

The Anti Cancer Council of Victoria FFQ: relative validity of nutrient intakes compared with weighed food records in young to middle-aged women in a study of iron supplementation

Abstract

Objective: To assess the validity of the Anti Cancer Council of Victoria food frequency questionnaire (ACCVFFQ) relative to seven-day weighed food records (WFRs) in 63 women of child-bearing age.

Method: 63 women completed WFRs to assess iron intake as part of a study on iron deficiency. These women also completed the ACCVFFQ. Nutrient intakes were computed independently for the WFRs and FFQs. Intakes were compared as group means, by correlation and by quintile classification, adjusting for day-to-day variation in intakes, and for energy intake. Individual differences in results were also examined.

Results: The strongest associations between WFR and FFQ results were energy-adjusted, log-transformed and adjusted for day-to-day variability in intake. Correlation coefficients ranged from 0.28 for vitamin A to 0.78 for carbohydrate. Mean intakes from the WFRs and FFQs were within +/- 20% for 21 of 27 nutrients. Poor agreement between FFQs and WFRs for retinol intake was due to the inclusion of liver in two WFRs, an item which is not included in the FFQ.

Conclusion: The ACCVFFQ performs as well as other FFQs for which validation data are available. The relatively poor measurement of retinol is consistent with other data, and with the limited number of foods in which this nutrient is abundant.

Implications: The availability of an optically scannable valid instrument for assessing dietary intake will facilitate epidemiological studies of diet and disease, an area of current research priority.

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In the late 1980s, the Anti Cancer Council of Victoria developed a food frequency questionnaire (ACCVFFQ) to measure dietary intake in the Melbourne Collaborative Cohort Study (MCCS), which includes middle-aged Greek, Italian and Australian-born men and women.¹

The items included in the ACCVFFQ were based on those found in a pilot study to make important contributions to nutrient intakes of volunteers from the same ethnic backgrounds as cohort members.

The original version of the ACCVFFQ included 121 items, with additional questions on food habits, but no data on portion size, as conventional wisdom at the time held that frequency of intake contributed more to variation in nutrient intakes.² The reproducibility of the ACCVFFQ was assessed over 12 months, and intakes compared with subjective estimates based on expected energy expenditure and urinary protein and potassium excretion.

As a result of these studies, the ACCVFFQ

evolved to its current format with fewer items in the frequency section, and more detailed questions on specific foods. A series of photos was also included to enable estimation of portion size.

Although the new ACCVFFQ has been used in a number of large epidemiological studies in Australia, it has not been evaluated in its current format. An opportunity to validate the ACCVFFQ arose when women who completed seven-day weighed food records (WFRs) as part of a dietary intervention study of iron deficiency also completed the ACCVFFQ. Here, we assess the relative validity of the ACCVFFQ in this group of women.

Methods

Subjects

Women were eligible for the iron deficiency study if they met the following criteria:

1. iron status in accordance with definitions of iron replete or iron deficient;

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2. suffering no major illness or known organic cause for iron deficiency;
3. of child-bearing age;
4. still menstruating;
5. non-pregnant;
6. no hysterectomy;
7. 18 years or over (16-18 years included with parental consent); and
8. haemoglobin ≥ 90 g/L.

Iron deficiency was defined as serum ferritin < 15 mg/L OR ferritin 15-20 mg/L, and at least two of the following:

- a. serum iron < 10 mmol/L;
- b. total iron-binding capacity > 68 mmol/L; and
- c. transferrin saturation $< 15\%$.

Normal iron status was defined as serum ferritin > 20 mg/L and haemoglobin > 120 g/L.

Iron-deficient women were recruited through general practitioners and local media in the Hunter region. Iron-replete controls matched for age and parity were recruited through the university network.

For the iron study, women completed seven-day weighed food records pre-intervention and during the last week of intervention. The treatments consisted of iron supplement pills or dietary modification for a period of three months. The FFQ was not an integral part of the iron study, but the opportunity arose to compare the FFQ with the second set of WFRs. Sixty-three women (22 controls, 20 on high iron diet and 21 on iron supplements) completed both the FFQ and the WFRs. They were aged from 16 to 48 years, with a mean age of 33.3 years. Further demographic details of these women are presented in Table 1.

Table 1: Demographic details of women in the study.

