Public Health Nutrition: 9(4), 515–522 DOI: 10.1079/PHN2005876

Validation of a food-frequency questionnaire for use in pregnancy

Theodora Mouratidou*, Fiona Ford and Robert B Fraser
Academic Unit of Reproductive and Developmental Medicine, University of Sheffield, Level 4, The Jessop Wing, Tree Root Walk, Sheffield S10 2SF, UK

Submitted 3 February 2005: Accepted 23 August 2005

Abstract

Objectives: As a part of an ongoing project to develop a nutritional screening tool, we evaluated the performance of a semi-quantitative food-frequency questionnaire (FFQ) in terms of validity in a Sheffield Caucasian pregnant population using two different statistical approaches – the correlation coefficient and the limits of agreement (LOA). The FFQ was designed specifically for pregnant women and previously used in a large-scale study.
Design: A validation study.
Setting: A community-based field study of a general population of pregnant women booked for their first antenatal appointment at the Jessop Wing, Royal Hallamshire Hospital, Sheffield, UK.
Subjects: One hundred and twenty-three women of different socio-economic status, aged between 17 and 43 years, provided complete dietary data.
Results: The validity of the FFQ was tested against a series of two 24-hour recalls. As expected, the intakes of all examined nutrients, except for iodine, carotene, vitamin E, biotin, vitamin C and alcohol, were higher when determined by the FFQ than when determined by 24-hour recall. Pearson's correlation coefficient between the two methods ranged from 0.19 (added sugar, zinc) to 0.47 (Englyst fibre). The LOA were broader for some of the nutrients, e.g. protein, Southgate fibre and alcohol, and an increasing lack of agreement between the two methods was identified with higher dietary intakes.
Conclusions: The FFQ gave useful estimates of the nutrient intakes of Caucasian pregnant women and appears to be a valid tool for categorising pregnant women according to dietary intake. The FFQ performed well for most nutrients and had acceptable agreement with the 24-hour recall.

Keywords
Food frequency method
Pregnancy
Validation
Diet
Nutritional screening

Pregnancy is a critical period during which good maternal nutrition is a key factor influencing the health of both mother and child. Maternal nutrition prior to and during pregnancy is of known aetiological importance for the risk of low birth weight (LBW) (birth weight less than 2.5 kg). LBW is a major cause of mortality and morbidity; LBW babies are at risk of neurocognitive and motor development problems[1] and may have an increased susceptibility to cardiovascular disease in later life[2,3]. An increased risk of having an LBW baby exists amongst mothers who smoke[4], are of low socio-economic status[5,6], have low pre-pregnancy body mass index (BMI) and/or low gestational weight gain[7]. Poor dietary quality is common among groups of low socio-economic status and several studies have investigated its effect on pregnancy outcome. Various dietary studies of pregnant women have reported dietary differences between different social groups. The results of a study investigating the relationship between financial difficulties and diet showed that difficulty in affording food is associated particularly with lower intakes of protein, fibre, vitamin C, niacin, pyridoxine, iron, zinc, magnesium and potassium[8].

The Dietary and Nutritional Survey of British Adults[9] demonstrated a range of socio-economic differences in dietary intakes. A study conducted by Darmon *et al.*[10] investigated the impact of food budget on food selection patterns and dietary quality. The findings suggested that unhealthy eating patterns and nutritional inadequacy observed in persons of low socio-economic status are the result of economic constraint.

Assessment of nutritional risk is complex because there are very few well-validated nutritional screening instruments available in UK and those available are targeted at, for instance, the elderly, athletes or surgical patients[11–13]. To our knowledge no instruments have been developed and validated for nutritional screening risk in pregnancy. Screening with an appropriate a tool could identify a group of women at nutritional risk in whom interventions may be applied.

The food-frequency questionnaire (FFQ) is a tool commonly used in large epidemiological studies in different contexts, groups and populations[14–17]. FFQs are designed to assess eating habits and can be used for ranking individuals appropriately, according to their

*Corresponding author: Email t.mouratidou@sheffield.ac.uk

nutrient intakes. An optimal comparison method to assess the validity of the FFQ is the 24-hour recall method. 24-Hour recalls are commonly employed in nutritional epidemiology to evaluate the performance of FFQs, primarily because they do not require subject literacy and produce high levels of specificity. On the other hand, one day is unlikely to be representative of an individual's habitual intake owing to day-to-day variation; therefore two 24-hour recalls could reduce the chance variation between the methods.

In the present paper, as a part of an ongoing project to develop a nutritional screening tool, we evaluate the validity of nutrient and food intakes as estimated by an FFQ compared with dietary information obtained from two 24-hour recalls among a Sheffield Caucasian pregnant population.

