Available online: http://journal.ipb.ac.id/index.php/jgizipangan *J. Gizi Pangan, July 2022, 17(2):77-86*
ISSN 1978-1059 EISSN 2407-0920 *DOI: https://doi.org/10.25182/jgp.2022.17.2.77-86*

Research Article

Validity and Reproducibility of Malaysian Food Frequency Questionnaire for Dietary Intake Related to Colorectal Cancer

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Article History:
Received *13-12-2021*
Revised *10-04-2022*
Accepted *09-05-2022*
Published *31-07-2022*

Keywords:
colorectal cancer, food frequency questionnaire, food record, reproducibility, validation

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ABSTRACT

This study aims to report on the validity and reproducibility of a 142-food item Food Frequency Questionnaire (FFQ) for dietary factors related to colorectal cancer among Malaysians. Population aged 30 to 70 years from two cities of Peninsular Malaysia were recruited through voluntary participation. A semi-quantitative FFQ was modified from an established FFQ used in the national survey. It includes specific questions to measure the consumption of food sources related to colorectal cancer development. FFQ was administered two times in two weeks to evaluate reproducibility (FFQ1 and FFQ2). Then the validity was assessed by comparing FFQ against the 3-day Food Record method (FR). A total of 100 respondents (mean age 50.6 years) provided data for both validity and reproducibility. The FFQ had significantly higher estimates of most nutrients and food groups' intake than the FR. The Spearman correlation showed moderate agreement between FFQ and FR while moderate to strong correlation between FFQs. The limit of agreement between both methods using Bland Altman plot was acceptable for both validity and reproducibility. The classification into the same and adjacent quartiles was between 62 to 75% for validity and 77 to 89% for reproducibility assessment. Overall, the validity was satisfactory and reproducibility of the FFQ was good for estimating absolute nutrient and food group intakes. Hence, the FFQ could be used as a valid tool for assessing dietary intake among Malaysians to study dietary factors related to colorectal cancer risk.

INTRODUCTION

Globally, the estimated number of incident cases of Colorectal Cancer (CRC) is around 1,9 million and for death cases are 935,000. This estimation ranked CRC as fourth and second in terms of incidence and mortality respectively among other cancer sites. The highest rate of colon cancer incidence was found in European regions, Australia/New Zealand, and Northern America while for rectal cancer the rate of distribution among those regions is similar including Eastern Asia (International Agency for Research on Cancer 2020). The trend of CRC incidence is increasing, the incidence of colon cancer was found to increase in 10 out of 36 countries from 2007 to 2016, 2006 to 2015 or 2005 to 2014 where India dominated the highest increment followed by Poland (International Agency for Research on Cancer 2020). In Malaysia, the estimated number of new cases of colon and rectum cancer is around 3,816 and 2,690 respectively while the death cases of colon and rectum cancer are 2,035 and 1,385 respectively (International Agency for Research on Cancer 2020). A study by Ibrahim and colleagues (Ibrahim *et al*. 2020) reported that the age-standardised incidence and mortality trends from 2007 to 2017 for patients under 50 years of age were stable but this group were found to constitute a considerable proportion of CRC in northern Malaysia.

There are various risk factors of CRC namely non-modifiable and modifiable risk factors. Non-modifiable risk factors comprising race and ethnicity, sex, age, hereditary mutations, inflammatory bowel disease, abdominal radiation, cystic fibrosis, cholecystectomy, and androgen deprivation therapy while modifiable risk factors including obesity and physical inactivity, diet, smoking, alcohol, medications, and diabetes and insulin resistance (Rawla *et al.* 2019). Single foods and nutrients and dietary patterns become a significant determinant either to increased or decreased CRC risks. A meta-analysis study conducted by McNabb and colleagues (McNabb *et al.* 2020) showed that heavier drinker of alcohol increased CRC risks while another systematic review and meta-analysis study by Morze and colleagues (Morze *et al.* 2021) observed that Mediterranean dietary pattern reduced the cancer mortality in general population and all-cause mortality among cancer survivors as well as colorectal, head and neck, respiratory, gastric, liver and bladder cancer risks.

