Austin Journal of Nutrition and Food Sciences

Open Access

Austin Publishing Group

Research Article

Reproducibility and Relative Validity of a Short Food Frequency Questionnaire for Chinese Pregnant Women in Hong Kong

Kenneth Lo[1], Liz Li[2], Jason Leung[3], Tam WH[4] and Ruth Chan[1]*

[1]Department of Applied Biology and Chemical Technology, The Hong Kong Polytechnic University, Hung Hom, Hong Kong, China

[2]Department of Medicine and Therapeutics, The Chinese University of Hong Kong, Shatin, Hong Kong

[3]Jockey Club Centre for Osteoporosis Care and Control, The Chinese University of Hong Kong, Shatin, Hong Kong

[4]Department of Obstetrics and Gynaecology, The Chinese University of Hong Kong, Shatin, Hong Kong

***Corresponding author:** Ruth Chan, Department of Applied Biology and Chemical Technology, The Hong Kong Polytechnic University, Hung Hom, Hong Kong, China

Received: September 29, 2020; **Accepted:** October 21, 2020; **Published:** October 28, 2020

Abstract

Food Frequency Questionnaire (FFQ) should be tailored and shown to be reliable and valid for use in a specific population. Therefore, we developed a short Food Frequency Questionnaire (FFQ) for Chinese pregnant women in Hong Kong and evaluated its reproducibility and validity. We recruited 45 pregnant women from a hospital or maternal and child health centers during 29 November 2018 to 14 November 2019, then the short FFQ was administered twice in one month. Three-day Dietary Recalls (DR) were conducted between two FFQ administrations. Relative validity and reproducibility the short FFQ over a period of 1 month. Reliability of dietary intake was evaluated by Intraclass Correlation Coefficient (ICC), and the relationship between FFQ- and DR-reported values was examined using Pearson correlation. The reliability of nutrient intake was moderate (0.50 to 0.75) to good (0.75 to 0.90), but only poor (<0.5) to moderate for food group intake. Most nutrients reported by the short FFQ significantly correlated with values reported by dietary recalls. Meanwhile, only several food groups showed significant correlations in the values reported by short FFQ and dietary recalls. When looking across nutrient and food group categories, it is notable that fiber and fruit intake have demonstrated good reliability and validity. To conclude, our short FFQ can serve as a quick assessment tool to identify pregnant women with unhealthy diet in community level and is particularly useful to classify individuals with low fruits or fiber intake.

Keywords: Food Frequency Questionnaire; Dietary Recall; Pregnant Women; Reliability; Validation Study; Asian Diet

Abbreviations

DR: Dietary Recall; FFQ: Food Frequency Questionnaire; GDM: Gestational Diabetes Mellitus; ICC: Intra-Class Correlation Coefficient; MCHC: Maternal and Child Health Center

Introduction

Optimal maternal nutrition is important for long-term health of both mother and offspring. Over-nutrition during pregnancy leads to maternal obesity and is of global public health concern [1,2]. Adverse in utero environment increase the risk of childhood obesity and associated disorders, through the foetal programming [3]. Evidence from animal and human studies shows that foetus exposed to excess nutrient supply before birth is associated with an increased risk of obesity and associated metabolic disorders in later life [2,4]. Moreover, maternal Gestational Diabetes Mellitus (GDM) and gestational weight gain increased the offspring's cardiometabolic risk [5,6]. Taken together, maternal dietary habits during pregnancy should be carefully monitored to prevent adverse health consequences for mothers and children.

In Hong Kong, the prevalence of GDM is raising from 14.2% in early 90s to 32.5% in 2014 [7,8], which is alongside with the rising epidemic of obesity and diabetes in Hong Kong in the past decades [9]. Although the importance of maternal nutrition on mother's and offspring's health is highly recognized, there is no brief and validated dietary assessment tool available for Hong Kong pregnant women. One of the commonly used tools for dietary assessments would be Food Frequency Questionnaire (FFQ), especially for large-scale epidemiological studies [10]. FFQ is a valid and reliable tool for assessing nutrient or food intakes for pregnant women in different countries including China [11-13].

Since dietary habits vary greatly in population with different regional, ethnic, or cultural background, the FFQ should be tailored and validated for use in a specific population. Moreover, food frequency questionnaire usually contains >100 items [14], which may become a burden for pregnant women during administration. Therefore, we have developed a short FFQ with 50 items and have tailored for the dietary habits of Hong Kong pregnant women, which is a mix of Westernized and Chinese diet. In this study, we evaluated the reproducibility and relative validity of this short FFQ to assess food group consumption and nutrient intake for Chinese pregnant women in Hong Kong.

Materials and Methods

Study Design and Participants

Participants were pregnant women attending the antenatal clinic of the Prince of Wales Hospital or Maternal and Child Health Centers (MCHCs) in Hong Kong and being recruited using convenience

Citation: Lo K, Li L, Leung J, Tam WH and Chan R. Reproducibility and Relative Validity of a Short Food Frequency Questionnaire for Chinese Pregnant Women in Hong Kong. Austin J Nutri Food Sci. 2020; 8(3): 1146.

sampling. Participants were interviewed by a trained research staff for dietary assessment and questionnaire completion after their written consent. The study protocol was performed in compliance with the Declaration of Helsinki and approved by the Clinical Research Ethics Committee of The Chinese University of Hong Kong (CREC Ref. No.: 2018.440) and the Ethics Committee of the Department of Health in Hong Kong (LM 29/2019).

Participants were eligible if they fulfill the following criteria.

Inclusion criteria:

1. Hong Kong Chinese citizen
2. Reside in Hong Kong
3. Age at or above 18 years old
4. With antenatal registry in Prince of Wales Hospital or Maternal and Child Health Centers
5. Singleton pregnancy
6. Could speak and understand Chinese
7. Willing to follow the study procedures.

Exclusion criteria:

1. Currently participating in any clinical trial or trial with dietary intervention
2. Multiple pregnancy
3. With any renal, liver, or thyroid dysfunction, any other indication of a major medical or psychological illness, as judged by the investigators as ineligible to participate the study.

Data Collection

Maternal information was collected using questionnaires and retrieved from the hospital or clinic record. Physical examination measurements of participants included weight and height, which was measured using electronic scales and stadiometer, and pre-pregnancy weight was self-reported. Demographic characteristics, including mother's age, education, occupation, family income, and smoking status were collected using a standardized questionnaire and retrieved from the hospital/clinic record.