Materials and methods

Subjects

The study population consisted of Caucasian pregnant women attending their first antenatal booking visit at the Jessop Wing, Royal Hallamshire Hospital, Sheffield, UK. Women with a gestational age of less than 14 weeks or more than 18 weeks were excluded. Women were also excluded if they did not speak English, or if they had any nutrition-related pre-existing medical conditions such as diabetes or coeliac disease.

Study design

The data collection was carried out from October 2003 to February 2004. The subjects were approached about the study by the researcher in the antenatal clinic and informed consent was obtained. Sociodemographic and anthropometric data were collected using a questionnaire with closed questions. Data collected included height, weight, education level, occupation, partner's occupation, smoking status and any supplement usage. The employment status of the head of the household was used to categorise women into social-class groups in a way similar to that used in the Dietary and Nutritional Survey of British Adults[9]. The FFQ was administered prior to the 24-hour recalls. The same trained nutritionist (T.M.) conducted all the interviews.

Ethical approval

All subjects gave informed consent to participate in the study. The North and South Sheffield Local Research Ethics Committees approved the study protocol.

Dietary assessment methods

Semi-quantitative FFQ

The Sheffield FFQ is an adaptation of the FFQ developed and evaluated by Rogers *et al.*[18] for the Avon Longitudinal Study of Pregnancy and Childhood (ALSPAC), where the dietary intakes of 11 923 pregnant women were assessed. The ALSPAC FFQ contains 84 quantitative and qualitative questions and was piloted in 110 women in Sheffield, then adapted and revised by eliminating some items found not to be consumed or to be consumed very rarely by Sheffield women, e.g. liver, liver pâté, peanuts and tahini. The revised food list of the FFQ included 62 quantitative and qualitative questions, 40 of which queried about the frequency of consumption of meat, poultry, fish and seafood, common vegetables and fruits, cereals and confectionery. There were also detailed questions about the type and amount of fat, bread, alcohol and milk consumed. Participants were asked to report the frequency of consumption of the food items contained in the FFQ over the 4 weeks prior to administration. The frequency options included: never or rarely, once a fortnight, 1–3 times a week, 4–7 times a week and more than once a day. To increase the simplicity and the inclusion of a wide range of food eaten, no portion size quantification was asked; thus standard portion sizes were assumed throughout.

24-Hour dietary recalls

The reference method was a series of two 24-hour dietary recalls. The first 24-hour recall was collected at the initial interview with the subjects and after administration of the FFQ. The choice of the 24-hour recall was based on the assumption that the response rate would be much higher than that of other dietary assessment methods such as food records[19]. The second 24-hour recall was administered via telephone after a period of 10–14 days. Statistically significant differences were found between the two recall methods. All subjects were asked to provide telephone numbers and it was emphasised to them that they would be contacted after an appropriate period of time. The date was not specified, as some of the subjects might choose to change their eating habits. For a number of participants weekend dietary information was randomly collected. The foods were recalled chronologically from the previous day. Household measurements were used to estimate portion sizes. At the end of the interview the foods were summarised for the respondent. Mean daily intake was estimated from the two 24-hour recalls.

Analysis of food consumption data

The daily intakes of energy, nutrients and food items obtained from the FFQ were analysed using the Q-Builder[20] Questionnaire Design System (version 1). Q-Builder is a questionnaire design program which incorporates nutritional analysis. It enables generation of any type of open or closed questions; e.g. for the type of food, the type of bread, frequency of consumption, amount consumed. It includes an up-to-date food composition database with the nutrient contents of approximately 5000 foods and a database of portion sizes for 3800 foods. The nutritional analysis of Q-Builder is based on the UK food tables (*McCance & Widdowson's The Composition of Foods*, 5th edition, plus nine supplements; HMSO, London). Information on food consumption collected by the FFQ is converted by Q-Builder into a list of foods and weights, to generate mean daily food and nutrient intakes. The approximate daily intake was calculated by multiplying the weekly frequency of consumption of a food by the nutrient content of a standard portion. Each one of the frequency options the questionnaire allocated was mapped as follows: never or rarely = 0, once a fortnight = 0.5, 1–3 times a week = 2, 4–7 times a week = 5.5 and more than once a day = 14. A complete set of values for 38 nutrients of interest were calculated. Q-Builder also enables analysis of the qualitative dietary behaviour questions included in the FFQ, such as 'Are you vegetarian?' or 'Do you buy organic foods?'