Number	63
Mean age \pm SD (yrs)	33.3 \pm 9.5
Marital status (%)	
Married/de facto	53.9
Single	33.3
Separated/divorced	12.7
Education (%)	
No formal education	3.2
School only	44.4
Trade/certificate	20.6
University	31.7
Employment status (%)	
Full-time work	28.6
Part-time work	31.7
Home duties	14.3
Student	23.8
Unable to work/unemployed	1.6
Main occupation (%)	
Prof/para prof/manager	49.2
Administration/service/trade	30.2
Manual/other job	19.1
Never had paid job	1.6

Nutrient intakes

Nutrient intakes were computed from the FFQ using software developed by the Anti Cancer Council of Victoria, which is based on the NUTTAB95 (Australian Government Publishing Service, Canberra) nutrient composition data. Copies of the FFQ are available on request from the authors. The first page of the FFQ includes questions on how many pieces of fresh fruit and how many different vegetables are consumed daily. The results of these questions are used to adjust the results from the frequency component of the FFQ, which tends to over-estimate intakes. For example, if the response to question 1 was '2 pieces of fruit per day' and the total fruit intake from question 15 was three pieces per day, the daily intake for each fruit consumed would be scaled down by 2/3. The same applies to vegetables. Other questions determine the amount and type of milk and bread eaten, the type of fat spread used, the amount of sugar consumed daily, the weekly intake of eggs and the type of cheese eaten. With the questions specifying types of foods, more than one answer can be selected and nutrients are computed assuming equal intakes of each type of milk, bread, spread or cheese.

The second page of the FFQ consists of four sets of photos depicting three different serving sizes for potatoes, vegetables, steak and casserole. For each food, photograph A represents the 25th percentile, B the median and C the 75th percentile of the distribution of serving sizes reported in the pilot study of 810 Australian, Italian and Greek-born men and women.² By selecting serving sizes that are less than, equivalent to, between or more than the serving sizes shown in the photos, seven different serving sizes can be attributed to each food class. These serves are allocated scores: never eat=0, $< A=0.4$, $A=0.5$, $A-B=0.75$, $B=1.0$, $B-C=1.5$, $C=2.0$, $> C=2.5$, which are then averaged for an individual. For those items on the FFQ that showed variation in serving size between genders and ethnic groups in the pilot study, this single portion size factor is used to scale the standard portion up or down.

Pages 3 and 4 of the ACCVFFQ consist of a list of 74 items with 10 frequency options, ranging from never to three or more times per day, along with more detailed information about the consumption of alcoholic beverages.

Nutrient analysis for the WFRs was completed at the University of Newcastle using Diet 1 (Version 4, 1991, Xyris Software, Brisbane) software and the NUTTAB95 food composition database.

Statistical analysis

Comparisons between the two dietary tools were based on correlations between WFR and FFQ results, differences between means, and agreement between the two methods for classifying women into quintiles of nutrient intakes. Comparisons were made on natural log-transformed data and log_e-transformed data adjusted for energy intake by the regression method of Willett et al.³ While it has been argued that these analyses do not adequately compare the different dietary methods,⁴ most other validation studies use these approaches. The technique recommended by Bland and Altman⁴ was used to assess the level of agreement between the two dietary measures.

Statistical significance is not a useful means of assessing agreement between methods in dietary validation studies, as even weak correlations will be significant if sufficient subjects are included.⁶ Hence, the validity of the FFQ in this sample of women is assessed by comparison with the performance of similar instruments reported in the literature.

In most instances where dietary data are used in relation to risk of disease outcomes, the major interest is in ranking subjects accurately, for which correlations and cross-quintile evaluation are satisfactory.^{5,6} However, it is important when translating results into public health messages that the amounts measured are similar in magnitude to, and not just correlated with, 'true' intakes. Bland and Altman have published an approach for comparing two different methods of measurement that is designed to answer the question "could one method replace the other without any effect?"⁷ To calculate the 95% limits of agreement, the mean and standard error of the difference between the two methods are calculated. Provided the differences follow a normal distribution and are independent of the magnitude of measurement, 95% of differences are expected to lie between $d-1.96SD_d$ and $d+1.96SD_d$.

However, interpretation relies on determining what is an acceptable difference between the two measures.