There are several methods often utilized in epidemiological study for example, Food Records (FR) and 24-hour recalls for current intake assessment and dietary history and Food Frequency Questionnaire (FFQ) for usual or habitual intake assessment (Ocké *et al.* 2020). All these methods had its own strength and limitation and the selection of the method are depending on the purpose and target group of the study (Ocké *et al.* 2020). In investigating the relationship between diets with CRC in Malaysia, FFQ is found to be the most appropriate tool to evaluate the population's habitual or long-term consumption (El Kinany *et al.* 2018). In fact, this tool is cost effective and time-saving. Before the FFQ could be utilised, the validity and reproducibility study should be first conducted. A validation study will examine how accurately the dietary tools measures the true intakes while a reproducibility study will examine the variation in measurements made on respondent over a period of time (Ocké *et al.* 2020). Both validity and reproducibility study on FFQ related to CRC had been conducted earlier among Belgians (Tollosa *et al.* 2017), Dutch (Koole *et al.* 2020), Norwegians (Henriksen *et al.* 2018), and Canadians (Liu *et al.* 2013). In Malaysia, the inadequacy of food items of FFQ from NHMS 2014 to measure CRC has led to FFQ modification. To date there is no validity and reproducibility study on FFQ related to CRC conducted among Malaysian and a study should be carried out as each population has different food supply and dietary habits. Therefore, the study aimed to evaluate the validity and reproducibility of FFQ which includes all colorectal cancer dietary factors in Malaysian adults.

METHODS

Design, location, and time

All respondents voluntarily participated in this study from March to June 2020 and were recruited from Kuala Lumpur (cities of Peninsular Malaysia) and Kota Bharu, Kelantan representing urban and suburban areas respectively. Due to good cooperation, respondents were conveniently recruited. Ethical clearance for the study was granted on 3rd March 2020 by the Human Research Ethics Committee of Universiti Sains Malaysia (USM/JEPeM/19060354).

Sampling

The inclusion criteria for the selection were Malaysian, aged 30 to 70, and did not practice any diet regime. No exclusion of respondents out of 100 respondents into the validation and reproducibility study based on energy intake of 500 to 3,500 kcal/day (van Dongen *et al.* 2019; Willett 2012). According to Cade (2004), the sample size recommended for validation study was 50 to 100 respondents for each demographic group.

The respondents were informed on the objective and methodology of the study and those who agreed to participate were requested to sign the consent form. The dietary information of respondents was assessed using semi-quantitative FFQ1 and the same information was collected again after two weeks using semi-quantitative FFQ2. The three-day Food Record (FR) was distributed to respondents after completion of semi-quantitative FFQ2 in order to avoid bias introduced by increased awareness when completing FR.

Data collection

The semi-quantitative FFQ applied in the study is basically a modification from the National Health and Morbidity Survey (NHMS) 2014. The FFQ from NHMS 2014 consist of 165 food items and several of foods and drinks were excluded at the initial step of the new FFQ development. Forty-one food items were excluded on the basis of rarely consumed by the population and 22 foods or drinks were combined into 1 food item due to its similarities in food group such as white meats, fruit vegetables, legumes, flavours, bread spread, fruits, local fruits, and drinks. Six high risk and protective foods and drinks against CRC was added to FFQ by identifying it from the previous literature and cancer report of continuous update project (World Cancer Research Fund 2018). About 34 food items in FFQ from NHMS 2014 had high risk and protective value to be retained in our present FFQ while remaining 102 items were maintained as frequently eaten by Malaysians. High risk foods were foods that containing high fat (red and processed meat), heme-iron (meat/poultry/ certain fish), nitrite/nitrate (processed meat), and cooking method (baked/ grilled/ deep fried). Protective foods were foods containing omega-3 fatty acids (nut, legumes, fish, and seafood), vitamin D (mushrooms and barley drink), calcium (milk), and fibre (fruits and vegetables). Face and content validity were conducted by two nutritionists to verify the food list and added prominent food to the list. A total number of 142 food items were finalized as the food items list in the FFQ. During data collection, the respondents were requested to recall the intake frequency of foods and drinks and the intake amount for the past one year. The intake frequency provides four options including per day, per weeks, per months, and per year/never. FFQ1 and FFQ2 was administered once each in a period of two weeks.

Three-day FR was carried out to examine the validity of semi-quantitative FFQ by comparing the foods and nutrient intakes between both assessment methods. The respondents were requested to record their diet on three non-consecutive days (2 weekdays and 1 weekend) on type of food and beverages, time of meals, place of eating, and price for take-away foods (Luftimas *et al.* 2021). This is done to capture the variation in meal consumption of the respondents. Photographs of household measurements including glass, cup, tablespoon, teaspoon, etc were provided to aid respondents in estimating the portion sizes of the foods that they consumed.