The daily intakes of energy and nutrients obtained from the mean of the two 24-hour recalls were analysed using the WISP[21] Food Intake Nutritional Analysis System (version 3). WISP is a nutritional analysis program that enables the user to conduct a broad nutritional analysis. The nutritional analysis of WISP is based on the UK food tables (see above).

Statistical analysis

All statistical analyses were performed using SPSS version 12.0 (SPSS Inc., Chicago, IL, USA). Means and standard deviations (SD) of absolute intakes for energy, macro- and micronutrients were calculated from the FFQ and the 24-hour recalls, as well as the contribution from the main food groups. The relationship between the two dietary assessment methods was assessed by the use of two statistical approaches. First, the Pearson correlation coefficient was used to determine agreement for nutrient and food intakes obtained from the FFQ and 24-hour recalls. The agreement between the two methods was further examined by classification of absolute nutrient intakes divided into quintiles.

Second, an alternative statistical approach based on a graphical technique and simple calculation to assess the agreement between two methods of measurement – the Bland–Altman analysis[22] – was used to assess agreement between the FFQ and 24-hour recall in terms of absolute energy, macro- and micronutrient intakes. This is accomplished by plotting the differences between the two measurements against the mean of the two measurements. The plot of the difference against the mean allows investigation of the potential relationship between the measurement error and the true value. The analysis assessed agreement in individuals, defined as the limit of agreement (LOA; ±2SD of the bias).

Results

Of the 130 women invited to participate, 123 (95%) agreed to complete the study; four (3%) refused to participate but reported no reason and three (2%) were excluded from the analysis because of incomplete data. Table 1 presents the anthropometric characteristics of the study population. The mean (±SD) age of the women was 29 ± 6.6 years. The mean (±SD) BMI was 23.1 ± 8.0 kg m^{-2} and the mean (±SD) gestational age was 15 ± 0.9 weeks. During their pregnancy 14.6% of the women were self-reported smokers. The social class distribution was non-manual 45.5% and manual 39.0% (Table 2).

Of the 123 women, 49.6% were nulliparous. Folic acid supplement intake during pregnancy was reported by 95.9%. Some 76.4% of the women reported planning their pregnancies, but only 47.2% reported periconceptional vitamin or mineral usage (Table 2).

Nutrient intakes

The mean daily intakes of energy, macro- and micronutrients as assessed by the FFQ and the 24-hour recall are given in Tables 3, 4 and 5. The FFQ reported higher energy and macronutrients intakes except for alcohol. The Pearson correlation coefficients for nutrients estimated by the test and the reference method are also shown in Tables 3–5. Highly significant correlations were demonstrated for most nutrients, from 0.19 for

Table 1 Age and anthropometric characteristics of participants

	Mean ± SD	*n*
Age (years)	29 ± 6.4	119
Weight (kg)	60.6 ± 24.9	109
Height (m)	1.65 ± 0.60	117
Gestational age (weeks)	15 ± 0.9	122
Body mass index (kg m^{-2})	23.1 ± 8.06	117

SD – standard deviation.

Table 2 Social and behavioural characteristics of participants (*n* = 123)

	%
Self-reported smoking status	
Non-smoker	85.4
Current smoker	14.6
Social class	
Non-manual	45.5
Manual	39.0
Unclassified	15.4
Periconceptional supplement usage	
Yes*	47.2
No	52.8
Folic acid supplements during pregnancy	
Yes	95.9
No	4.1
Education	
No qualifications	0.8
GCSE A Level	40.6
Higher education below degree	21.1
Degree	23.6
Other qualification	13.8

*Percentage of participants taking supplements of folic acid alone is unknown.

https://doi.org/10.1079/PHN2005876 Published online by Cambridge University Press

added sugar and zinc to 0.47 for Englyst fibre (mean correlation value for all nutrients: 0.20). For most nutrients positive correlations between the two methods were observed; however, not for alcohol, protein, starch, retinol and biotin.

Nutrient intakes were divided into quintiles in order to evaluate the ability of the FFQ to rank individuals into the same quintile of intake as the 24-hour recall. Table 6 shows the overall proportion of participants categorised into the same quintile of the distribution of total nutrient intake. An average of 59.2% of intakes by the two methods was assigned to the same quintile. The percentage of participants classified into the same quintile ranged from 48.0% for alcohol to 70.7% for Englyst fibre.

Figures 1 and 2 demonstrate the findings of the Bland–Altman analysis for energy and folate, where the average intake from the FFQ and 24-hour recall was plotted on the *x*-axis and the difference in intake between the two methods was plotted on the *y*-axis. For most of the nutrients, the plots resulting from the analysis were similar to Figs 1 and 2.