Dietary Assessments

Dietary intake was assessed by two dietary assessment methods, including three 24-hour dietary recalls and a newly developed Food Frequency Questionnaire (FFQ). The 50-item FFQ was newly developed by clinical experience from a panel of dietitians, nutritionists, nurses and doctors, and with reference to a FFQ available for the local adult population [15], as well as other FFQs for pregnant women from the literature [11-13]. Each participant was asked to complete FFQ twice within 3 to 4 weeks interval (for reproducibility evaluation), and three 24-hour dietary recalls in between the two administrations of the FFQ as a reference method to validate the FFQ (for validity evaluation). The three 24-hour dietary recalls included two weekdays and one weekend day.

On the interview day in which the 1st FFQ was administrated (FFQ1), each participant was explained by trained research staff on how to complete the FFQ by herself with the provision of the food portion booklet. Each participant was asked to complete the 1st FFQ regarding her intake of various food groups over the past month. The frequency of food group intake was reported per day, week or month, and portions were reported based on standard referent portion sizes, as pieces, glasses, cups, spoons, milliliters, or grams. On the same interview day, participant was also asked by trained research staff to recall all foods and beverages that have been consumed over the past 24 hours. Food photo albums and eating utensils of standardized portions were displayed to help recall. The 2nd administration of the FFQ (FFQ2) was done 3 to 4 weeks after the 1st administration of the FFQ. The FFQ2 and the food portion booklet as well as the additional 24-hour recall forms were given to the participants by email, smart phone messages or post within 3 to 4 weeks after the 1st administration of the FFQ (FFQ1). Between the intervals of two FFQs, the research staff gave phone call or smart phone messages to the participant on two separate days to complete two more 24-hour dietary recalls for validity evaluation purpose. Daily dietary and nutrient intake collected by both FFQs and 24-hour recalls were entered and calculated using the nutrition analysis software Food Processor Nutrition analysis and Fitness software version 8.0 (ESHA Research, Salem, USA) including local foods selected from food composition tables from China and Hong Kong.

Statistical Analysis

Continuous variables were presented as mean (standard deviations) for parametric data and as median (interquartile range) for nonparametric data. Categorical variables were presented as number (percentage). Intra-class correlation coefficients (ICC) were calculated to examine the reproducibility between FFQ1 and FFQ2. Based on the reported ICC, the reliability of dietary intake can be categorized into poor (<0.5), moderate (0.5 to 0.75), good (0.75 to 0.90) and excellent (>0.90) respectively [16].

Pearson's correlations were used to validate results of FFQ1 against the average of three 24-hour recalls. As an alternative analysis, we applied energy adjustment using the residual method of Willett [17], and computed the Pearson correlation using the energy-adjusted nutrient and food group intake. Differences in nutrient and food group intakes between the first FFQ and the average of three 24-hour recalls were examined using one-sample t-test. We also examined if the differences in nutrient and food group intakes between the first FFQ and the average of three 24-hour recalls increased with the average of FFQ1 and 24-hour recalls, with the use of linear regression. A quartile classification analysis was used to categorize the nutrient intake and food group intake calculated from the FFQ and the three 24-hour recalls. Below is the list of categories of nutrient and food group intake.

Category of nutrient intake: energy; protein; carbohydrates; fibre; total sugar; total fat; saturated fat; trans-fat; cholesterol; % energy from protein; % energy from carbohydrates; % energy from total fat, % energy from saturated fat; vitamin C; calcium; iron; magnesium; phosphorus; potassium; sodium; zinc

Category of food group intake: condiment; grains; fruits; vegetables; meat, poultry, processed and organ meat; fish and sea foods; eggs; dairy and dairy products; beverages; tea or coffee; soy and soy products; legumes; nuts and seeds; sugary snacks; water; fast food; savory snacks; dim sum (Chinese cuisine of small dishes); oil.

Table 1: Characteristics of 45 participants.

Characteristics	Mean (SD)/ N (%)
Age (years)	32.0 (5.1)
Gestational age (week)	25.4 (6.2)
Pre-pregnancy weight (kg)	53.5 (7.8)
Height (m)	1.58 (0.06)
BMI at enrolment(kg/m^2)	24.4 (3.1)
Pre-pregnancy BMI category	
Underweight (<18.5)	1 (2.2)
Normal (18.5 to <22)	14 (31.1)
Overweight (22 to <25)	9 (20.0)
Obese (>=25)	21 (46.7)
Parity	
0	27 (60.0)
>=1	18 (40.0)
Education	
Secondary or below	25 (55.6)
Tertiary or above	20 (44.4)
Marital status	
Married	41 (91.1)
Others [a]	4 (8.9)
Working status	
Working	23 (51.1)
Non-working[b]	22 (48.9)
Monthly family income (HK$)[c]	
Less than 20,000	19 (43.2)
20,000 or above	25 (56.8)
Smoking status	
Never smoke	42 (93.3)
Ex-smoker	3 (6.7)

[a]Others included never married, widowed, separated, and divorced.
[b]Non-working included unemployment and housewife.
[c]One subject with missing data.

In addition, the percentage of correctly classified subjects into the same, adjacent (±1 quartile) or extreme quintiles (±3 quartiles) were calculated. Lastly, for nutrients or food groups with at least moderate reliability and validity, Bland-Altman plots was performed to visually present the agreement between the first FFQ and three 24-hour recalls. All statistical analyses were performed using the statistical package SPSS version 24.0 (SPSS Inc., Illinois, US). All statistical tests were two-tailed, and significance were set at $p < 0.05$.

Results

Demographic Characteristics

Table 1 presented the demographic characteristics of 45 participating women. The average age was 32.0-year-old, and the gestational week was 25.4 on average. Out of 45 participants, 60% were first-time mothers. A total of 66.7% participants were overweight or obese before pregnancy, 44.4% of them received tertiary education, 91.1% of them were married. Around half of the participants (51.1%) were working, and 56.8% of them earnt HK$20,000 (approximately USD$2500) or above per month. There were 6.7% of mothers have consumed cigarettes.

Reproductivity of FFQ

Table 2 and Table 3 presented the reliability of nutrient and food group intake between two FFQ administration (N=36), respectively. For the nutrient intake (Table 2), the Intraclass Correlation Coefficients (ICC) ranged from 0.50 (% dietary energy from total fat) to 0.80 (iron). The intake of fiber, vitamin C and iron has good reliability, while other nutrients have moderate reliability. For the food group intake (Table 3), the ICC ranged from 0.03 (fast food) to 0.85 (water). Out of the 19 food groups, the intake of dairy products and water has good reliability. However, the intake of grains, vegetables, tea or coffee, nuts and seeds, sugary snacks, fast food, and oil has poor reliability (ICC<0.50).

