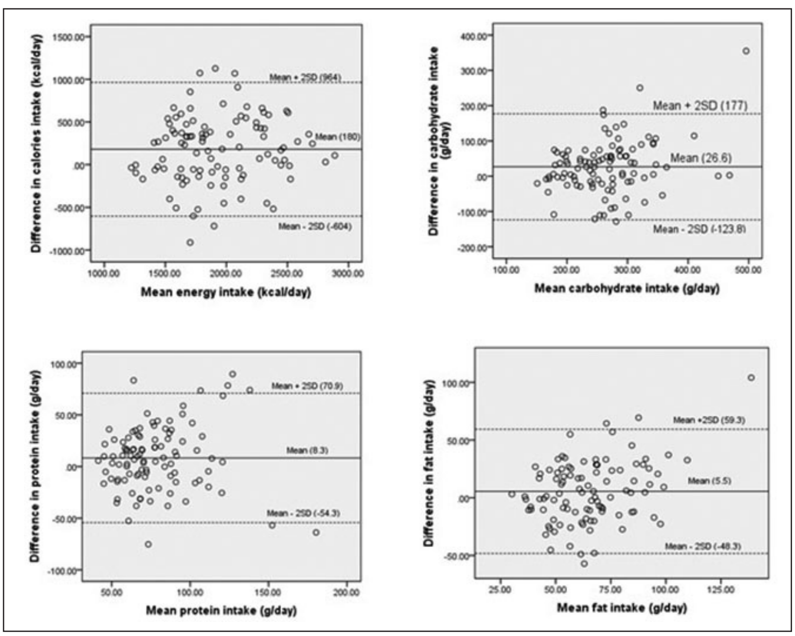

Figure 2. Bland Altman plots showing agreement between FFQ and multiple 2-day dietary records for energy and macronutrients intake. The agreement between both dietary methods is indicated by representing the mean difference with a solid line while the dashed line represents the level of agreement (Mean ± 2SD).

Table 3. Reproducibility study - mean intake of nutrient, intraclass correlation coefficient and cross -classification for comparison of FFQ1 and FFQ2 (n=32)

Nutrient	*FFQ1*	*FFQ2*			*Cross-classification into quartiles (%)*	
	Mean (SD)	*Mean(SD)*	*p-value**	*ICC§*	*Correctly classified*	*Grossly misclassified*
Energy (kcal/d)	1911.9 (435.2)	1798.9 (473.0)	0.16	0.68	81	3
Protein (g/d)	83.5 (26.4)	72.6 (23.4)	0.05	0.46	72	6
Carbohydrate (g/d)	252.9 (68.0)	220.0 (89.8)	0.06	0.47	72	6
Fat (g/d)	65.2 (21.4)	68.8 (34.3)	0.45	0.73	91	3
Saturated fat (g/d)	15.3 (5.4)	16.2 (7.3)	0.38	0.75	81	-
Cholesterol (mg/d)	183.0 (114.3)	307.5 (177.4)	<0.05*	0.40	72	3
MUFA (g/d)	12.9 (5.7)	16.0 (8.5)	0.04*	0.52	81	-
PUFA (g/d)	7.4 (3.1)	8.5 (4.1)	0.16	0.40	81	3
Calcium (mg/d)	840.8 (290.6)	778.3 (307.2)	0.29	0.57	81	-
Iron (mg/d)	16.9 (9.3)	17.6 (13.3)	0.57	0.92	84	3
Sodium (mg/d)	1938.7 (748.7)	1613.7 (479.2)	0.02*	0.46	53	6
Dietary fibre (g/d)	10.0 (6.5)	9.3 (4.0)	0.53	0.45	84	3
Vitamin C (mg/d)	106.4 (44.2)	108.4 (56.8)	0.86	0.25	63	9
Folate (mg/d)	211.9 (344.4)	173.0 (123.3)	0.45	0.55	59	9
Vit B12 (mg/d)	9.9 (10.6)	4.5 (4.0)	0.01*	0.27	63	3
Vitamin A (mg/d)	948.4 (473.5)	844.3 (394.7)	0.30	0.33	72	6

* Significantly different at *p*-value <0.05
§ ICC values

Asians (Sevak *et al.,* 2004; Kelemen *et al.,* 2003). The time taken to complete the FFQ appeared to be close to previous studies reflecting the suitability of total food items listed (Cade *et al*., 2004).

Although minority ethnic groups have been generally regarded as a challenging group to capture due to sample size issues, geographical diversity, socio-economic standing and cooperation (Ngo *et al*., 2009), we were able to recruit an adequate number of individuals. As suggested by (Cade *et al*., 2004), a sample of 100 is deemed suitable for a validation study. The food items included in the FFQ represent both the Malaysian and Punjabi diet and this was verified by conducting content validity involving experts in the field and population studied.