Data analysis

All the dietary information from the semi quantitative FFQ and three-day FR were analysed using Nutritionist Pro™ Diet Analysis Software version 7.8.0 (Axxya Systems, version 2020, Redmond, USA).

Nutrients and food group's analysis. The Nutrient Composition of Malaysian Foods reference list in the Nutritionist ProTM database was used to select a total of 142 food items from FFQ. To obtain the energy and nutrients values, the daily intake of each food item was entered by calculating using the following formula: frequency of intake per day x total number of servings x weight of food in one serving. For three-day FR, the energy and nutrient values was obtained straight away by selecting the foods and recipes from the reference list of Nutrient Composition of Malaysian Foods. Recipes which were not available in the reference list were added into the database where the portion sizes were calculated based on standard recipe sizes for example total serving and per serving size. Weight of foods or ingredients to make the recipes were referred from the Atlas of Food Exchanges & Portion Sizes, Nutrient Composition of Malaysian Foods, Malaysian Food Album (IPH 2011) and Malaysian Food Composition Database (MyFCD 2020). Nutritional content of the food product was obtained from its packaging or MyFCD and was inserted into the database.

The following food groups were allocated to each of the 142 food items: cereal products, meats, fish and seafoods, eggs, vegetables, legumes, bread spreads, fruits, confectionaries, fast foods, non-sugary drinks, sugar sweetened drinks, alcoholic drinks, condiments and dairy products. In order to obtain the food group intake value from the FFQ, the daily gram intake of food items was summed up according to its food group category. For FR, the total gram intake of foods and meals listed was summed up and divided by 3 days according to its food group.

Reproducibility analysis. Nutrients and food groups' data for FFQ1 and FFQ2 were checked for normality. The mean and 5^{th} and 95^{th} percentiles of nutrients and food groups were calculated for FFQ1 and FFQ2. Comparison of energy and nutrient intakes between FFQ1 and FFQ2 were analysed using Wilcoxon's sign rank test while relationship between FFQs were determined using Spearman correlation (absolute values and energy-adjusted values). The reproducibility of absolute nutrient and food intakes from the both methods were further assessed by cross-classification analysis. All statistical analysis was performed using IBM SPSS Statistics, Version 26.0 (Chicago, IL, USA). $p<0.05$ was considered as statistically significant.

Validity analysis. Nutrients and food groups' data for FFQ1 and FR were checked for normality. The mean and 5th and 95th percentiles of nutrients and food groups were computed for both assessment methods of FFQ1 and FR. Differences of energy and nutrient intakes between FFQ1 and FR were analysed using paired t-test or Wilcoxon's sign rank test. Spearman or Pearson correlation were used to calculate the strength of the relationship between the two methods. Residual method was used to calculate energy-adjusted values from the total energy intake (Willett 2012). Cross-classification analysis was performed to indicate the potency of the FFQ when matched up with FR to classify individuals into the same or within one quartile of the nutrient and food groups. The agreements between FFQ1 and FR was further assess using Bland-Altman plot and limit of agreement (LOA; ±2SD) was used to define it.

RESULTS AND DISCUSSION

Respondents' characteristics

A total of 100 respondents participated in the reproducibility and validation studies (Table 1). Respondents were recruited from urban (50%) and suburban (50%) area to represent the whole population in Malaysia from different socio-economic background. Mean age of study respondents was 50.6 years; 80% of the respondents aged more than 50 years were enrolled to represent the CRC patients because the CRC incidence increased after the age of 60 years (National Cancer Institute 2019). Meanwhile respondents aged above 30 years represent the cancer patients as the cancer incidence increased after the age of 30 years (National Cancer Institute 2019).

Table 1. Sociodemographic characteristics of study respondents

Characteristics	Total (n=100)* n (%)	Urban (n=50) n (%)	Suburban (n=50) n (%)
Age groups (years) mean (SD)	50.6 (10.1)	52.3 (3.5)	49.0 (13.8)
30−50	20 (20.0)	0 (0.0)	20 (40.0)
50−70	80 (80.0)	50 (100)	30 (60.0)
Race			
Malay	70 (70.0)	20 (40.0)	50 (100.0)
Chinese	17 (17.0)	17 (34.0)	0 (0.0)
Indian	13 (13.0)	13 (26.0)	0 (0.0)
Educational level			
Primary school	10 (10.0)	6 (12.0)	4 (8.0)
Secondary school	51 (51.0)	32 (64.0)	19 (38.0)
University	38 (38.0)	12 (24.0)	26 (52.0)
Unschooling	1 (1.0)	0 (0.0)	1 (2.0)
Household number			
1−5	81 (81.8)	49 (98.0)	32 (65.3)
6−10	13 (13.1)	1 (2.0)	12 (24.5)
≥11	5 (5.1)	0 (0.0)	5 (10.2)
Income classification by household**			
B40	88 (88.0)	48 (96.0)	40 (80.0)
M40	12 (12.0)	2 (4.0)	10 (20.0)
T20	0 (0.0)	0 (0.0)	0 (0.0)