Dietary patterns

The Pearson correlation coefficients for 17 food groups as assessed by the two methods are shown in Table 7. Positive correlation coefficients ranged from 0.62 (other drinks) to 0.99 (breads). For all food groups except for alcoholic drinks, cheese and biscuits, cakes & puddings, the correlations were significant at the 0.001 level.

Discussion

This validation study was undertaken because of a lack of available instruments to assess the dietary intakes of pregnant women in Sheffield. The study population was a non-random sample, as only women between 14 and 18 weeks of pregnancy were selected for inclusion. The choice of the specific gestational age period was opportunistic because between 14 and 18 weeks the women are attending their first antenatal appointments. The women were much less likely to be affected by nausea and vomiting, which is known to occur in the first trimester and to decrease at the beginning of the second trimester[23].

As shown in published data of other validation studies conducted in populations of pregnant women[24,25], there was good agreement for energy and many nutrients. Robinson *et al.*[26] compared nutrient intakes assessed in a population of pregnant women by an FFQ and a food diary. They suggested that higher intakes estimated by the FFQ might have been due to the portion sizes used in the FFQ being too large or overreporting of the frequency of consumption of foods, or the result of underreporting of consumption of food in the diaries. In a population of low-income adult women, Goldy *et al.*[17] reported that nutrients which were significantly overestimated included fibre, calcium, potassium, saturated fat, vitamin C, vitamin D and vitamin E.

The correlation coefficient values observed in the present study were similar and comparable for most of the nutrients to those observed in other validation studies evaluating FFQ performance among pregnant women. However, the findings of our study are not directly comparable with the results of other validation studies in pregnant groups as the result of differences in sample size, ethnic origin, stages of pregnancy and reference method between the studies. Erkkola *et al.*[27] used a 181-item FFQ and food records as the reference method, and provided mean daily intakes of nutrients and mean daily intakes of foods. Robinson *et al.*[26] used food diaries and provided data of the contribution of selected food groups to energy, fat, protein and carbohydrate. Suitor *et al.*[24] used the 24-hour recall as reference method and evaluated the performance of the questionnaire for eight index nutrients. Wei *et al.*[25] extended the study conducted by Suitor *et al.* by assessing the validity of the FFQ for 17 additional

Table 3 Mean daily energy and macronutrient intakes based on the food-frequency questionnaire (FFQ) and 24-hour recall ($n = 123$)

	FFQ		24-Hour recall		Pearson's correlation coefficient (r)
	Mean ± SD	Range	Mean ± SD	Range	
Energy (kcal)	1923 ± 516	958–3804	1546 ± 370	657–2391	0.26**
Protein (g)	70.0 ± 20.5	32.2–132.6	54.8 ± 15.2	21.9–101	−0.14
Total fat (g)	85.7 ± 28.4	31.0–164.0	65.4 ± 19.6	25.0–110.9	0.28**
Carbohydrate (g)	228.3 ± 61.6	112.2–499.9	195.9 ± 55.8	51.1–400.9	0.25**
Saturated fat (mg)	32.9 ± 12.6	11.4–73.8	22.3 ± 9.1	5.8–47.8	0.23**
Monounsaturated fatty acids (g)	28.9 ± 9.8	10.7–57.1	18.5 ± 6.7	5.1–35.0	0.22*
Polyunsaturated fatty acids (g)	13.9 ± 4.9	4.7–30.5	9.2 ± 5.1	2.9–28.2	−0.14
Cholesterol (mg)	223.8 ± 83.1	74.0–461.0	152.6 ± 95.2	20.0–718.0	−0.11
Sugars (g)	82.8 ± 35.2	25.4–226.8	76.5 ± 37.6	10.4–271.6	0.19*
Starch (g)	145.0 ± 35.9	64.3–272.6	116.3 ± 32.9	17.1–200.2	−0.14
Southgate fibre (g)	19.6 ± 5.4	7.9–34.5	14.0 ± 5.6	3.1–39.7	0.36**
Englyst fibre (g)	14.1 ± 4.5	4.2–25.1	10.8 ± 4.5	1.9–39.0	0.47**
Alcohol (g)	0.1 ± 0.1	0–0.7	0.4 ± 2.1	0–17.0	−0.11

SD – standard deviation.
*Correlation significant at $P < 0.05$ level; **correlation significant at $P < 0.01$ level.

https://doi.org/10.1079/PHN2005876 Published online by Cambridge University Press

Table 4 Mean daily mineral intakes based on the food-frequency questionnaire (FFQ) and 24-hour recall ($n = 123$)

