ORIGINAL ARTICLE

Validity and Reproducibility of an Interviewer-administered Food Frequency Questionnaire for the Assessment of Riboflavin Intake in Malaysian Women in Selangor

Ru En How[1], Su Peng Loh[1,2], Geok Lin Khor[1]

[1] Department of Nutrition and Dietetics, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia
[2] Research Centre of Excellence, Nutrition and Non-Communicable Diseases (NNCD), Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia

ABSTRACT

Introduction: The aim of this study was to assess the validity and reproducibility of a food frequency questionnaire (FFQ) specifically developed for the assessment of riboflavin intake among Malaysian women in Selangor. **Methods:** The study was carried out in Universiti Putra Malaysia (UPM), which consisted of 204 healthy women (102 Chinese and 102 Malay) aged between 19 and 45 years. The FFQs were interviewer-administered, which were completed twice; at the beginning of the study (FFQ-1) and two weeks thereafter (FFQ-2). A two-day 24-hour dietary recall (24DR) was interviewer-administered as the standard criteria method. Data were analyzed using Wilcoxon signed ranks test, Spearman correlation coefficient (SCC), intra-class correlation coefficient (ICC) and Bland-Altman plots to determine the validity and reproducibility. **Results:** Median riboflavin intake derived from 24DRs was significantly higher than FFQ-2 ($p<0.01$). Both FFQ-1 and FFQ-2 correlated significantly ($p<0.01$) with 24DRs with r-value of 0.264 and 0.227, respectively. As for reproducibility between FFQs, SCC value was statistically significant ($p<0.01$) at 0.545 whereby ICC value was 0.752, which considered as good. Most data points fell between the limits of agreements and were found closer to the horizontal line in the middle. However, the plots showed no linear trend existed between FFQ and 24DR over the range of mean riboflavin intake. **Conclusion:** The newly developed FFQ were found to be valid and relatively reproducible in the assessment of riboflavin intake among Malaysian women in Selangor.

Keywords: Food frequency questionnaire (FFQ), Riboflavin, Validity, Reproducibility, Women

Corresponding Author:
Loh Su Peng, PhD
Email: sploh@upm.edu.my
Tel: +603-89472432

INTRODUCTION

Riboflavin (7, 8-dimethyl-10-ribityl-isoalloxazine), which is known as vitamin B2, is a water-soluble B vitamin that presents in a wide variety of food. The classic role of riboflavin is as a cofactor in redox metabolic reactions involving energy production and is crucial for the production, conversion and reutilization of vitamin B3 (niacin), B6 (pyridoxine) and B9 (folate) (1). Its derivatives exert directs antioxidant properties and increase endogenous antioxidant status vital cofactors in glutathione oxidation-reduction cycle (2).

The clinical symptoms of riboflavin deficiency in human do not have the specificity but various symptoms may be manifested, such as weakness, fatigue, cracks and sores at the corners of the mouth, eye disorders and skin lesions (3). Further, severe deficiency may cause cheilosis, angular stomatitis, photophobia, dermatitis, anemia and elevated blood pressure in certain individuals (4). Inadequate dietary intake of riboflavin is the major cause of hypo-riboflavinosis (5). However, there is a lack of data reporting on riboflavin status among Malaysian. Only in a previous cross-sectional study conducted in Klang Valley by Gan et al (6), using two-day 24-hour dietary recall, reported that 72% of university female students had failed to reach the recommended nutrient intake (RNI) for riboflavin, which is 1.1mg per day for childbearing women aged 19 to 65 years old (7).

Various methods have been developed and can be used to assess the intake of dietary nutrient which included 24-hour dietary recalls (24DR), diet histories, food records and Food Frequency Questionnaires (FFQs). Although food record and 24DR have a better validity in providing information on daily nutrients intake, these methods were found to be less suitable for large-scale epidemiological studies. In this case, FFQs are favored because they are time-saving, cheaper, less intrusive, easier to administer and more convenient for both interviewers and participants (8). Additionally, FFQs measure average long-term diet that covers a longer duration of dietary recalls varying from months to years.

The accuracy of dietary intake measured from FFQ allows the researchers to examine the possible relationship between diet and study outcomes. Hence, the validity and reproducibility of the FFQ are essential and should be compared with a “gold standard” for enabling it to be adapted for a specific population. In Malaysia, the validated FFQs to assess the intake of riboflavin are rather scarce especially among women. The key component in developing FFQ is to include the food items that match its nutrient yield with the recommended requirement. Thus, this study sought to validate the FFQ specially developed for the estimation of riboflavin intake among Malaysian Malay and Chinese women. Malay and Chinese women are chosen because they are the major ethnic groups in Malaysia. We postulate that different ethnic have different dietary practices which could make them at greater risk of riboflavin deficiency.