Relative Validity of FFQ and 3-Day Dietary Recall

Table 4 has shown the relationship between the first FFQ administration and 3-day dietary recall in terms of nutrient. FFQ-reported nutrient intake significantly correlated with dietary recall-reported values for most variables, except for total fat, saturated fat, % dietary energy from carbohydrates, total fat, or saturated fat. The relationship remained consistent for most energy-adjusted nutrient intake. Moreover, FFQ-reported food group intake only had significant correlation with dietary recall-reported values for several variables, namely condiment, fruits, fish and sea foods, dairy and dairy products, beverages, tea or coffee, nuts and seeds, water (Table 5). The relationship remained consistent for most energy-adjusted food group intake.

In addition to correlation analysis, we cross-tabulated the quartiles of dietary intake as reported by first FFQ administration and 3-day dietary recall to evaluate the agreement between different dietary assessments. For nutrient intake (Table 6), the percentage of 'same quartile' classification ranged from 22.2% (total fat) to 51.1% (fiber). Energy adjustment did not change the classification results substantially; fiber was the only nutrient with more than 10% changes (51.1% to 31.1%). As for food group intake (Table 7), the percentage of 'same quartile' classification ranged from 11.1% (condiment) to 62.2% (water). Energy adjustment has substantial impact on the level of agreement for several food groups, including condiment (11.1% to 60.0%), meat, poultry, processed and organ meat (33.3% to 20.0%), tea of coffee (60.0% to 31.1%), fast food (33.3% to 48.9%), savory snacks (44.4% to 22.2%) and dim sum (20.0% to 35.6%).

In Table 8, we have examined whether the difference between the dietary intake reported by FFQ and dietary recalls was significant using one-sample t-test. We have detected significant differences for carbohydrates, % dietary energy from carbohydrates and total fat, calcium, iron, sodium, tea or coffee, water, fast food, and oil. Among these differences, % dietary energy from total fat, and the consumption of oil were significantly higher for values reported by FFQ. Moreover, we performed linear regression to evaluate if the difference between the dietary intake reported by FFQ and dietary recalls changed significantly with the levels of dietary intakes. We have detected significant positive association for protein, saturated fat, cholesterol, iron, zinc, meat, poultry, processed and organ meat,

Table 2: Mean daily intake of energy and selected nutrients and intraclass correlation coefficients between the two FFQs administered to the study participants (n=36).

Parameters	FFQ1					FFQ2					ICC (95% CI)[a]
	Mean	SD	Median	25th	75th	Mean	SD	Median	25th	75th	
Energy (kcal)	1847.2	566.4	1895.8	1367.6	2236.1	1941.6	636.5	1872.6	1397.7	2416.2	0.69 (0.47-0.83)
Protein (g)	93.3	39.7	89.1	66.8	116.6	101.2	50.3	94.1	63.8	135.2	0.64(0.40-0.80)
Carbohydrates (g)	188.6	52.8	184.8	145.4	236.4	183.2	55.4	176.5	144.1	221.2	0.52 (0.23-0.72)
Fibre (g)	13.0	4.8	12.7	9.6	15.6	11.9	4.8	10.4	8.8	14.7	0.76 (0.57-0.87)
Total sugar (g)	49.9	17.6	50.2	34.8	59.5	47.5	16.1	45.7	34.6	56.4	0.55 (0.28-0.74)
Total fat (g)	81.3	29.7	81.5	56.9	100.0	90.1	37.3	88.4	63.2	113.2	0.69 (0.47-0.83)
Saturated fat (g)	21.9	9.8	20.7	15.2	28.1	24.9*	12.5	22.4	15.7	29.9	0.68 (0.46-0.83)
Trans fat (g)	0.8	0.5	0.6	0.4	0.9	0.7	0.5	0.7	0.4	1.0	0.60 (0.34-0.77)
Cholesterol (mg)	524.8	289.7	543.5	324.7	665.1	544.4	286.1	526.4	311.2	730.8	0.70 (0.49-0.84)
%E protein	19.7	3.6	19.5	16.9	22.1	20.0	4.2	20.0	16.7	23.3	0.60 (0.34-0.77)
% E carbohydrates	41.8	7.5	41.8	36.2	47.7	39.4	9.9	38.9	33.5	46.1	0.62 (0.37-0.79)
%E total fat	39.3	5.6	39.4	35.8	42.9	41.0	6.6	41.6	37.2	45.1	0.50 (0.22-0.71)
% E saturated fat	10.3	2.0	10.5	8.6	11.6	11.1*	2.7	11.7	9.2	12.6	0.63 (0.39-0.79)
Vitamin C (mg)	101.9	50.3	91.6	73.1	125.9	101.3	70.5	85.7	67.3	122.6	0.76 (0.57-0.87)
Calcium (mg)	591.1	237.4	625.9	410.1	754.9	596.6	258.0	555.7	436.3	696.6	0.75 (0.57-0.87)
Iron (mg)	14.8	6.3	14.6	9.8	18.1	15.2	7.3	13.6	9.6	19.6	0.80 (0.64-0.89)
Magnesium (mg)	236.4	79.3	250.3	168.9	284.9	233.1	80.9	243.8	166.1	289.4	0.70 (0.48-0.83)
Phosphorus (mg)	1112.1	419.3	1156.4	795.9	1386.9	1163.5	471.1	1131.0	800.4	1468.6	0.66 (0.42-0.81)
Potassium (mg)	2035.2	723.1	2040.7	1524.6	2670.9	2079.0	820.9	1920.2	1468.3	2729.7	0.68 (0.46-0.82)
Sodium (mg)	3224.1	860.1	3285.8	2651.6	3580.1	3264.9	703.4	3160.6	2896.1	3635.1	0.74 (0.55-0.86)
Zinc (mg)	12.2	5.5	12.1	8.1	14.8	13.2	7.1	11.6	7.4	17.7	0.66 (0.42-0.81)

*P<0.05 Compared with intakes estimated by FFQ1 using Paired Sample t test or Wilcoxon's signed rank test whenever appropriate.
[a]Value of intraclass correlation coefficients between two FFQ administrations.
Abbreviations: FFQ: Food Frequency Questionnaire; g: Gram; ICC: Intraclass Correlation Coefficient; kcal: kilocalorie; mg: micro-gram; sd: Standard Deviation

Table 3: Mean daily intake of food groups and intraclass correlation coefficients between the two FFQs administered to the study participants (n=36).