[a]Sample size was not always n=100 due to missing values because one respondent did not answer on the household number

[b]Source: Household Income and Basic Amenities Survey Report 2019; Department of Statistics Malaysia: B40-income less than RM4,849 (1,158.39 USD); M40-income range RM4,850 to RM10,959 (1,158.62 to 2,618.01 USD); T20-income more than RM10,960 (2,618.25 USD); SD: Standard Deviation

There was zero respondent withdrawal as the completeness of three dietary assessments were achieved. Hundred sample size was adequate to determine questionnaire's validity (Willett 2012). The study did not exclude any respondents on the basis of under- and over-reporting dietary intake less than 500 kcal and more than 3,500 kcal (van Dongen *et al.* 2019; Willet 2012). Misreporting has been avoided by energy adjustment approach via residual method instead of respondent exclusion (Liu *et al*. 2013).

Reproducibility

Reproducibility of the FFQ was generated to establish the potency of the FFQ to evaluate nutrient and food group intakes two weeks apart. The FFQ had acceptable reproducibility two weeks apart, with correlation values more than 0.40 for the majority of nutrients (Cade *et al.* 2004). Table 2 present the data analysis between the FFQ1 and FFQ2. Relatively moderate correlation on macronutrients between FFQ1 and FFQ2 from 0.45 (carbohydrate) to 0.64 (protein).

Table 2. Reproducibility of nutrient and food group between food frequency questionnaire (FFQ1 and FFQ2)

Energy, nutrients, and food groups	FFQ1 (n=100)	FFQ2 (n=100)	p^a	Spearman correlation		Cross-classification into quartiles (%)	
	Mean (P_5, P_{95})	Mean (P_5, P_{95})		Unadjusted	Energy adjusted	Correctly classified	Grossly misclassified
Energy (kcal)	2,352 (1,338, 3,393)	2,399 (1,103, 3,182)	0.020	0.60[b]	-	84	2
Protein (g)	97.2 (54.8, 145.7)	106.4 (44.9, 156.1)	0.006	0.64[b]	0.15	88	4
Carbohydrate (g)	312.6 (191.5, 460.6)	328.8 (169.2, 449.0)	0.009	0.45[b]	0.42[b]	80	8
Fat (g)	75.7 (38.8, 119.0)	75.0 (27.5, 118.2)	0.145	0.58[b]	0.45[bc]	89	2
Saturated fat (g)	12.8 (6.0, 22.1)	13.5 (5.0, 25.4)	0.010	0.53[b]	0.38[b]	81	4
Monounsaturated fatty acids (g)	12.4 (6.2, 21.4)	13.1 (4.8, 21.5)	0.006	0.51[b]	0.33[b]	81	3
Polyunsaturated fatty acids (g)	8.7 (3.5, 13.5)	8.9 (2.9, 13.2)	0.034	0.44[b]	0.45[b]	77	5
Cholesterol (mg/d)	368.9 (150.3, 672.2)	338.0 (109.2, 689.1)	0.143	0.50[b]	0.44[b]	83	6
Calcium (mg/d)	517.4 (290.2, 842.8)	567.7 (302.7, 922.2)	<0.001	0.59[b]	0.49[b]	87	5
Magnesium (mg/d)	184.0 (91.2, 278.6)	212.5 (130.8, 319.7)	<0.001	0.40[b]	0.39[bc]	84	7
Fibre (g/d)	6.0 (2.9,10.2)	8.5 (3.2, 15.9)	<0.001	0.59[b]	0.31[b]	88	3
Sodium (mg/d)	3,641.5 (1,841.4, 5,972.8)	4,080.0 (1,494.9, 6,561.4)	0.001	0.50[b]	0.45[b]	80	3
Iron (mg/d)	21.8 (11.3, 35.5)	22.6 (10.9, 33.8)	0.016	0.66[b]	0.28[b]	87	1
Vitamin C (mg/d)	110.8 (41.8, 199.6)	144.5 (29.1, 370.0)	0.001	0.40[b]	0.38[b]	77	4
Cereal products	615.9 (312.5, 883.9)	589.2 (221.9, 862.0)	0.170	0.53[b]	0.50[b]	77	5
Meats	130.2 (33.7, 305.6)	121.1 (15.0, 296.2)	0.098	0.48[b]	0.41[b]	83	6
Fish and other seafood	84.9 (23.4, 154.3)	87.8 (22.2, 163.1)	0.644	0.57[b]	0.58[b]	85	4
Eggs	30.8 (8.6, 72.4)	31.9 (2.8, 80.7)	0.176	0.51[b]	0.41[b]	84	4
Vegetables	140.1 (50.8, 283.2)	172.0 (34.8, 381.9)	0.021	0.47[b]	0.44[b]	83	4
Legume	13.5 (0.0, 54.8)	14.0 (0.0, 44.1)	0.157	0.74[b]	0.70[b]	88	1
Bread spread	2.9 (0.0, 6.5)	10.5 (0.0, 21.5)	<0.001	0.23[b]	0.18[b]	63	9
Fruits	200.8 (48.3, 419.5)	326.8 (34.2, 765.4)	<0.001	0.20[b]	0.19[b]	72	7
Confectionaries	82.4 (18.3, 257.1)	80.5 (11.8, 257.1)	0.694	0.52[b]	0.55[b]	84	5
Fast food	21.1 (0.0, 42.9)	34.8 (0.0, 135.4)	0.004	0.65[b]	0.55[b]	88	1
Non-sugary drinks	642.5 (250.0, 2,000.0)	966.3 (0.0, 2,975.0)	<0.001	0.67[b]	0.66[b]	96	0
Sugary drinks	367.6 (43.9, 928.7)	337.4 (42.0, 849.2)	1.000	0.62[b]	0.61[b]	85	5
Alcohol drinks	25.1 (0.0, 35.0)	1.5 (0.0, 7.8)	0.172	0.64[b]	0.88[b]	-	-
Condiments	17.9 (2.2, 36.0)	36.8 (7.4, 72.7)	<0.001	0.22	0.22[b]	69	7
Dairy products	8.6 (0.0, 49.5)	8.4 (0.0, 50.0)	0.843	0.84[b]	0.83[b]	93	1