MATERIALS AND METHODS

Study participants

In this observational, cross-sectional study, a convenience sample of 210 healthy women of childbearing age between 19 and 45 years (105 Chinese and 105 Malay) was recruited in Universiti Putra Malaysia (UPM), Serdang for the validation and reproducibility of FFQ for the riboflavin intake. Data collection was conducted between May and June 2016. The study had been approved by the Ethics Committee for Research Involving Human Subjects Universiti Putra Malaysia.

Study protocol

Participants volunteered in the study for the duration of one month. Face-to-face interviews were conducted twice at different faculties at the Universiti Putra Malaysia. During the first face-to-face interview, a social-demographic questionnaire, the first FFQ (FFQ-1) and the first two-day 24-hour DR (24DR-1) were completed. Anthropometric data was also obtained during the first meeting. For short-term reliability verification of the FFQ, we compared each participant’s first and second FFQ sets within an interval of two weeks. Hence, after two weeks, the second face-to-face interview was carried out in which the participants completed the second FFQ-2 and 24DR-2. The study design was relatively the same as Wong et al. (9) and Mohammadifard et al. (10). All interview sessions were carried out by the same researcher to minimized interviewer bias.

Out of 210 participants, only 204 women (102 Chinese and 102 Malay) showed up for both of the visits. The reasons for participants being dropped out including not showing up during the follow-up session as well as the questionnaire was not been filled up properly. Despite the dropout, the number is considered sufficient for validation studies of dietary nutrient intake with ideal sample suggested in Willett (8), which is between 100 and 200 of participants.

Data collection

Socio-demographic questionnaire

The socio-demographic questionnaire comprised data on education, marital status, ethnicity, annual income, lifestyle habits and medical information.

Anthropometric assessment

Anthropometric measurements including weight (in kilogram) and height (in centimeter) were obtained using TANITA weighing scale and SECA body meter respectively. Before stepping on the weighing scale, participants were asked to take off as much outwear as possible. Participants were weighed to the nearest 0.1kg in bare feet. Height was measured to the nearest 0.1cm. The calculation of Body Mass Index (BMI) was based on formula weight (kg)/ height (m2). Waist circumference (WC) was taken as well using SECA 201 measuring tape. All the measurements were duplicated and mean results were reported in the analysis.

Dietary intake assessment

The FFQ comprised of three sections, which are the list of foods, the portion size and the frequency of consumption. A total of 56 listed closed-ended food item questions covering the foods and beverages known to be the important source of riboflavin were selected based on the Nutrient Composition of Malaysian Food. FFQ was assembled into five food groups: milk and milk products, vegetables, legumes and nuts, meat and meat products as well as fish and fish products, which is presented in Table 1. For portion size, the participants indicated their food intake according to a reference portion size, in which for every single food item is regarded as one standard serving exhibited in household measures (cups, spoons and plates) and/ or common packing size. The visual diagram of food

Table I: Studied food and food groups of Food Frequency Questionnaire (FFQ).

Food Groups	Types of Food
Milk and milk products	Fresh milk, UHT milk (full cream), UHT milk (low fat), Apricot flavoured yogurt, Powdered milk (full cream), Powdered milk (skim milk), Evaporated milk, Cheese
Vegetables	Dried seaweed, *Kangkung*, Grey oyster mushroom, White mushroom, *Pucuk ubi kayu*, Winter melon, *Kau-kei*, *Sawi*, *Pak choy*, *Pucuk ubi keledek*, Lettuce, Shiitake mushroom, French bean, *Petai*
Legumes and nuts	Mung bean, Almond, *Tempeh*, Peanut, Fried soy bean curd, Red bean, Soya bean
Meat and meat products	Pork liver, Salted duck egg, Quail egg, Chicken liver, Century egg, Hen egg, Ox liver, Pork, Duck egg, Mutton, Veal, Bacon, Duck, Beef lean
Fish and seafood	Clams, Trout, Canned sardine, Atlantic Mackerel, *Tenggiri batang*, *Ketam batu*, Sardine, *Ketam bunga*, Atlantic Herring, Oysters, Pacific Herring, *Siakap* (tail portion), Mussels

portion was printed and used to ease the quantification of the reference portion size as well. The frequency of consumption was expressed by how frequently the participants ate the food items belonging to certain food groups over the past one year, with five frequency options ranging from “daily” to “annually”. Then, the frequency per day was multiplied by the portion size of food item in the FFQ for the sum amount of each and every food eaten per day. Approximately 20 minutes was required to complete the FFQ.