	FFQ		24-Hour recall		Pearson correlation coefficient (r)
	Mean ± SD	Range	Mean ± SD	Range	
Sodium (mg)	2417 ± 679.6	1291–4962	2311 ± 789.5	407–6160	−0.07
Potassium (mg)	2532 ± 646.2	874–5088	2179 ± 741.4	947–5208	−0.15
Calcium (mg)	715.2 ± 226.2	275–1346	654.1 ± 246.2	164–1264	−0.12
Magnesium (mg)	235.2 ± 68.2	88–402	188.4 ± 66.8	75–547	0.37**
Phosphorus (mg)	1153 ± 318.3	439–2065	916.2 ± 258.2	390–1707	0.18**
Iron (mg)	11.2 ± 3.9	4.7–21.1	8.0 ± 2.8	2.6–17.8	0.32**
Copper (mg)	1.1 ± 0.3	0.5–2.3	0.9 ± 0.6	0.2–4.6	0.008
Zinc (mg)	7.8 ± 2.3	3.1–14.6	6.2 ± 2.1	2.3–11.3	0.19*
Manganese (mg)	1.8 ± 0.6	0.7–3.8	2.1 ± 1.0	0.6–6.9	0.40**
Selenium (μg)	39.9 ± 15.2	8.0–92	36.4 ± 15.9	8.0–86	−0.03
Iodine (μg)	79.2 ± 27.8	15–43	82.8 ± 65.8	20–567	−0.03

SD – standard deviation.
*Correlation significant at $P < 0.05$ level; **correlation significant at $P < 0.01$ level.

nutrients. Most of the studies concluded that the FFQ had reasonable validity across a wide range of nutrients and was a useful tool for categorisation of pregnant women according to energy intake.

In the present study we used Bland–Altman analysis to assess agreement between the FFQ and the 24-hour recall and to obtain further information that the correlation coefficient itself cannot provide. A systematic increase in lack of agreement between the two methods was observed with an increase in dietary intake. The scatter plots provided evidence of both under- and overreporting with the FFQ compared with the 24-hour recall. For some macronutrients such as protein, Southgate fibre, alcohol and mono- and polyunsaturated fatty acids, the LOA – defined as the bias (±2SD) of the difference – were wide, unlike for most of the minerals and vitamins analysed. The reason for this is unclear.

The dietary patterns shown in Table 7 were similar between the two dietary assessment methods, but there were some differences between them in the mean contribution made by selected food groups to energy. The Pearson correlation coefficients showed strong agreement between the two methods.

As expected, variation between actual and self-reported dietary intake has been demonstrated. The effects of some limitations of the 24-hour recall method, e.g. reliance on memory and high day-to-day variation, might have been decreased by the collection of more than two dietary recalls[28], but time limitations on the research project and the progression of the women's pregnancy and subsequent diet alterations prevented the collection of additional 24-hour recalls. Some other sources of error in this study included portion size estimation and nutritional analysis errors.

An additional issue that might have had an effect on the results was the emotional and psychological status of the mother, e.g. the location where the interview took place, the presence of the partner or other family members. Social acceptability might have affected a number of the participants as they might have overreported fruit and vegetable intake and underreported sweets or alcohol intake.

Table 5 Mean daily vitamin intakes based on the food-frequency questionnaire (FFQ) and 24-hour recall ($n = 123$)

	FFQ		24-Hour recall		Pearson correlation coefficient (r)
	Mean ± SD	Range	Mean ± SD	Range	
Retinol (μg)	369.2 ± 152.0	44–876	276.8 ± 141.5	11–795	−0.09
Carotene (μg)	1228 ± 570.9	154–3162	1287.6 ± 1364	33–9095	0.26**
Vitamin D (μg)	2.7 ± 1.4	0.5–9.5	1.6 ± 1.4	0.1–9.4	0.20*
Vitamin E (mg)	4.3 ± 1.7	1.3–10.1	5.0 ± 2.4	0.6–12.4	0.20*
Thiamine (mg)	1.5 ± 0.4	0.7–2.8	1.2 ± 0.4	0.5–2.4	0.22*
Riboflavin (mg)	1.3 ± 0.5	0.4–2.7	1.1 ± 0.4	0.4–2.4	0.33**
Niacin (mg)	18.5 ± 6.2	5.0–40.3	13.3 ± 5.3	4.4–28.5	0.20*
Potential niacin (mg)	14.3 ± 4.1	6.6–26.6	11.2 ± 3.3	4.7–19.2	−0.16
Vitamin B_6 (mg)	2.0 ± 0.6	0.8–4.4	1.4 ± 0.5	0.4–2.8	0.27**
Vitamin B_{12} (μg)	3.5 ± 1.5	0.7–9.0	2.4 ± 1.3	0.1–6.4	−0.09
Folate (μg)	229.2 ± 67.7	94–412	179.7 ± 62.6	62–350	0.29**
Pantothenic acid (mg)	3.5 ± 1.0	1.1–6.2	3.0 ± 1.1	1.3–7.9	0.24**
Biotin (μg)	18.2 ± 7.2	4.5–36.6	18.7 ± 9.9	4.5–79.0	−0.09
Vitamin C (mg)	73.9 ± 29.1	10.0–154	74.6 ± 52.5	3.0–294	0.42**