To correct for effects of day-to-day variation in the nutrient intakes from the diet records, deattenuated correlations were calculated by multiplying the original values by $[1+(Sw^2/Sb^2/7)]^{1/2}$, where Sw is the estimated standard deviation within subjects, and Sb the standard deviation between subjects.^{7,8} STATA was used for all statistical analysis.⁹

Linear regression models were computed using the \log_e -transformed, energy-adjusted intakes from the WFRs as the dependent variable, and transformed intakes from the FFQ, along with treatment group and an interaction term as the independent variables. This analysis was included to determine whether the associations between WFRs and FFQs were different across treatment groups.

Results

Table 2 shows the correlations between unadjusted nutrient intakes computed from the seven-day WFRs and the FFQ. Pearson correlation coefficients ranged from 0.20 for potassium

Table 2: Correlations of nutrient intakes from WFRs and FFQ in 63 women.

Nutrient	Pearson correlation	Spearman correlation	\log_e transformed	Energy adjusted \log_e values ^a
Energy (kJ)	0.25	0.23	0.19	
Protein (g)	0.34	0.36	0.29	0.32
Fat (g)	0.39	0.36	0.38	0.68
Saturated fat (g)	0.32	0.38	0.38	0.59
Monounsaturated fat (g)	0.42	0.41	0.41	0.59
Polyunsaturated fat (g)	0.52	0.52	0.50	0.55
Carbohydrate (g)	0.38	0.37	0.38	0.70
Sugars (g)	0.44	0.45	0.50	0.66
Starch (g)	0.38	0.35	0.34	0.29
Alcohol (g)	0.60	0.58	0.57	0.61
Fibre (g)	0.49	0.47	0.48	0.66
Cholesterol (mg)	0.42	0.43	0.45	0.55
Retinol (μ g)	0.14	0.40	0.42	0.38
β -carotene (μ g)	0.40	0.33	0.38	0.43
Total vitamin A (μ g)	0.14	0.31	0.29	0.19
Vitamin C (μ g)	0.40	0.42	0.41	0.52
Thiamin (μ g)	0.36	0.35	0.35	0.42
Riboflavin (μ g)	0.56	0.42	0.50	0.50
Niacin (mg)	0.42	0.33	0.33	0.34
Niacin equivalents (mg)	0.42	0.38	0.37	0.35
Sodium (mg)	0.26	0.16	0.20	0.22
Potassium (mg)	0.20	0.23	0.22	0.44
Magnesium (mg)	0.40	0.42	0.41	0.64
Calcium (mg)	0.35	0.40	0.39	0.51
Phosphorous (mg)	0.36	0.37	0.33	0.47
Iron (mg)	0.44	0.42	0.40	0.45
Zinc (mg)	0.40	0.37	0.39	0.45

Note:

(a) Pearson correlation coefficients.

to 0.60 for alcohol, excluding the low correlations for vitamin A and retinol, which were caused by two records with very high intakes of these nutrients. Spearman rank correlation coefficients were similar to Pearson coefficients for most nutrients, and were considerably higher for vitamin A and retinol. Following \log_e transformation, correlations for vitamin A and retinol were of a similar magnitude to those for other nutrients. Correlations between energy-adjusted values were generally stronger than for unadjusted values (see Table 2). De-attenuated correlations corrected for daily variation in nutrient intake are presented in Table 3. These range between 0.28 for total vitamin A and 0.78 for carbohydrate after energy adjustment.

The linear regression models indicated that treatment (diet vs. supplements vs. control) significantly modified the association between intakes from WFRs and FFQs for total fat, monounsaturated fat, niacin equivalent and phosphorous (data not shown).

For most nutrients, the mean intakes estimated by the FFQ and WFRs varied by less than 10% (see Table 4), although for

total carbohydrate, sugars, starch, alcohol, cholesterol, retinol, β -carotene and vitamin A, the differences were considerably greater. There was no consistent direction of difference, about half the means were higher for the FFQ and half for the WFRs. Geometric means were more similar for retinol, β -carotene and vitamin A than were untransformed means, but for the other nutrients \log_e transformation did not have much effect. Energy adjustment of \log_e transformed variables did not alter the means, although individual values were changed, hence these means have not been presented separately.