The 24DRs were conducted according to the Multiple Pass Food Recall (MPR) five-step approach (11). This approach has shown impact in addressing the limitations of 24DRs consistently. The MPR five-step approach comprised of quick recall of the food list, probing of the forgotten food, collects time and occasion of food taken, detail cycle (including quantities consumed) and final probe (last chance to recall any food not reported previously). One weekday and one weekend day were collected for the 24DR, yielding a total of four recalls (two weekdays and two weekends) for each participant within two weeks. For each 24DR collected, we took the information regarding the intake time of each meal, the type and/or brand of food and beverages consumed, portion size and preparation method. The FFQ was validated against the mean of riboflavin intakes determined by the average of four recalls (24DRs).

The riboflavin intake was analyzed with the Nutritionist Pro software (version 5.1.0, 2014, First Data Bank, Nutritionist Pro, Axxya Systems, San Bruno, CA). Standardized recipes were added to the Nutritionist Pro Software for the composite and mixed dishes by using single food items. For the food consumed that were not found in the Nutritionist Pro software database, the amount of riboflavin was obtained by referring to food listed in the Nutrient Composition of Malaysian Food (12) and ASEAN Food Composition Database (13).

Statistical analysis

The data were analyzed using SPSS for windows version 22.0. Normality was examined for the distributions of dietary intake values through the Kolmogorov-Smirnov test. The data was non-normally distributed. Hence, non-parametric tests were performed. The significance of differences in dietary riboflavin intake values between the FFQs and the 24DRs were tested with the Wilcoxon signed rank test by comparing the median riboflavin intake. Validation of the FFQ was determined using Spearman correlation coefficients between daily consumption of food groups high in riboflavin, which assessed by the FFQ and the qualitative amount of daily food intake accessed by 24DRs. Intra-class correlation coefficients (ICC) were used to determine the reproducibility of FFQs (14) by assessing the agreement in addition to Spearman correlation coefficient (SCC). Bland-Altman plots were constructed to visually assess the agreement of riboflavin intake values from two different dietary methods. Bland-Altman limits of agreement (LOA) were determined according to the mean agreement (the mean difference between riboflavin intake values) and 95% LOA (mean±1.96 standard deviation of differences). Statistical significant was considered as P <0.05.

RESULTS

Table II shows the socio-demographic characteristics and anthropometric measurements of the participants. Among 204 participants, the mean age was 23.31 ± 2.90 years old and almost half of the participants had completed post-secondary education (52.9%). Majority of the participants (70.6%) were within the normal (18.5-24.9 kg/m2) according to the WHO BMI cut-offs derived from morbidity and mortality data (15).

Table II: Characteristics of respondents in the study

Variables	Total (n=204)	Malay (n=102)	Chinese (n=102)
Age (years), mean±SD	23.31 ± 2.905	23.28 ± 3.135	23.33 ± 2.671
Marital Status, n (%)			
Single	194 (95.1)	94 (92.2)	100 (98.0)
Married	10 (4.9)	8 (7.8)	2 (2.0)
Education Level (Completed), n (%)			
Secondary School	10 (4.9)	6 (5.9)	4 (3.9)
Post-secondary Education	108 (52.9)	51 (50.0)	57 (55.9)
Bachelor’s Degree	70 (34.3)	38 (37.3)	32 (31.4)
Degrees higher than Bachelor’s	16 (7.8)	7 (6.9)	9 (8.8)
Smoking Status, n (%)			
Yes	0	0	0
No	204 (100)	102 (100)	102 (100)
Waist Circumference[a] (cm), mean±SD	72.55 ± 8.547	74.10 ± 9.948	71.01 ± 6.562
≤ 80 cm	174 (85.3)	79 (77.5)	95 (93.1)
>80 cm	30 (14.7)	23 (22.5)	7 (6.9)
Body Mass Index[b] (BMI) (kg/m^2), n (%)			
Underweight	28 (13.7)	14 (13.7)	14 (13.7)
Normal weight	144 (70.6)	62 (60.8)	82 (80.4)
Overweight	23 (11.3)	18 (17.6)	5 (4.9)
Obese	9 (4.4)	8 (7.9)	1 (1.0)

n= number
SD= standard deviation
[a] Cut-off point based on WHO/IASO/IOTF (2000)
[b] Cut-off point based on WHO (1998)

The median riboflavin intake estimated by both methods was shown in Table III. There was no significant difference between FFQ-1 and 24DRs (p>0.05) in median riboflavin intake. On the other hand, the median riboflavin intake derived from 24DRs was significantly higher than FFQ-2 (p=0.007).