Parameters	FFQ1					FFQ2					ICC (95% CI)[a]
	Mean	SD	Median	25th	75th	Mean	SD	Median	25th	75th	
Condiment (g)	24.3	7.3	24.0	24.0	24.0	25.0	5.3	24.0	24.0	24.0	0.50 (0.21, 0.71)
Grains (g)	395.0	136.5	400.0	284.7	490.8	392.3	162.4	407.0	261.0	449.7	0.25 (-0.08, 0.53)
Fruits (g)	191.5	92.3	150.4	150.0	300.0	182.1	109.7	150.0	89.3	300.0	0.74 (0.55, 0.86)
Vegetables (g)	152.3	82.2	150.6	98.6	160.3	130.4	115.9	125.8	61.0	152.6	0.48 (0.18, 0.70)
Meat, poultry, processed and organ meat (g)	190.4	126.5	156.7	96.7	279.3	227.6	176.8	168.5	104.5	313.0	0.56 (0.29, 0.75)
Fish and seafoods (g)	37.2	30.1	28.5	13.8	56.5	32.1	27.5	22.0	15.4	40.5	0.71 (0.51, 0.84)
Eggs (g)	40.3	36.4	40.0	13.3	50.0	38.8	27.7	40.0	13.3	50.0	0.55 (0.28, 0.74)
Dairy and dairy products (g)	119.5	108.6	78.7	21.3	241.4	127.8	129.2	59.5	27.6	241.4	0.81 (0.66, 0.90)
Beverages (ml)	34.0	60.9	8.3	0.0	33.3	28.7	47.0	9.2	0.0	26.8	0.62 (0.37, 0.79)
Tea or coffee (ml)	16.7	32.2	0.0	0.0	23.4	41.4	160.2	0.0	0.0	19.1	0.23 (-0.10, 0.52)
Soy and soy products (g)	58.4	76.2	26.3	8.6	76.2	69.7	83.6	32.9	10.6	113.1	0.63 (0.38, 0.79)
Legumes (g)	19.3	32.3	6.0	0.4	24.0	20.1	32.6	7.5	0.0	21.8	0.57 (0.31, 0.76)
Nuts and seeds (g)	2.8	4.7	0.7	0.0	2.7	0.9	2.1	0.3	0.0	0.8	0.26 (-0.07, 0.54)
Sugary snacks (g)	18.7	19.6	13.3	2.0	27.4	14.3	16.8	10.0	2.8	20.9	0.27 (-0.06, 0.55)
Water (ml)	1595.3	686.5	1530.0	1200.0	1920.0	1483.9	602.9	1440.0	1020.0	1920.0	0.85 (0.73, 0.92)
Fast food (g)	5.3	8.1	2.5	0.0	8.0	6.7	14.2	2.5	2.0	6.0	0.03 (-0.30, 0.35)
Savory snacks (g)	5.5	8.9	3.3	0.0	8.3	7.6	10.7	3.3	0.0	12.1	0.72 (0.51, 0.85)
Dim sum (g)	26.9	26.7	21.8	7.5	32.6	28.4	26.1	21.1	11.7	33.5	0.71 (0.51, 0.84)
Oil (ml)	21.8	10.2	27.0	13.5	27.2	24.6	10.5	27.0	14.7	28.0	0.46 (0.15, 0.68)

[a]Value of intraclass correlation coefficients between two FFQ administrations.
Abbreviations: FFQ: Food Frequency Questionnaire; g: gram; ICC: Intraclass Correlation Coefficient; ml: millilitre; SD: Standard Deviation.

Table 4: Mean daily intake of energy and selected nutrients and Pearson correlation coefficient between the FFQ and the average of three 24-h DRs (n=45).

Parameters	FFQ1					24-h DRs					Pearson Coefficient Correlation	
	Mean	SD	Median	25th	75th	Mean	SD	Median	25th	75th	Crude	Energy adjusted
Energy (kcal)	1864.1	550.7	1934.3	1368.8	2278.3	2002.7	448.7	1928.8	1741.6	2280.1	0.38*	---
Protein (g)	94.6	40.8	95.6	66.5	116.1	94.8	27.0	88.3	75.0	109.7	0.41*	0.16
Carbohydrates (g)	186.6	49.3	184.3	150.0	230.6	218.2	51.8	213.8	185.9	242.5	0.39*	0.04
Fibre (g)	12.6	4.4	12.4	9.9	15.4	13.1	5.2	12.8	9.1	15.8	0.73*	0.71*
Total sugar (g)	49.8	16.4	50.1	37.2	59.2	54.1	19.9	54.4	36.3	67.2	0.36*	0.14
Total fat (g)	83.4	29.5	83.0	58.2	103.1	84.0	23.4	84.1	64.6	100.6	0.19	-0.06
Saturated fat (g)	22.4	10.0	20.8	15.5	29.0	22.0	7.2	20.4	16.1	26.9	0.19	0.33*
Trans fat (g)	0.8	0.6	0.7	0.4	1.0	0.7	0.7	0.6	0.3	1.0	0.52*	0.47*
Cholesterol (mg)	530.2	292.9	543.9	291.9	687.3	456.7	175.1	439.9	324.1	543.6	0.40*	0.07
%E protein	19.7	3.9	19.4	16.9	22.2	18.9	3.1	19.0	16.4	21.3	0.47*	---
% E carbohydrates	41.2	7.7	40.4	34.9	47.7	43.8	5.9	42.9	39.5	47.8	0.20	---
%E total fat	39.9	5.4	40.2	35.9	43.6	37.5	5.1	37.4	34.0	40.0	-0.04	---
% E saturated fat	10.5	2.1	10.6	9.0	11.7	9.8	2.3	9.4	8.3	11.6	0.26	---
Vitamin C (mg)	98.0	46.5	90.0	70.4	121.3	95.0	64.0	95.4	34.0	130.4	0.52*	0.61*
Calcium (mg)	577.1	225.3	606.8	388.6	737.1	671.6	294.7	674.6	434.6	871.9	0.59*	0.62*
Iron (mg)	14.8	6.2	14.8	9.9	18.1	12.3	4.0	11.6	9.6	15.1	0.50*	0.52*
Magnesium (mg)	234.0	75.2	247.5	176.9	284.3	243.0	70.2	237.3	182.9	284.8	0.51*	0.59*
Phosphorus (mg)	1114.8	414.5	1165.0	777.5	1383.7	1106.7	318.1	1067.2	862.6	1281.7	0.44*	0.47*
Potassium (mg)	2024.1	703.9	2038.3	1544.9	2664.0	2060.9	668.1	2032.5	1574.7	2375.0	0.43*	0.40*
Sodium (mg)	3244.4	828.9	3271.0	2693.7	3636.9	3754.6	813.2	3627.7	3216.6	4202.2	0.41*	0.22
Zinc (mg)	12.3	5.8	11.7	8.0	14.7	10.8	4.0	9.7	7.8	12.7	0.39*	0.38*

Abbreviations: DR: Dietary Recall; FFQ: Food Frequency Questionnaire; g: gram; kcal: kilocalorie; mg: micro-gram; SD: Standard Deviation.