SD – standard deviation.
*Correlation significant at $P < 0.05$ level; **correlation significant at $P < 0.01$ level.

https://doi.org/10.1079/PHN2005876 Published online by Cambridge University Press

Table 6 Percentage of women categorised into the same quintile of the distribution according to the food-frequency questionnaire and the 24-hour recall

Nutrient	Overall proportion categorised into the same quintile (%)
Energy	64.2
Protein	54.5
Total fat	67.5
Carbohydrate	56.1
Saturated fat	64.2
Monounsaturated fatty acids	61.0
Polyunsaturated fatty acids	59.3
Cholesterol	61.0
Sugars	60.2
Starch	57.7
Southgate fibre	65.0
Englyst fibre	70.7
Alcohol	48.0
Sodium	58.5
Potassium	58.5
Calcium	59.3
Magnesium	63.4
Phosphorus	58.5
Iron	61.0
Copper	58.5
Zinc	55.3
Manganese	66.7
Selenium	49.6
Iodine	52.8
Retinol	55.3
Carotene	52.8
Vitamin D	61.0
Vitamin E	61.0
Thiamine	57.7
Riboflavin	61.8
Niacin	49.6
Potential niacin	58.5
Vitamin B_6	62.6
Vitamin B_{12}	56.9
Folate	59.3
Pantothenic acid	61.0
Biotin	59.3
Vitamin C	62.6

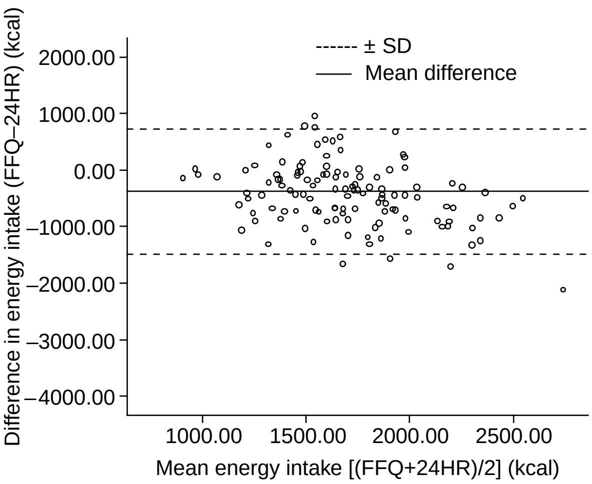

Fig. 1 Bland–Altman plot showing agreement between the food-frequency questionnaire (FFQ) and the 24-hour recall (24HR) for energy (kcal) (SD – standard deviation)

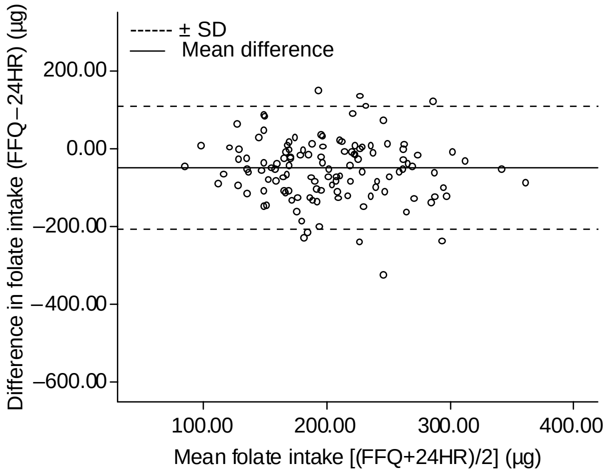

Fig. 2 Bland–Altman plot showing agreement between the food-frequency questionnaire (FFQ) and the 24-hour recall (24HR) for dietary folate (µg) (SD – standard deviation)

In conclusion, the FFQ showed correlations similar to those obtained in validation studies conducted in other similar groups. Positive correlations between the measurements were observed that ranged from 0.19 to 0.47 for most nutrients and from 0.62 to 0.99 for food groups. No significant correlations were observed for 13 out of 38 examined nutrients, which might be the result of not applying log-transformation on the data, not doing correction for measurement error and finally not doing adjustments for energy intake.