The Spearman correlation coefficient (SCC) for mean total riboflavin intake between the two administrations

Table III: Mean and median riboflavin intake (mg) estimated by the two food frequency questionnaires (FFQs) and average of 24-hour dietary recalls (24DRs) based on ethnicity.

Methods	Total (n=204)		Malay (n=102)		Chinese (n=102)	
	Mean ± SD	Median (P_{25}, P_{75})	Mean ± SD	Median (P_{25}, P_{75})	Mean ± SD	Median (P_{25}, P_{75})
FFQ-1	0.953 ± 0.73	0.775 (0.49-1.20)	0.872 ± 0.67	0.694 (0.41-1.15)	1.033 ± 0.79	0.797 (0.52-1.21)
FFQ-2	0.923 ± 0.77	0.759 (0.52-1.08)*	0.831 ± 0.61	0.683 (0.39-1.04)	1.014 ± 0.90	0.829 (0.60-1.10)*
24DRs	0.913 ± 0.33	0.865 (0.69-1.11)	0.852 ± 0.34	0.775 (0.62-1.08)	0.973 ± 0.31	0.955 (0.74-1.13)

n= number
SD= standard deviation
P_{25}= 25th Percentile; P_{75}= 75th Percentile
FFQ-1 indicates first administration of FFQ; FFQ-2 indicates second administration of FFQ.
* Significant at p<0.05: Compared with riboflavin intakes estimated by 24DRs using Wilcoxon signed ranks test

of FFQs was 0.545 and SCC ranged from 0.392 for fish and seafood to 0.645 for vegetables (Table IV). Both FFQ-1 and FFQ-2 correlated significantly (p<0.01) with 24DRs with r-value of 0.264 and 0.227, respectively (Table V). Intra-class correlation coefficient (ICC) was considered and reported in Table V because kappa test wasn't suitable as the scale wasn't nominal and ICC took account of within and between subject variability. ICC values of 0.400 to 0.750 are considered to be fair to good, which can be observed in food group of meat and meat products (0.402), legumes and nuts (0.506), fish and seafood (0.513) and also in milk and milk products (0.742). An ICC value >0.750 is preferred, which can be observed in vegetables (0.776). The ICC value of 0.752 was observed between FFQ-1 and FFQ-2.

Table IV: Daily riboflavin intake (Mean ± SD) and correlation of the FFQs for the consumption of food groups.

Food groups	FFQ-1	FFQ-2	FFQ-2/ FFQ-1 (n=204)	Spearman correlation coefficient
	Total (n=204)	Total (n=204)		
Milk and milk products	0.225±0.292	0.202±0.282	0.900	0.631**
Vegetables	0.293±0.345	0.298±0.346	1.017	0.645**
Legumes and nuts	0.120±0.163	0.115±0.204	0.958	0.480**
Meat and meat products	0.234±0.253	0.229±0.271	0.979	0.396**
Fish and seafood	0.080±0.129	0.081±0.119	1.013	0.392**
Total	0.953±0.734	0.923±0.772	0.969	0.545**

SD= standard deviation
FFQ-1 indicates first administration of food frequency questionnaire.
FFQ-2 indicates second administration of food frequency questionnaire.
** Significant at p<0.01

The mean difference of riboflavin intake was not significantly different (p>0.05) from zero using the Bland-Altman analysis. The mean agreement (95% LOA) which had been reported in Table V was 0.03 (-1.289, 1.347) for riboflavin intake values between two FFQs, was 0.04 (-1.391, 1.471) for FFQ-1 versus 24DRs and was 0.102 (-1.490, 1.510) for FFQ-2 versus 24DRs. From the Bland-Altman plots between the two FFQs as well as between FFQs and 24DRs, no apparent deviation was seen for riboflavin intake values (Figure 1 & 2). Most of the data points were closer to the middles horizontal line and lied between the LOAs. However, it seemed no systematic trend showed in the scatter plots.

DISCUSSION

Validation studies are commonly carried out for newly designed FFQ in order to assess the extent to which they agree with a reference method. Although biological markers are suggested as the "gold standard" for

Table V: Correlation of both methods and the limit of agreement (LOA) for total riboflavin intake derived from FFQ-1, FFQ-2 and 24DRs.