[a]Differences between FFQ1 and FFQ2 using Wilcoxon signed rank test; FFQ1: Food Frequency Questionnaire 1; FFQ2: Food Frequency Questionnaire 2; [b]p<.05
[c]Pearson correlation due to normal distribution data

Majority of nutrients and food groups do not exhibit significant difference between FFQs. Correlation for micronutrients ranged from 0.40 (magnesium) to 0.66 (iron) whereas food groups ranged from 0.20 (fruits) to 0.84 (dairy products). The lowest correlation coefficient for food groups was 0.20 compared to nutrients possibly due to more variances in food groups as opposed to the nutrient intake. In another study, fruits intake had over-estimation may due to complicacy in translating the stated dietary values into the real dietary intakes (Loy *et al.* 2011). However, true validity of FFQ1 is similar to that of FFQ2 against FR due to its highly correlated between FFQs. Classification into the same and adjacent quartile more than 63% for nutrients and food groups also may come from the short duration of administration between FFQs. Thus, the FFQ is found to be reproducible.

Validity

The FFQ had significantly higher estimates of most nutrients' and food groups' intake than the FR (Table 3). A systematic review showed that the overestimated nutrient and food groups from FFQ with respect to the reference method has been reported in several studies which could also be observed in the current study (Sierra-Ruelas *et al.* 2021). The overestimation FFQ intake can be clarified by the extensive list of food items and predetermined portion sizes compared to actual intake in FR (Loy *et al*. 2011). Some of the food items consumed in the FFQ was not consumed in FR which may lead to overestimation (Tollosa *et al.* 2017). However, only sugary drinks mean intake from FFQ lower from FR (Table 3), in line with previous study showed lower mean intake of soft drinks (with sugar) from FFQ than 4 days FR among healthy population in Jena, Germany (Steinemann *et al.* 2017).