In several validation studies conducted on pregnant women, log-transformation of nutrients has been applied to correct for skewness[26,27] and others have used non-parametric tests to deal with the problem[29]. In our data,

Table 7 Mean contribution made by selected food groups to energy according to the food-frequency questionnaire (FFQ) and the 24-hour recall

Food group	FFQ (%)	24-Hour recall (%)	Pearson's correlation coefficient (r)
Breads	10	10	0.99**
Breakfast cereals	6	21	0.73**
Meats	11	5	0.86**
Fish	4	14	0.94**
Vegetables	17	4	0.64**
Biscuits, cakes & puddings	6	7	0.21
Fruit	2	1	0.66**
Eggs	2	4	0.91**
Milk/cream	4	1	0.85**
Cheese	5	4	0.33
Fats	9	4	0.85**
Alcoholic drinks	1	2	−0.85
Other drinks	5	8	0.62**
Added sugar	6	2	0.91**
Rice & pasta	6	1	0.74**
Other cereals	3	3	0.32**
Other foods	4	9	0.80**

** Correlation significant at $P < 0.01$ level.

https://doi.org/10.1079/PHN2005876 Published online by Cambridge University Press

tests for normal distribution were without skewness in the majority of cases and no corrections were applied. Even though the FFQ suggested greater nutrient intakes compared with the reference method, the validity observed in this study suggests a reasonable ability of the FFQ to rank individuals by levels of intake and that the FFQ is a useful tool in the collection of dietary data.

Future research

Data will be obtained from a larger sample of low-income women and divided into tertiles, in order to address the question of which food items (discriminant foods) of the FFQ make women from a homogeneous social and lifestyle environment have different intakes of key nutrients. Calculation of the mean contribution of each food item from the FFQ to key nutrients, e.g. folate, calcium, etc., will follow and the major sources of each nutrient of interest will be identified. The screening tool will consist of a simple list of discriminant food items and a scoring system similar to those used in the Healthy Eating Index and the Dietary Quality Index will be developed[30,31]. This will enable health professionals and community staff, such as those working in Sure Start projects with little nutrition assessment training, to administer the screening tool to the majority of low-income pregnant women and identify those at nutritional risk.

Acknowledgements

The authors wish to thank the ALSPAC team for allowing us to use their FFQ, the pregnant women for their time and co-operation, and finally Jean M Russell for her help with the statistical analysis.