Comparison[a]	Intra-class Correlation Coefficient (95% CI)			Spearman correlation coefficient (r)	Limit of agreement (LOA)[b]	
	Total (n=204)	Malay (n=102)	Chinese (n=102)		Mean agreement (95% LOA)	LOA difference
FFQ-1 vs FFQ-2	0.752 (0.673-0.812)**	0.636 (0.461-0.754)**	0.805 (0.710-0.868)**	0.545**	0.030 (-1.289, 1.347)	2.636
Milk and milk products	0.742 (0.660-0.804)**	0.661 (0.498-0.771)**	0.821 (0.735-0.879)**			
Vegetables	0.776 (0.704-0.830)**	0.702 (0.559-0.799)**	0.796 (0.698-0.862)**			
Legumes and nuts	0.506 (0.348-0.625)**	0.424 (0.145-0.611)**	0.549 (0.331-0.695)**			
Meat and meat products	0.402 (0.212-0.547)**	0.431 (0.155-0.616)**	0.356 (0.044-0.566)*			
Fish and seafood	0.513 (0.357-0.630)**	0.575 (0.371-0.713)**	0.441 (0.171-0.623)**			
FFQ-1 vs. 24DRs				0.264**	0.040 (-1.391, 1.471)	2.862
FFQ-2 vs. 24DRs				0.227**	0.102 (-1.490, 1.510)	3.101

[a] FFQ-1, the first FFQ administration; FFQ-2, the second FFQ administration; 24DRs, the average of the 24-hour dietary recalls.
[b] Mean agreement indicates mean of difference between total riboflavin intake; 95% LOA indicates the mean agreement ± 1.96 standard deviation; LOA difference equal to 2.5% LOA to 97.5% LOA.
* Significant at p<0.05
** Significant at p<0.01

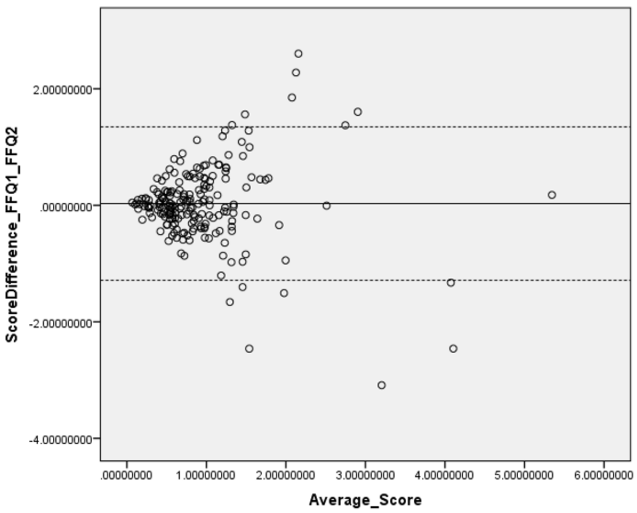
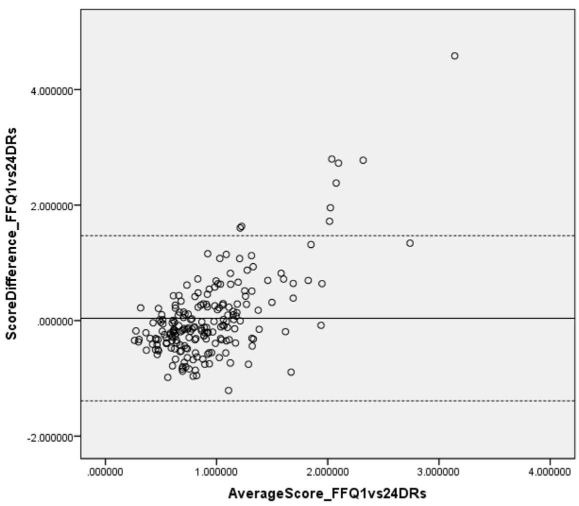
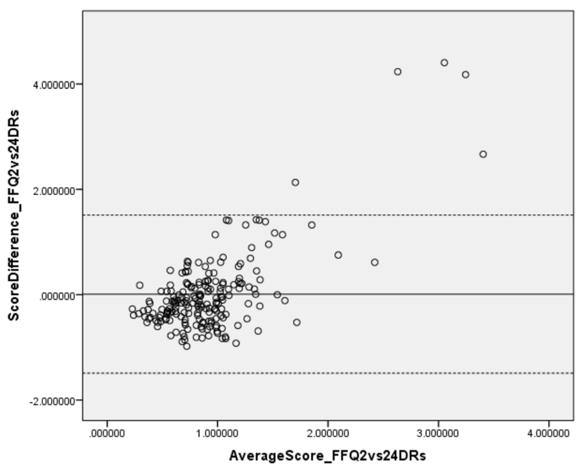


Figure 1: Bland-Altman plots for scores of total riboflavin intake derived from FFQ-1 and FFQ-2. The solid line represents the mean differences (FFQ1-FFQ2); the dash lines represent the limits of agreement (LOA) (mean difference ± 1.96 standard deviations).