In a systematic review on semi-quantitative FFQ validation among adults reported the most frequently mentioned elements by the studies were energy, macronutrients, saturated fatty acid, polyunsaturated fatty acid, cholesterol, calcium, fibre, vitamin C and iron (Sierra-Ruelas *et al.* 2021). This present study reported a weak to moderate correlation coefficient for nutrients and food groups derived from FFQ and FR significantly ranged from 0.23 to 0.64. Spearman coefficients were mostly applied to evaluate the relation strength linking FFQ and FR as it is less sensitive to extreme values compared to Pearson coefficients. Absolute magnitude in interpreting a correlation coefficient as follows: 0.00−0.10 as negligible; 0.10−0.39 as weak; 0.40−0.69 as moderate; 0.70−0.89 as strong and 0.90−1.00 as very strong correlation.

Energy adjustment reduced and did not improve the correlation for almost all nutrients in this study. A consistent outcome was also revealed in other FFQ validation studies (Kaur *et al*. 2016; Loy *et al.* 2011). The present findings are comparable to other studies conducted among adults or older adults in systematic review. Previous FFQ validation studies reported the lowest correlation coefficient of 0.28 for energy, 0.30 for protein, 0.17 for fat and 0.24 for carbohydrate (Sierra-Ruelas *et al.* 2021). The weak correlations for food groups of cereals products (0.33), meats (0.29), fish and seafoods (0.25), fruits (0.26), confectionaries (0.35), sugary drinks (0.28) and condiments (0.34) may be explained by the complicacy in translating the amount consumed into the real intakes and higher variations in food groups (Loy *et al.* 2011). Eggs, legume and bread spread were not significantly correlated between FFQ and FR may be due to periodically consumed group of food instead of frequently consumed and these food groups may not have been consumed during three days FR compared to the FFQ. Correlation should not be used alone to assess validity as it provides only the association degree between two methods. Therefore, the Bland–Altman method often practiced together to measure the agreement linking two methods rather than correlation only (Lee & Park 2016).

Energy had the largest percentage of respondents classified into the same and adjacent quartiles (75%) while calcium had the lowest (62%). Only four nutrients had more than 10% gross classification, indicating that misclassification was low (monounsaturated fatty acids 11%, polyunsaturated fatty acids 11%, fibre 11% and sodium 12%). For food groups, correctly classification had an average 74% respondents (58% to 92%) while mean of gross classification was 7%. Cross-classification provide a more accurate view of the FFQ's performance than the correlation coefficients (Loy *et al.* 2011). The FFQ performance was account as valid if respondents were correctly classified into ≥50% and ≤10% grossly misclassified of the tertiles (Kaur *et al.* 2016). Similar result by other validation study among multi-ethnic population in the Malaysian

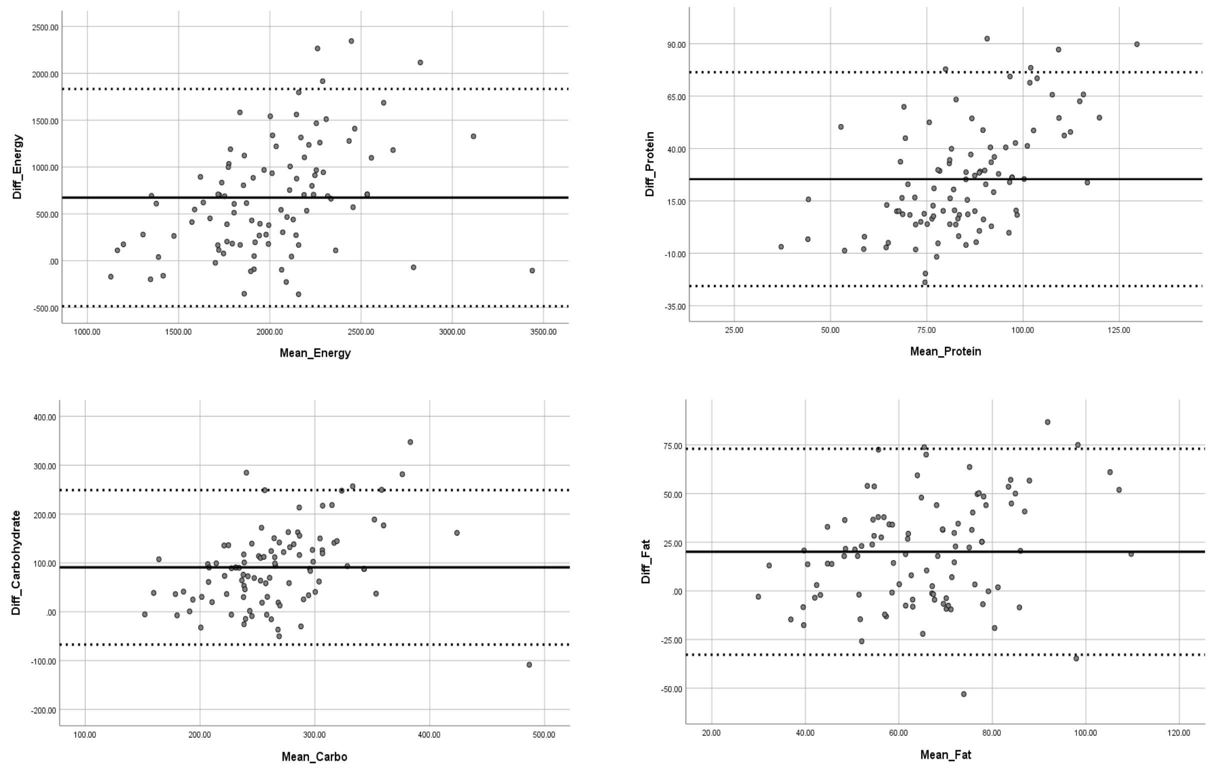
Table 3. Validation of nutrient and food group between food frequency questionnaire (FFQ1) and food record