The response for completing the validation study appeared to be satisfactory with a sufficient number of individuals participating; however the reproducibility study had a lower response (32%). Validation studies often require higher respondent cooperation in completing the FFQ together with keeping records of their dietary intake. Nevertheless, this response rate appeared to be sufficient to undertake the FFQ validation (Yokota, Miyazaki & Ito, 2010) and reproducibility studies (Marques-Vidal *et al*., 2011), both of which had a similar number recruited. Dietary record was chosen to serve as the reference method mainly as it differs from FFQ administration technique and was shown to provide high precision for dietary intake among individuals (Pereira *et al.,* 2010). Further, Cade *et al*. (2004) state that the dietary record method is the second most preferred reference method used.

The validity of the FFQ developed is acceptable as it had moderate correlation between the FFQ and dietary records for energy (0.54), protein (0.38), carbohydrate (0.47) and fat intake (0.31). The FFQ developed for South Asians in the UK previously had reported similar energy correlation values to the present study with r-value of 0.3 (Norimah & Margetts 1997) and 0.48 (Sevak *et al*., 2004). In addition (Willett & Lenart, 1998) reported that correlation coefficients of between 0.5 to 0.7 are appropriate for validation studies. Energy adjustment did not improve all correlations values in this study. A similar pattern was also observed in several FFQ validation studies (Buscemia *et al.*, 2015; Ishihara *et al*., 2009; Silva *et al*., 2013). Although we did not account for food group determination in this study, it has been reported that dietary intake that depends largely on a particular staple food would affect the overall energy intake. Performing energy adjustment analysis subsequent to that will lead to over adjustment of the nutrients and eliminate large variations thus lowering the correlation values (Silva *et al*., 2013). Based on the cross-classification analysis, more than 60% of individuals were also correctly classified into the same and adjacent quartile. Gross classification was comparable to other studies related to the South Asian population (Pandey *et al*., 2005; Sevak *et al*., 2004) as it is mostly below 10% except for cholesterol (11%), iron (11%) and sodium (12%). The range of gross classification from the studies done on the South Asians in the UK was between 0-10% (Sevak *et al*., 2004) and 0-14% among those residing in urban India (Pandey *et al*., 2005). Masson *et al.* (2003) reported that individuals who were correctly classified into more than 50% and less than 10% of the tertile are acceptable to verify validity of a FFQ. Agreement and correlation values have been viewed to better represent validity and thus energy adjustment may not be warranted if these are in good agreement (Silva *et al*., 2013).

The reproducibility of the FFQ six months apart was acceptable with the correlation coefficients for most nutrients being above 0.4 except for vitamin A, C and B12. Cade *et al.* (2004) suggest that correlations above 0.4 are acceptable for determination of reproducibility of an instrument. Vitamin C (Iqbal *et al.*, 2014) and Vitamin A (Watson *et al.*,2009) have been reported to reflect a lower agreement to reproduce similar values as in the present study. The present study had ICC values of 0.68 for energy; 0.46 - 0.73 for macronutrients and 0.29 - 0.92 for micronutrients. In comparison to a study done in Argentina (Dehghan *et al.,* 2012), this study reflected higher ICC values although the Argentinian study had a smaller range (0.31- 0.50 for macronutrients and 0.30-0.56 for micronutrients). FFQs that are developed have the ability to assess some but not all nutrients, mostly the micronutrients (Iqbal *et al*., 2014; Watson *et al*., 2009) due to large day-to-day variation in these nutrient intakes; they also tend to miss food items in the FFQ that make up an individual's dietary sources (Iqbal *et al*., 2014).

A higher correlation has been noted for more specific populations such as pregnant women (Loy *et al.*, 2011) as their intake does not vary greatly in a short period of time as compared to normal adults. Changes in the foods consumed during acute periods when recording their food intake and FFQ has been noted to affect the outcome of reporting representativeness of the dietary intake in an individual (Kassam-Khamis *et al*., 1999). A shorter time interval of FFQ administration (Marques-Vidal *et al.* 2011), interview administered FFQ (Kassam-Khamis *et al.*, 1999) and increasing the number of FFQ administered may be able to improve the correlation coefficient values.

The study's limitation could be addressed by incorporating nutrient biomarkers to further ascertain the validation of a FFQ as this has been accepted as the gold standard for nutrient assessment. Replicating the dietary records to at least 5 days of dietary intake may also help in generating closer to accurate nutrient values for an individual.

Sampling method could also be improved by diversifying participants from a wider geographical area in Malaysia with the inclusion of rural regions.

The development and validation of this FFQ to determine the Punjabi population's dietary intake is the first such attempt in Malaysia. This FFQ is able to determine the energy and macronutrients well by taking into account traditional related foods; however, future work may be needed for specific nutrients. The tool developed can be utilised to determine the intake of a larger population. This FFQ may help in understanding the intake pattern of the Malaysian Punjabis.

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