(A)



(B)

Figure 2: Bland-Altman plots for scores of total riboflavin intake derived from FFQs and 24DRs. (A): FFQ-1 versus 24DRs, (B): FFQ-2 versus 24DRs. The solid line represents the mean differences (FFQs-24DRs); the dash lines represent the limits of agreement (LOA) (mean difference ± 1.96 standard deviations).

evaluating nutrient intake, several limitations including cost and variability in the measurement have restricted their use in validation studies (16). This FFQ was validated by comparing with four 24DRs, which has been suggested as another comparison standard method because of its feasibility. There was approximately 75% of the validation research of the FFQ were validated against 24DR (17).

Consistent with findings from the previous studies by Shu et al. (18) and Zhang & Ho (19), we found that FFQ-1 in general was higher in the intake of nutrients than that obtained from FFQ-2. The possible reasons might due to participants have a better understanding regarding their diets and thus, able to quantify their food intake during second administration of the questionnaire.

A generally acceptable correlation coefficient (r-value) between an FFQ and the gold standard method is between 0.5 and 0.7 (17, 20). However, the r-values obtained from riboflavin intake assessed by FFQs and 24DRs in this study were considered weak. The r-values for riboflavin intake obtained in this study were in a comparable range as observed in a previous validation study, in which the crude r-value value is 0.22 (21). In contrast, our finding had shown to be lower than that obtained from a cohort study done in Ho Chi Minh City, Vietnam with r-value of 0.39 for riboflavin intake estimated by both methods (22). The inconsistencies between the validity of FFQ in assessing riboflavin might be relevant to various reference methods, sample size, culture of the populations in different studies. Besides, differences between 24DR and FFQ are expected because FFQ belongs to long-term memory, and 24DR recall short-term memory (23).

The Spearman correlation coefficient (SCC) for mean total riboflavin intake between FFQ-1 and FFQ-2 in two weeks intervals was significant and relatively good with r-value >0.50. The finding was in range with another study carried out among Shanghai's women (18) as well as among Malaysian Malay adolescents (21). SCC was lower for food group of fish and seafood, meat and meat products and legumes and nuts with r-value <0.50 when compared to food group of vegetables and milk and milk products. Dietary reproducibility indicates both variability in diet and reporting errors. Hence, food groups that do not contribute to a regular eating pattern had higher possibility more prone to low reproducibility than food groups that are frequently consumed (24).

Minimum acceptable values of an ICC had been reported in Fleiss (25) that the value from 0.40 to 0.75 was considered as "fair to good", in which the value could be observed in meat and meat products, legumes and nuts, fish and seafood as well as milk and milk products. The recommend value >0.75 for continuous scales used in health research (26) could also be seen in the ICC between both FFQs and vegetable group. Through the indication from ICC, we discovered the foods that were eaten regularly (e.g. milk and milk products and vegetables) were able to recall with higher consistency than foods that were eaten only in occasional (e.g. fish and seafood, meat and meat products, legumes and nuts), as observed in the study by Wong et al. (9). In addition, a study conducted by Hosseini Esfahani et al. (27) also reported similar result for vegetables, legumes and nuts. Furthermore, the short-term period of study might be the reason for the relatively higher reliability of this study.

As suggested in a consensus statement on methods for assessing FFQ, the Bland-Altman method that estimates the mean agreement and the LOA is suitable to estimate the absolute validity (17). The mean agreement, which is an indication of the mean difference between riboflavin intake values, was approximately equal to zero between FFQs and 24DRs. The 95% LOA was acceptable. No systematic trend was seen in the scatter plots may indicate that the difference in riboflavin intake derived from the FFQ and 24DR did not appear to depend on the "true" intake as assessed by the 24DR (19).

In this study, FFQ was validated against the mean of riboflavin intakes determined by the average of four recalls (24DRs), which totaling of two weekdays and two weekends (8). Dietary consumption on one weekday and one weekend was recorded in order to reduce the impact of different diets between weekdays and weekends. The considerable differences in average riboflavin intake estimates between FFQ and 24DR might be due to the estimation of portion sizes. Close-ended questions with preset portion sizes were used in FFQ, whereby the consumed amounts were quantified as detailed as possible in 24DR. Moreover, certain foods like vegetables and meat are usually eaten as part of mixed dishes. Furthermore, FFQ depends on the ability of participants to quantify the food eaten from both single foods and mixed dishes. On the other hands, the foods eaten as part of mixed dishes were quantified separately in 24DR (23).