Table 5: Mean daily intake of energy and selected nutrients and Pearson correlation coefficient between the FFQ and the average of three 24-h DRs (n=45).

Parameters	FFQ1					24-h DRs					Pearson correlation coefficient	
	Mean	SD	Median	25th	75th	Mean	SD	Median	25th	75th	Crude	Energy adjusted
Condiment (g)	24.3	7.0	24.0	24.0	24.0	26.1	7.6	24.0	24.0	31.3	0.44*	0.42*
Grains (g)	387.3	129.4	400.0	281.1	475.3	430.0	147.1	413.3	325.5	506.3	0.24	0.18
Fruits (g)	176.7	94.7	150.0	122.8	300.0	159.2	113.9	156.7	71.0	250.0	0.57*	0.53*
Vegetables (g)	154.8	77.8	151.2	107.2	160.4	160.2	102.8	135.0	79.8	219.9	0.13	0.06
Meat, poultry, processed and organ meat (g)	196.9	132.6	168.8	98.7	278.0	170.1	78.3	160.0	110.3	230.5	0.29	-0.09
Fish and seafoods (g)	36.8	30.0	31.7	13.8	53.0	32.4	43.9	16.7	0.0	50.8	0.52*	0.46*
Eggs (g)	40.3	36.5	40.0	13.3	50.0	40.8	27.3	33.3	16.7	64.6	0.26	0.12
Dairy and dairy products (g)	105.5	104.2	48.3	19.7	209.6	131.1	148.0	50.0	0.7	253.5	0.61*	0.62*
Beverages (ml)	46.1	73.3	16.6	0.0	59.9	46.7	95.7	0.0	0.0	63.6	0.34*	0.34*
Tea or coffee (ml)	19.7	32.5	0.0	0.0	30.7	40.3	73.8	0.0	0.0	74.2	0.41*	0.47*
Soy and soy products (g)	72.4	88.2	40.0	12.5	92.6	77.3	101.5	58.9	0.0	115.3	0.56*	0.56*
Legumes (g)	17.9	29.6	7.5	0.0	24.0	8.2	15.5	0.0	0.0	9.2	0.04	0.04
Nuts and seeds (g)	2.6	4.3	0.7	0.0	2.7	4.4	10.2	0.0	0.0	1.7	0.32*	0.33*
Sugary snacks (g)	21.2	20.1	15.3	4.5	31.3	36.3	51.5	15.8	0.0	66.3	0.11	0.09
Water (ml)	1494.9	691.8	1440.0	960.0	1920.0	1705.9	765.4	1483.3	1262.5	2121.7	0.82*	0.80*
Fast food (g)	6.3	8.7	2.5	0.3	9.0	19.6	34.1	0.0	0.0	33.3	0.26	0.27
Savory snacks (g)	6.3	8.8	4.2	0.0	8.3	6.3	14.7	0.0	0.0	5.3	0.24	0.32*
Dim sum (g)	27.8	24.9	24.0	9.2	37.8	39.0	49.8	16.7	0.0	70.8	0.26	0.35*
Oil (ml)	22.6	10.6	27.0	13.5	27.2	16.5	8.3	15.2	11.3	21.9	0.02	-0.01

Abbreviations: DR: Dietary Recall; FFQ: Food Frequency Questionnaire; g: gram; ml: millilitre; SD: Standard Deviation.

Table 6: Cross-classification of energy and nutrient intake quartiles from the FFQ1 and the average of three 24-h DRs (n=45).

Parameters	Crude[a]			Adjusted for energy[a]		
	Same quartile	Adjacent quartile[b]	Extreme quartile[c]	Same quartile	Adjacent quartile[b]	Extreme quartile[c]
Energy (kcal)	26.7	46.7	2.2	---	---	---
Protein (g)	33.3	44.4	0.0	37.8	31.1	6.7
Carbohydrates (g)	24.4	55.6	6.7	31.1	33.3	8.9
Fibre (g)	51.1	28.9	2.2	31.1	51.1	0.0
Total sugar (g)	33.3	33.3	6.7	24.4	48.9	15.6
Total fat (g)	22.2	46.7	11.1	26.7	44.4	22.2
Saturated fat (g)	24.4	40.0	8.9	31.1	37.8	4.4
Trans fat (g)	26.7	42.2	6.7	26.7	37.8	11.1
Cholesterol (mg)	31.1	44.4	0.0	37.8	17.8	15.6
%E protein	33.3	44.4	0.0	---	---	---
% E carbohydrates	24.4	44.4	6.7	---	---	---
%E total fat	26.7	35.6	17.8	---	---	---
% E saturated fat	33.3	35.6	6.7	---	---	---
Vitamin C (mg)	37.8	42.2	2.2	28.9	46.7	2.2
Calcium (mg)	42.2	35.6	0.0	40.0	40.0	2.2
Iron (mg)	37.8	35.6	4.4	40.0	33.3	4.4
Magnesium (mg)	40.0	44.4	4.4	37.8	44.4	2.2
Phosphorus (mg)	44.4	33.3	6.7	42.2	40.0	4.4
Potassium (mg)	31.1	40.0	8.9	31.1	46.7	8.9
Sodium (mg)	35.6	37.8	6.7	44.4	26.7	11.1
Zinc (mg)	33.3	44.4	4.4	26.7	46.7	11.1

[a]Percentage of all categories may not be rounded up to 100% exactly.
[b]Same ±1 quartile.
[c]Misclassification by same ±3 quartiles.
Abbreviations: g: gram; kcal: kilocalorie; mg: micro-gram.

Table 7: Cross-classification of food group intake quartiles from the FFQ1 and the average of three 24-h DRs (n=45).