Energy, nutrients, and food groups	FFQ1 (n=100)	FFQ2 (n=100)	p[a]	Spearman correlation		Cross-classification into quartiles (%)	
	Mean (P_5, P_{95})	Mean (P_5, P_{95})		Unadjusted	Energy adjusted	Correctly classified	Grossly misclassified
Energy (kcal)	2,352 (1,338, 3,393)	1,678 (1,110, 2,300)	<0.001	0.25[b]	-	75	0
Protein (g)	97.2 (54.8, 145.7)	71.8 (41.1, 92.4)	<0.001	0.27[b]	0.44[b]	41	9
Carbohydrate (g)	312.6 (191.5, 460.6)	221.7 (153.3, 299.1)	<0.001	0.29[b]	0.11	74	9
Fat (g)	75.7 (38.8, 119.0)	55.6 (28.3, 89.6)	<0.001	0.17	0.13[c]	63	7
Saturated fat (g)	12.8 (6.0, 22.1)	9.3 (3.1, 18.2)	<0.001	0.25[b]	0.26[b]	66	6
Monounsaturated fatty acids (g)	12.4 (6.2, 21.4)	9.0 (3.5, 16.6)	<0.001	0.14	0.26[b]	66	11
Polyunsaturated fatty acids (g)	8.7 (3.5, 13.5)	7.2 (2.2, 13.1)	0.001	0.06	0.16	66	11
Cholesterol (mg/d)	368.9 (150.3, 672.2)	292.8 (82.8, 552.3)	0.001	0.23[b]	0.26[b]	67	8
Calcium (mg/d)	517.4 (290.2, 842.8)	463.7 (262.1, 784.4)	0.017	0.10	0.06	62	7
Magnesium (mg/d)	184.0 (91.2, 278.6)	126.3 (63.2, 190.2)	<0.001	0.25[b]	0.26[bc]	68	9
Fibre (g/d)	6.0 (2.9,10.2)	3.8 (1.4, 7.3)	<0.001	0.12	0.23	64	11
Sodium (mg/d)	3,641.5 (1,841.4, 5,972.8)	3,398.8 (1,818.1, 5,349.8)	0.212	0.12	0.28[b]	73	12
Iron (mg/d)	21.8 (11.3, 35.5)	17.9 (8.1, 29.8)	<0.001	0.16	0.16	64	10
Vitamin C (mg/d)	110.8 (41.8, 199.6)	63.9 (11.2, 114.4)	<0.001	0.08	0.13	66	9
Cereal products	615.9 (312.5, 883.9)	520.7 (284.1, 772.9)	<0.001	0.33[b]	0.30[bc]	73	5
Meats	130.2 (33.7, 305.6)	119.2 (0.0, 268.6)	0.388	0.29[b]	0.17	72	8
Fish and other seafood	84.9 (23.4, 154.3)	69.9 (9.0, 165.2)	0.004	0.25[b]	0.20[b]	73	6
Eggs	30.8 (8.6, 72.4)	25.8 (0.0, 64.8)	0.149	-0.04	-0.03	58	13
Vegetables	140.1 (50.8, 283.2)	117.6 (5.6, 237.9)	0.007	0.55[b]	0.51[b]	89	4
Legume	13.5 (0.0, 54.8)	8.4 (0.0, 50.8)	0.003	0.07	0.15	68	7
Bread spread	2.9 (0.0, 6.5)	1.8 (0.0, 8.2)	<0.001	0.12	0.02	74	7
Fruits	200.8 (48.3, 419.5)	109.4 (0.0, 314.9	<0.001	0.26[b]	0.24[b]	70	11
Confectionaries	82.4 (18.3, 257.1)	64.6 (0.0, 203.2)	0.009	0.35[b]	0.40[b]	71	7
Fast food	21.1 (0.0, 42.9)	11.0 (0.0, 79.9)	<0.001	0.41[b]	0.21[b]	74	0
Non-sugary drinks	642.5 (250.0, 2000.0)	491.7 (166.7, 1166.7)	0.006	0.64[b]	0.59[b]	92	5
Sugary drinks	367.6 (43.9, 928.7)	388.3 (80.9, 764.6)	0.030	0.28[b]	0.23[b]	74	8
Alcohol drinks	25.1 (0.0, 35.0)	0.0 (0.0, 0.0)	0.018	-	-	-	-
Condiments	17.9 (2.2, 36.0)	15.9 (0.0, 42.0)	0.124	0.34[b]	0.35[b]	72	7
Dairy products	8.6 (0.0, 49.5)	29.9 (0.0, 223.4)	0.413	0.24[b]	0.07	47	18