The strength of this study includes it is practical for time-constrained surveys through the usage of a non-quantitative FFQ where food intakes are not likely to be measured in detail. Besides that, this FFQ was highly repeatable. The FFQ could be completed within 20 minutes in order to address the limited motivation. Limitations of this present validation study need to be acknowledged. Firstly, of the sample of recruited participants was a convenience sample aged between 20-45 years old; hence, it might restrict the FFQ to apply to older adults. Secondly, we adopted the riboflavin intake derived from the 24DRs as a reference method. However, 24DR might also subject to recall bias and not covering seasonal variation in food intake within two weeks intervals. Moreover, the reproducibility was also examined in a short period. Thus, it might cause over-estimating or under-estimating of food intake.

CONCLUSION

In this study, our FFQ was validated against four days of 24DRs and reproduced at interval of two weeks. We believe that these could be improved in future studies by incorporating more days for the dietary recall and to repeat the administration of FFQ at an interval of one year to capture the seasonal variation in food intakes. In addition, biological markers could be used as the reference for both FFQs and 24DRs so that the estimation of nutrient intake may have been closer to true intake. Moreover, Indian women of childbearing age could also be included in future studies.

In conclusion, the results suggest that this FFQ is reasonably and fairly reproducible and valid in assessing the dietary riboflavin consumptions among Malaysian women in Selangor. We believe that this FFQ can serve as the basic tool for the determination of riboflavin intake among Malaysian women.

ACKNOWLEDGEMENTS

This research was supported partly from a grant by University of British Columbia (Vote number: 6386900). The authors wish to thank the participants who have willingly shared their time during the interview process.

REFERENCES

1. Rivlin RS. Riboflavin (vitamin B2). In Handbook of Vitamins, 4th ed.; Zempleni, J., Rucker, R. B., McCormick, D. B., Suttie, J. W., Eds.; CRC Press: Boca Raton, FL, USA, pp. 233-251; 2007.
2. Ashoori M, & Saedisomeolia A. Riboflavin (vitamin B2) and oxidative stress: a review. British Journal of Nutrition. 2014;111(11):1985-1991. doi:10.1017/s0007114514000178.
3. Ross AC, Caballero B, Cousins RJ, Tucker KL, Ziegler TR. Vitamins. In: Said HM, Ross AC, eds. Modern nutrition in health and disease. 11th ed. Baltimore, MD:Wolters Kluwer Health/Lippincott Williams & Wilkins; 325; 2014.
4. Powers HJ, Hill MH, Mushtaq S, Dainty JR, Majsak-Newman G & Williams EA. Correcting a marginal riboflavin deficiency improves hematologic status in young women in the United Kingdom (RIBOFEM). Am J Clin Nutr. 2011;93(6):1274-1284.
5. Moltedo, A., Troubat, N., Lokshin, M., Sajaia, Z., & World Bank. (2014). Analyzing food security using household survey data.
6. Gan WY, Mohd NM, Zalilah MS & Hazizi AS. Differences in eating behaviours, dietary intake and body weight status between male and female Malaysian university students. Malays J Nutr. 2011;17(2):213-228.