References

1 Chaudhari S, Otiv M, Chitale A, Pandit A, Hoge M. Pune low birth weight study – cognitive abilities and educational performance at twelve years. *Indian Pediatrics* 2004; **41**(2): 121–8.
2 Barker DJ, Gluckman PD, Godfrey KM, Harding JE, Owens JA, Robinson JS. Fetal nutrition and cardiovascular disease in adult life. *Lancet* 1993; **341**(8850): 938–41.
3 Barker DJ, Osmond C, Golding J, Kuh D, Wadsworth ME. Growth *in utero*, blood pressure in childhood and adult life, and mortality from cardiovascular disease. *British Medical Journal* 1989; **298**(6673): 564–7.
4 Dewan N, Brabin B, Wood L, Dramond S, Cooper C. The effects of smoking on birth weight-for-gestational-age curves in teenage and adult primigravidae. *Public Health* 2003; **117**(1): 31–5.
5 Spencer N, Logan S. Social influences on birth weight. *Journal of Epidemiology and Community Health* 2002; **56**(5): 326–7.
6 Moser K, Li L, Power C. Social inequalities in low birth weight in England and Wales: trends and implications for population health. *Journal of Epidemiology and Community Health* 2003; **57**(9): 687–91.
7 Bull J, Mulvihille C, Quigley R. *Prevention of Low Birth Weight: Assessing the Effectiveness of Smoking Cessation and Nutritional Intervention – Evidence Briefing*. London: Health Development Agency, July 2003.
8 Rogers I, Emmett P, Baker D, Golding J. Financial difficulties, smoking habits, composition of the diet and birth weight in a population of pregnant women in the South West of England. ALSPAC Study Team. Avon Longitudinal Study of Pregnancy and Childhood. *European Journal of Clinical Nutrition* 1998; **52**(4): 251–60.
9 Gregory J, Foster K, Tyler H, Wiseman M. *The Dietary and Nutritional Survey of British Adults*. London: HMSO, 1990.
10 Darmon N, Ferguson EL, Briend A. A cost constraint alone has adverse effects on food selection and nutrient density: an analysis of human diets by linear programming. *Journal of Nutrition* 2002; **132**(12): 3764–71.
11 Ward J, Close J, Little J, Boorman J, Perkins A, Close SJ, *et al.* Development of a screening tool for assessing risk of under nutrition in patients in community. *Journal of Human Nutrition and Dietetics* 1998; **11**: 323–30.
12 Wright L. A nutritional screening tool for use by nurses in residential and nursing homes for elderly people: development and pilot study results. *Journal of Human Nutrition and Dietetics* 1999; **12**: 437–43.
13 McNulty KY, Adams CH, Anderson JM, Affenito SG. Development and validation of a screening tool to identify eating disorders in female athletes. *Journal of the American Dietetic Association* 2001; **101**(8): 886–92.
14 Shu X, Yang G, Jin F, Liu D, Kushi L, Wen W, *et al.* 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.
15 Katsouyanni K, Rimm EB, Gnardellis C, Trichopoulos D, Polychronopoulos E, Trichopoulou A. Reproducibility and relative validity of an extensive semi-quantitative food frequency questionnaire using dietary records and biochemical markers among Greek schoolteachers. *International Journal of Epidemiology* 1997; **26**(Suppl. 1): S118–27.
16 Friis S, Kruger Kjaer S, Stripp C, Overvad K. Reproducibility and relative validity of a self-administered semi quantitative food frequency questionnaire applied to younger women. *Journal of Clinical Epidemiology* 1997; **50**(3): 303–11.
17 Chacko-George G, Milani T, Hans-Nuss H, Kim M-S, Freeland-Graves JH. Development and validation of a semi-quantitative food frequency questionnaire for young adult women in the southwestern United States. *Nutrition Research* 2004; **24**: 29–43.
18 Rogers I, Emmett P. Diet during pregnancy in a population of pregnant women in South West England. ALSPAC Study Team. Avon Longitudinal Study of Pregnancy and Childhood. *European Journal of Clinical Nutrition* 1998; **52**(4): 246–50.
19 Margetts B, Nelson M. *Design Concepts in Nutritional Epidemiology*, 2nd ed. Oxford: Oxford University Press, 1997.
20 Tinuviel Software. *Q-Builder Users Manual. Version 1.0; Questionnaire Design and Intake Analysis System*. Warrington, UK: Tinuviel Software, 2002.
21 Tinuviel Software. *WISP Users Manual. Version 3.0; Intake and Recipe Analysis System*. Warrington, UK: Tinuviel Software, 2003.
22 Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurements. *Lancet* 1986; **1**(8476): 307–10.
23 Huxley RR. Nausea and vomiting in early pregnancy: its role in placental development. *Obstetrics and Gynecology* 2000; **95**(5): 779–82.
24 Suitor CJ, Gardner J, Willett WC. A comparison of food frequency and diet recall methods in studies of nutrient

intake of low-income pregnant women. *Journal of the American Dietetic Association* 1989; **89**(12): 1786–94.
25 Wei EK, Gardner J, Field AE, Rosner BA, Colditz GA, Suitor CW. Validity of a food frequency questionnaire in assessing nutrient intakes of low-income pregnant women. *Maternal and Child Health Journal* 1999; **3**(4): 241–6.
26 Robinson S, Godfrey K, Osmond C, Cox V, Barker D. Evaluation of a food frequency questionnaire used to assess nutrient intakes in pregnant women. *European Journal of Clinical Nutrition* 1996; **50**(5): 302–8.
27 Erkkola M, Karppinen M, Javanainen J, Rasanen L, Knip M, Virtanen SM. Validity and reproducibility of a food frequency questionnaire for pregnant Finnish women. *American Journal of Epidemiology* 2001; **154**(5): 466–76.
28 Willet WC. *Nutritional Epidemiology*, 2nd ed. New York: Oxford University Press, 1998.
29 Andersen LF, Lande B, Trygg K, Hay G. Validation of a semi-quantitative food-frequency questionnaire used among 2-year-old Norwegian children. *Public Health Nutrition* 2004; **7**(6): 757–64.
30 Kennedy ET, Ohls J, Carlson S, Fleming K. The Healthy Eating Index: design and applications. *Journal of the American Dietetic Association* 1995; **95**(10): 1103–8.
31 Haines PS, Siega-Riz AM, Popkin BM. The Diet Quality Index revised: a measurement instrument for populations. *Journal of the American Dietetic Association* 1999; **99**(6): 697–704.