Parameters	Crude[a]			Adjusted for energy[a]		
	Same quartile	Adjacent quartile[b]	Extreme quartile[c]	Same quartile	Adjacent quartile[b]	Extreme quartile[c]
Condiment (g)	11.1	62.2	2.2	60.0	24.4	4.4
Grains (g)	40.0	40.0	6.7	44.4	33.3	8.9
Fruits (g)	44.4	40.0	4.4	51.1	33.3	6.7
Vegetables (g)	26.7	35.6	11.1	31.1	33.3	8.9
Meat, poultry, processed and organ meat (g)	33.3	40.0	4.4	20.0	37.8	13.3
Fish and seafoods (g)	42.2	37.8	4.4	37.8	40.0	4.4
Eggs (g)	31.1	48.9	2.2	37.8	33.3	6.7
Dairy and dairy products (g)	44.4	42.2	4.4	37.8	53.3	4.4
Beverages (ml)	44.4	17.8	11.1	44.4	31.1	6.7
Tea or coffee (ml)	60.0	2.2	20.0	31.1	33.3	4.4
Soy and soy products (g)	31.1	35.6	15.6	33.3	33.3	6.7
Legumes (g)	31.1	28.9	8.9	28.9	37.8	2.2
Nuts and seeds (g)	51.1	13.3	8.9	57.8	24.4	4.4
Sugary snacks (g)	28.9	33.3	8.9	26.7	48.9	8.9
Water (ml)	62.2	28.9	2.2	60.0	31.1	2.2
Fast food (g)	33.3	26.7	15.6	48.9	20.0	4.4
Savory snacks (g)	44.4	24.4	22.2	22.2	37.8	6.7
Dim sum (g)	20.0	40.0	15.6	35.6	33.3	4.4
Oil (ml)	33.3	40.0	6.7	26.7	44.4	15.6

[a]Percentage of all categories may not be rounded up to 100% exactly.
[b]Same ±1 quartile.
[c]Misclassification by same ± 3 quartiles.
Abbreviations: g: gram; ml: milliliter.

Table 8: Results from one-sample t-test and linear regression.

Nutrients	Mean difference[#]	p-values	Beta-coefficients	p-values
Energy (kcal)	-138.648	0.106	0.295	0.151
Protein (g)	-0.155	0.979	0.568	0.004*
Carbohydrates (g)	-31.545	<0.001*	-0.070	0.731
Fibre (g)	-0.437	0.424	-0.183	0.135
Total sugar (g)	-4.368	0.167	-0.284	0.179
Total fat (g)	-0.569	0.911	0.381	0.128
Saturated fat (g)	0.418	0.803	0.531	0.033*
Trans fat (g)	0.068	0.485	-0.246	0.156
Cholesterol (mg)	73.509	0.080	0.702	<0.001*
%E protein	0.793	0.154	0.316	0.087
% E carbohydrates	-2.648	0.048*	0.442	0.074
%E total fat	2.331	0.046*	0.132	0.680
% E saturated fat	0.614	0.131	-0.098	0.677
Vitamin C (mg)	2.921	0.699	-0.387	0.009*
Calcium (mg)	-94.515	0.012*	-0.334	0.033*
Iron (mg)	2.569	0.003*	0.555	0.002*
Magnesium (mg)	-9.040	0.406	0.092	0.601
Phosphorus (mg)	8.090	0.892	0.364	0.057
Potassium (mg)	-36.758	0.738	0.073	0.706
Sodium (mg)	-510.236	<0.001*	0.027	0.892
Zinc (mg)	1.517	0.076	0.511	0.011*
Food group				
Condiment (g)	-1.877	0.112	-0.120	0.532
Grains (g)	-42.718	0.102	-0.207	0.390
Fruits (g)	17.514	0.241	-0.234	0.148
Vegetables (g)	-5.354	0.767	-0.482	0.068
Meat, poultry, processed and organ meat (g)	26.831	0.183	0.769	<0.001*
Fish and seafoods (g)	4.341	0.448	-0.488	0.004*
Eggs (g)	-0.444	0.940	0.452	0.052
Dairy and dairy products (g)	-25.538	0.155	-0.429	0.005*
Beverages (ml)	-0.580	0.969	-0.392	0.066
Tea or coffee (ml)	-20.620	0.046*	-1.035	<0.001*
Soy and soy products (g)	-4.900	0.717	-0.180	0.272
Legumes (g)	9.685	0.055	1.103	<0.001*
Nuts and seeds (g)	-1.882	0.200	-1.131	<0.001*
Sugary snacks (g)	-15.155	0.062	-1.367	<0.001*
Water (ml)	-211.046	0.003*	-0.111	0.258
Fast food (g)	-13.319	0.009*	-1.559	<0.001*
Savory snacks (g)	-0.042	0.985	-0.774	0.001*
Dim sum (g)	-11.211	0.137	-0.998	<0.001*
Oil (ml)	6.047	0.004*	0.464	0.117

Abbreviations: g: gram; kcal: kilocalorie; mg: micro-gram; ml: milliliter.
[#]Mean difference computed by FFQ-reported values minus dietary recall-reported values.

legumes. Meanwhile, significant inverse association was found for vitamin C, calcium, fish and sea foods, dairy and dairy products, tea or coffee, nuts and seeds, sugary snacks, fast food, savory snacks, and dim sum. Regarding the moderate reliability and validity of energy, fiber and fruit intake, we further illustrated the results as reported in Table 8by Bland-Altman plots. Dietary energy (Figure 1), fiber (Figure 2) and fruit intake (Figure 3) did not have substantial number of outliners (beyond of the range of mean ±2 standard deviations).

Discussion

Summary of Main Findings

In the present study, we have acquired dietary intake of 45 Hong Kong pregnant women using a short version of FFQ and 3-day dietary recalls and evaluated the reliability and validity of short FFQ. As revealed by intraclass correlation coefficient, the reliability of nutrient intake was moderate to good reliability, but only poor to moderate for food group intake. Most nutrients reported by the short FFQ significantly correlated with values reported by dietary recalls. Meanwhile, only several food groups showed significant correlations in the values reported by short FFQ and dietary recalls.