[a]Differences between FFQ1 and FFQ2 using Wilcoxon signed rank test; FFQ1: Food Frequency Questionnaire 1; FFQ2: Food Frequency Questionnaire 2; [b]$p<0.05$
[c]Pearson correlation due to normal distribution data

Cohort Project varied showed cross-classification into adjacent quartile varied from 62.5 to 81.3% of the respondents (Shahar *et al.* 2021). Gross classification less than 10% of the tertiles are acceptable, in line with the present findings except for 4 nutrients. These findings suggest that the FFQ can rank respondents based on their dietary intake, which is significant for future colorectal cohort studies directing to determine the diet-disease association.

The Blant Altman plot (Figure 1) advanced to distinguish between FFQ and FR where the scattered plots were predominantly distributed for macronutrients within 95% level of agreement. As the scatter plot was primarily between the dotted lines (mean±2SD), the limit of agreement was considered to be fair. The Bland-Altman plot was used to interpret the agreement between FFQ and FR graphically at the group level, while correlation coefficient and cross-classification assess validity at the individual level (Harmouche-Karaki *et al.* 2020). Inconsistency was observed across the intake level of macronutrients whereby the mean differences increased as the level of intake further



(n=100)

Figure 1. Bland altman plots for energy and macronutrients between food frequency questionnaire and food record

increased, representing the agreement between two methods was better at lower rather than higher, average intake values. Findings reporting no systematic errors for most nutrients in Bland-Altman plot are consistent with the present study (Knudsen *et al.* 2016; Yuan *et al.* 2017; Denova-Gutiérrez *et al.* 2016; Bijani *et al.* 2018; Beck *et al.* 2020).

Strengths of the present study are as follow: the use of 3 non-consecutive days of FR and multiple statistical analysis to determine validity and reproducibility of the FFQ. In addition, the sample size of the present study corresponds to the recommendation (n=50−100) of FFQ validation studies (Cade *et al.* 2004) and the respondents were based on interview administered FFQ. Diversifying respondents during sampling method from a wider geographical area of urban and suburban area to represent Malaysia also part of the study strengths. However, there are some limitations could be addressed. First, the 142-food items FFQ might give burden to the respondent but no respondent withdrawal from implausible intake indicates satisfactory compliance of the respondents. Secondly, 3-day FR has limitation for estimating usual intake of foods not eaten daily or periodically consumed. Replicating the FR to 5 days may help in generating usual consumption. Third, the present study could be incorporating nutrient biomarker to strengthen the nutrient assessment of FFQ validation.

CONCLUSION

In conclusion, this FFQ is a valid and reproducible instrument to determine habitual intake among CRC patients in Malaysia. This FFQ is capable well to assess the energy, nutrients and food groups related to cancer and rank individuals by relative intake level. Thus, this FFQ is recommended as a valid instrument in a CRC prospective study for dietary data collection.

ACKNOWLEDGEMENT

The study is funded by the Long-Term Research Grant Scheme (LRGS)-Malaysia Research University Network (MRUN) (203/

PPSK/6720021, LRGS/MRUN/FI/02/2018/01 and LR001-2019).

DECLARATION OF CONFLICT OF INTERESTS

The authors have no conflicts of interest to disclose.

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