7. National Coordinating Committee on Food and Nutrition (NCCFN). Riboflavin (Vitamin B2). In RNI: Recommended nutrient intakes for Malaysia: a report of the technical working group on nutritional guidelines. Putrajaya: Ministry of Health Malaysia; 2017.
8. Willett W. Nutritional epidemiology. 3rd ed. Oxford: Oxford University Press; 2013.
9. Wong JE, Parnell WR, Black KE & Skidmore PM. Reliability and Relative Validity of a Food Frequency Questionnaire to Assess Food Group Intakes in New Zealand Adolescents. Nutrition Journal. 2012;11(1). doi:10.1186/1475-2891-11-65
10. Mohammadifard N, Sajjadi F, Maghroun M, Alikhasi H, Nilforoushzadeh F & Sarrafzadegan N. Validation of a Simplified Food Frequency Questionnaire for the Asessment of Dietary Habits in Iranian Adults: Isfahan Healthy Heart Program, Iran. ARYA Atheroscler. 2015;11(2):139-46.
11. Moshfegh AJ, Rhodes DG, Baer DJ, Murayi T, Clemens JC, Rumpler WV, Paul DR, Sebastian RS, Kuczynski KJ, Ingwersen LA, Staples RC & Cleveland LE. The US Department of Agriculture Automated Multiple-Pass Method reduces bias in the collection of energy intakes. Am J Clin Nutr. 2008;88:324-32.
12. Tee, E. S., Mohd Ismail, N, Mohd Nasir, A. & Khatijah, I. (1997). Nutrient Composition of Malaysian Foods (4th ed.). Kuala Lumpur, Malaysia: Institute for Medical Research.
13. Institute of Nutrition, Mahidol University (INMU). (2014). ASEAN Food Composition Database 2014. Thailand: ASEANFOODS Regional Centre and INFOODS Regional Database Centre, Institute of Nutrition, Mahidol University. Retrieved from http://www.inmu.mahidol.ac.th/aseanfoods/doc/Online ASEAN_FCD_V1_ 2014.pdf
14. Winer B. Statistical principles in experimental design. 2nd ed. 2nd ed ed. Tokyo: McGraw-Hill and Kogakusha; 1971.
15. World Health Organisation (WHO). (1998). Obesity: preventing and managing the global epidemic: report of a WHO consultation on obesity. (WHO technical report series 894). Gevena, Switzerland: World Health Organization.
16. Kristal, A. R., Feng, Z., Coates, R. J., Oberman, A., & George, V. (1997). Associations of Race/Ethnicity, Education, and Dietary Intervention with the Validity and Reliability of a Food Frequency Questionnaire: The Women's Health Trial Feasibility Study in Minority Populations. American Journal of Epidemiology, 146(10), 856-869. doi:10.1093/oxfordjournals.aje.a009203
17. Cade J, Thompson R, Burley V & Warm D. Development, validation and utilisation of food-frequency questionnaires - a review. Public Health Nutrition. 2002;5(4):567-587. doi:10.1079/phn2001318
18. Shu XO, Yang G, Jin F, Liu D, Kushi L, Wen W, Gao YT & Zheng W. Validity and reproducibility of the food frequency questionnaire used in the Shanghai Women's Health Study. European Journal of Clinical Nutrition. 2004;58(1):17-23. doi:10.1038/sj.ejcn.1601738.
19. Zhang CX & Ho SC. Validity and reproducibility of a food frequency questionnaire among Chinese women in Guangdong province. Asia Pac J Clin Nutr. 2009;18(2):240-250.
20. Kim E, Kim M & Sohn C. Validity and Reliability of a Self-administered Food Frequency Questionnaire to Assess Vitamin K Intake in Korean Adults. Clinical Nutrition Research. 2016;5(3):153. doi:10.7762/cnr.2016.5.3.153.
21. Nurul-Fadhilah A, Teo PS & Foo LH. Validity and Reproducibility of a Food Frequency Questionnaire (FFQ) for Dietary Assessment in Malay Adolescents in Malaysia. Asia Pac J Clin Nutr. 2012;21(1):97-103.
22. Hong TK, Dibley MJ & Sibbritt D. Validity and reliability of an FFQ for use with adolescents in Ho Chi Minh City, Vietnam. Public Health Nutrition. 2009;13(03):368. doi:10.1017/s136898000999125x.
23. Haftenberger M, Heuer T, Heidemann C, Kube F, Krems C & Mensink GB. Relative validation of a food frequency questionnaire for national health and nutrition monitoring. Nutrition Journal. 2010;9(1). doi:10.1186/1475-2891-9-36.
24. Lanfer A, Hebestreit A, Ahrens W, Krogh V, Sieri S, Lissner L, Eiben G, Siani A, Huybrechts I, Loit H-M., Papoutsou A, Kovacs E & Pala V. Reproducibility of food consumption frequencies derived from the Children's Eating Habits Questionnaire used in the IDEFICS study. International Journal of Obesity. 2011;35:S61-S68. doi:10.1038/ijo.2011.36.
25. Fleiss JL. The Design and Analysis of Clinical Experiments. New York: John Wiley & Sons; 1986.
26. Streiner DL & Norman GR. Health Measurement Scales: A Practical Guide to Their Development and Use. Oxford University Press; 1995.
27. Hosseini Esfahani, F., Asghari, G., Mirmiran, P., & Azizi, F. (2010). Reproducibility and Relative Validity of Food Group Intake in a Food Frequency Questionnaire Developed for the Tehran Lipid and Glucose Study. Journal of Epidemiology, 20(2), 150-158. doi:10.2188/jea.je20090083