Reproducibility of Short FFQ

As evaluated by intraclass correlation coefficients, the nutrient intake using short FFQ has most moderate reliability with few items with good reliability. In contrast, the intake of several food groups has shown poor reliability. It can be challenging to estimate food intake accurately for Asian cuisine. For grains, vegetables, tea or coffee, nuts and seeds, and oil, they are usually consumed in a mixed dish. Some validation studies conducted in Chinese pregnant women also found poor reliability of vegetable intake, which agreed with our findings [13,18]. Meanwhile, food taboos are commonly practiced during pregnancy to provide better health for mothers and infants [19]. From this perspective, sugary snacks and fast food are less likely to be consumed regularly during pregnancy.

Relative Validity of Short FFQ

In validation studies for FFQ, the correlation coefficient is reasonable if it ranged from 0.30 to 0.49 and is good if greater than 0.5 [20]. In the present study, the correlation between short FFQ and dietary recalls is reasonable or good for most nutrients. This finding was consistent with similar studies that examined both nutrient and food group intakes of pregnant women [13,18]. However, the correlation coefficients are smaller for food group intakes. Fluctuations in appetite and food preferences are common during pregnancy [12], therefore the food groups reported in dietary recalls may not agree perfectly with usual dietary habits as reported in FFQ.

Moreover, our FFQ was found to produce lower estimates for carbohydrates, % dietary energy from carbohydrates, calcium, iron, sodium, tea or coffee, water, and fast food when compared with 3-day dietary recalls. In contrast to the potential overestimation when FFQ contains over 100 items, [21] we observed under estimation of intake in the current FFQ. It is likely due to fewer items being included in the short FFQ. Despite the significant differences in estimation, the energy intake discrepancy (-138 kcal/day) was comparable with other FFQs designed for pregnant women in China (-49 kcal/day), France (+219 kcal/day), Greece (+32 kcal/day) and Lebanon (+378 kcal/day) [13, 22-24].

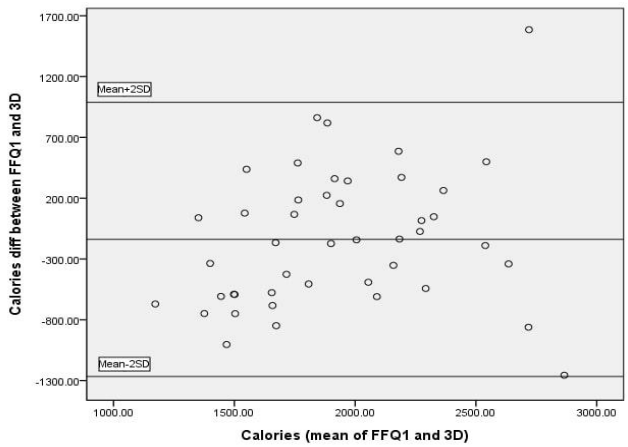

Figure 1: Bland-Altman plot of dietary energy.

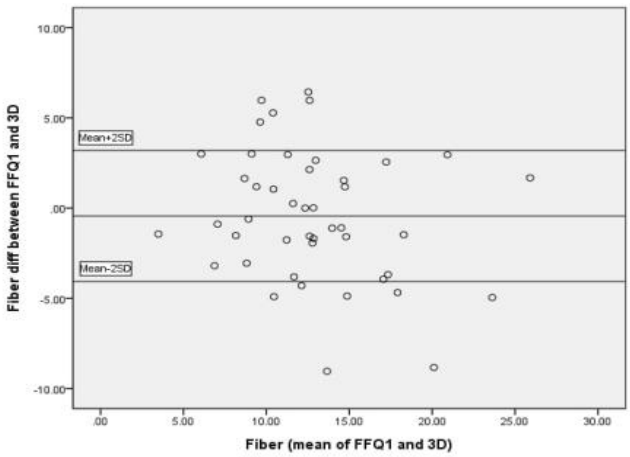

Figure 2: Bland-Altman plot of dietary fiber.

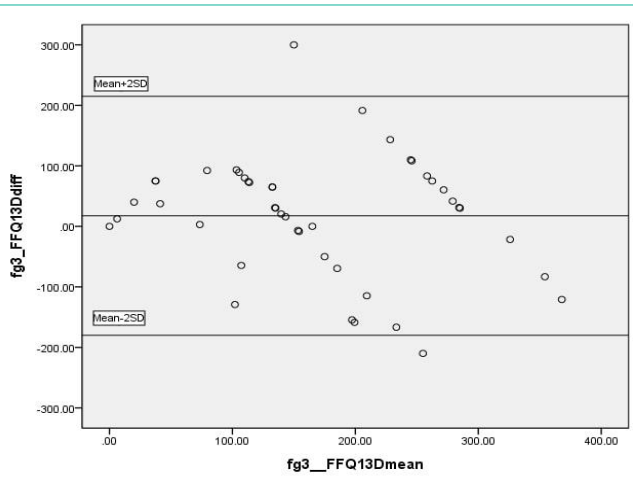

Figure 3: Bland-Altman plot of fruit intake.

Moreover, we have cross-classified participating mothers into quartiles, which reflects the extent of agreement of each dietary assessment method. The intake for most nutrients falls into the same of

adjacent quartile, while the issue of misclassification is more apparent for food group intake. To be specific, only 2 out of 21 nutrients had the percentage of extreme quartiles >10% (total fat and %energy from total fat), but 7 out of 19 food groups had the percentage of extreme quartiles >10% (vegetables, beverages, tea or coffee, soy and soy products, fast food, savory snacks, dim sum). It is also notable that energy adjustment has substantial improvement on the level of agreement for 6 food groups (condiment, meat, poultry, processed and organ meat, tea or coffee, fast food, savory snacks and dim sum). The misclassification issue probably originates from the variation in dietary energy and can be addressed by energy adjustment.

Food Categories with Good Reproducibility and Relative Validity

When looking across nutrient and food group categories, it is notable that fiber and fruit intake have demonstrated good reliability and validity. FFQ-reported fiber intake has good ICC (0.76) across two FFQ administrations, has significant correlation with dietary recalls (0.73 for crude intake and 0.71 for energy adjusted intake), good agreement (51.1% within same quartile) and did not have significant difference (as tested by one-sample t-test and linear regression) in values reported by FFQ and dietary recall. For FFQ-reported fruit intake, ICC was also good (0.74) across two FFQs, significant correlation with dietary recalls (0.57 for crude intake and 0.53 for energy adjusted intake), good agreement (44.4% within same quartile) and did not have significant difference (as tested by one-sample t-test and linear regression) in values reported by FFQ and dietary recall. When compared with another study performed among Chinese pregnant women, authors also observed better reliability and validity of fruit intake when comparing with other nutrients or food groups. Authors postulated that pregnant women preferred to consume fruits regularly and separately from a Chinese dish, while other foods such as meats and eggs were usually consumed as a part of mix dishes [13]. Furthermore, the Department of Health in Hong Kong suggested not less than 25 grams of dietary fiber per day (https://www.chp.gov.hk/en/static/90018.html), but the consumption level in our study population is far less than recommendation (75th percentile: 15.6 grams). Taken together, our short FFQ may serve as a quick screener for pregnant women with unhealthy diets, especially for fiber and fruit intake.

Limitations

In the present study, several limitations should be noted. First, we only had small sample size (45 women) and did not perform random sampling, therefore their dietary intake has limited representativeness. Second, dietary intake of participants was not verified by objective biomarkers. There might lead to recall bias and misreporting of diets. Despite the above limitations, the strength of our study was to develop a short FFQ culturally adapted to the diet of Hong Kong pregnant women.

Conclusion

In the present study, the 50-item FFQ has moderate reliability and acceptable validity as a quick assessment tool to identify Hong Kong pregnant women with unhealthy diet and is particularly useful to classify individuals with low fruits or fiber intake.

References

1. Segovia SA, Vickers MH, Reynolds CM. The impact of maternal obesity on inflammatory processes and consequences for later offspring health outcomes. J Dev Orig Health Dis. 2017; 8: 529-540.
2. Rooney K, Ozanne SE. Maternal over-nutrition and offspring obesity predisposition: targets for preventative interventions. Int J Obes (Lond). 2011; 35: 883-890.
3. Koletzko B, Symonds ME, Olsen SF. Early Nutrition Programming P, Early Nutrition A: Programming research: where are we and where do we go from here? Am J Clin Nutr. 2011; 94: 2036S-2043S.
4. Tarry-Adkins JL, Ozanne SE. Mechanisms of early life programming: current knowledge and future directions. Am J Clin Nutr. 2011; 94: 1765S-1771S.
5. Tam WH, Ma RCW, Ozaki R, Li AM, Chan MHM, Yuen LY, et al. In Utero Exposure to Maternal Hyperglycemia Increases Childhood Cardiometabolic Risk in Offspring. Diabetes Care. 2017; 40: 679-686.
6. Tam CHT, Ma RCW, Yuen LY, Ozaki R, Li AM, et al. The impact of maternal gestational weight gain on cardiometabolic risk factors in children. Diabetologia. 2018; 61: 2539-2548.
7. Ko GT, Tam WH, Chan JC, Rogers M. Prevalence of gestational diabetes mellitus in Hong Kong based on the 1998 WHO criteria. Diabet Med. 2002; 19: 80.
8. Cheuk QK, Lo TK, Wong SF, Lee CP. Association between pregnancy-associated plasma protein-A levels in the first trimester and gestational diabetes mellitus in Chinese women. Hong Kong Med J. 2016; 22: 30-38.
9. Ramachandran A, Ma RC, Snehalatha C. Diabetes in Asia. Lancet. 2010; 375: 408-418.
10. Biro G, Hulshof KF, Ovesen L, Amorim Cruz JA. Selection of methodology to assess food intake. Eur J Clin Nutr. 2002; 56: S25-32.
11. McGowan CA, Curran S, McAuliffe FM. Relative validity of a food frequency questionnaire to assess nutrient intake in pregnant women. J Hum Nutr Diet. 2014; 27: 167-174.
12. Ogawa K, Jwa SC, Kobayashi M, Morisaki N, Sago H, Fujiwara T. Validation of a food frequency questionnaire for Japanese pregnant women with and without nausea and vomiting in early pregnancy. J Epidemiol 2017, 27:201-208.
13. Zhang H, Qiu X, Zhong C, Zhang K, Xiao M, Yi N, et al. Reproducibility and relative validity of a semi-quantitative food frequency questionnaire for Chinese pregnant women. Nutr J. 2015; 14: 56.
14. Ortiz-Andrellucchi A, Doreste-Alonso J, Henriquez-Sanchez P, Cetin I, Serra-Majem L. Dietary assessment methods for micronutrient intake in pregnant women: a systematic review. Br J Nutr. 2009; 102: S64-86.
15. Woo J, Leung SSF, Ho SC, Lam TH, Janus ED. A food frequency questionnaire for use in the Chinese population in Hong Kong: Description and examination of validity. Nutr Res. 1997; 17: 1633-1641.
16. Koo TK, Li MY. A Guideline of Selecting and Reporting Intraclass Correlation Coefficients for Reliability Research. J Chiropr Med. 2016; 15:155-163.
17. Willet WC. Nutritional Epidemiology. New York: Oxford University Press. 1998.
18. Li M, Halldorsson TI, Bjerregaard AA, Che Y, Mao Y, Hu W, et al. Relative validity and reproducibility of a food frequency questionnaire used in pregnant women from a rural area of China. Acta Obstet Gynecol Scand. 2014; 93: 1141-1149.
19. Kohler R, Lambert C, Biesalski HK. Animal-based food taboos during pregnancy and the postpartum period of Southeast Asian women - A review of literature. Food Res Int. 2019; 115: 480-486.
20. Hankin JH, Wilkens LR, Kolonel LN, Yoshizawa CN. Validation of a quantitative diet history method in Hawaii. Am J Epidemiol. 1991; 133: 616-628.
21. Fernandez-Ballart JD, Pinol JL, Zazpe I, Corella D, Carrasco P, Toledo E, et al. Relative validity of a semi-quantitative food-frequency questionnaire in an

elderly Mediterranean population of Spain. Br J Nutr. 2010; 103: 1808-1816.

22. Verger EO, Armstrong P, Nielsen T, Chakaroun R, Aron-Wisnewsky J, Gobel RJ, et al. Dietary Assessment in the MetaCardis Study: Development and Relative Validity of an Online Food Frequency Questionnaire. J Acad Nutr Diet. 2017; 117: 878-888.

23. Athanasiadou E, Kyrkou C, Fotiou M, Tsakoumaki F, Dimitropoulou A, Polychroniadou E, et al. Development and Validation of a Mediterranean Oriented Culture-Specific Semi-Quantitative Food Frequency Questionnaire. Nutrients. 2016; 8: 522.

24. Papazian T, Hout H, Sibai D, Helou N, Younes H, El Osta N, et al. Development, reproducibility and validity of a food frequency questionnaire among pregnant women adherent to the Mediterranean dietary pattern. Clin Nutr. 2016; 35:1550-1556.