The proportion of women classified in the same quintile by both the FFQ and WFRs ranged from 22.2% for sodium to 38.1% for niacin in the unadjusted data, and 20.6% for vitamin A to 50.8% for iron in the \log_e -transformed and energy-adjusted data (see Table 5). For the adjusted data, at least 60% of women were classified in the same or next quintile, somewhat better than the results for the unadjusted data. Fewer than 10% of women were classified in the opposite extreme quintile with either crude or adjusted data.

The 95% limits of agreement for FFQs versus WFRs, as defined by Bland and Altman,⁴ are presented in Table 6. These figures indicated that although the group means of nutrient intakes varied by less than 10%, at the individual level there were large differences in the intakes estimated by the two methods. For example, although the group means for protein intake (77.0 g for the WFRs and 75.9 g for the FFQ) varied by only 1.4% overall, differences between the two measures ranged from -45.6 to 47.7 g, more than 50% either way, in 95% of individuals. This implies that for the other 5% of individuals, the differences were even greater. The \log_e -transformed, energy-adjusted estimates were generally more similar. Graphs of the differences between FFQ and WFR intakes against the mean of FFQ and WFR intakes were plotted, to determine whether differences were evenly distributed over mean intake. These graphs are not shown, but indicated that for the \log_e -transformed, energy-adjusted data there was little association between the size of the difference and the magnitude of mean nutrient intakes.

Discussion

Measurement of dietary intake is complex and no method is completely error free. In this study we used weighed food records as the 'gold standard', but this comparison between FFQ and WFRs is unusual because nutrient intakes from the two methods were computed independently by separate research groups. Although NUTTAB was used as the main source of nutrient composition for both, the specific coding of food items for the FFQ and WFRs was likely to be less consistent than if the same researchers had done both. The seven-day weighed records were completed during the dietary intervention and therefore may not have been representative of the 12 months covered by the FFQs. Notwithstanding, our results demonstrate that the FFQ developed for the MCCS performs at a similar level to other dietary instruments used in epidemiological studies.

Table 3: De-attenuated Pearson correlation coefficients between nutrient intakes from WFRs and FFQ in 63 women.

Nutrient	Crude data	\log_e transformed	Energy-adjusted
Energy (kj)	0.28	0.22	
Protein (g)	0.41	0.34	0.39
Fat (g)	0.43	0.42	0.73
Saturated fat (g)	0.35	0.41	0.64
Monounsaturated fat (g)	0.48	0.46	0.65
Polyunsaturated fat (g)	0.63	0.59	0.67
Carbohydrate (g)	0.41	0.42	0.78
Sugars (g)	0.47	0.54	0.73
Starch (g)	0.44	0.39	0.35
Alcohol (g)	0.77	0.62	0.65
Fibre (g)	0.52	0.52	0.72
Cholesterol (mg)	0.58	0.54	0.66
Retinol (μ g)	- ^a	0.47	0.45
β -carotene (μ g)	0.52	0.48	0.64
Total vitamin A (μ g)	- ^a	0.37	0.28
Vitamin C (μ g)	0.44	0.46	0.60
Thiamin (μ g)	0.40	0.40	0.49
Riboflavin (μ g)	0.63	0.55	0.57
Niacin (mg)	0.51	0.40	0.44
Niacin equivalents (mg)	0.49	0.43	0.41
Sodium (mg)	0.38	0.25	0.30
Potassium (mg)	0.23	0.25	0.50
Magnesium (mg)	0.43	0.43	0.69
Calcium (mg)	0.40	0.43	0.59
Phosphorous (mg)	0.39	0.36	0.52
Iron (mg)	0.50	0.45	0.51
Zinc (mg)	0.52	0.46	0.58

Note:

(a) Sw and Sb could not be calculated for these untransformed variables.

Extensive evaluations of dietary instruments developed for the European Prospective Investigation into Cancer and Nutrition (EPIC) study have been reported recently. Most of the correlation coefficients in these studies were between 0.5 and 0.7, implying that one-half to three-quarters of the total variance in questionnaire measurements is not actually related to true intake levels, but rather is the result of random measurement error. These correlations were considered acceptable as they were of similar magnitude to those previously reported.⁵

In our study, the strongest correlations between FFQ and WFRs were energy-adjusted and de-attenuated, with the lowest coefficient 0.28 for total vitamin A and the highest 0.78 for carbohydrate. Of the 26 non-energy nutrients we studied, nine had de-attenuated correlation coefficients lower than 0.5. Thus, some of our correlations are relatively low compared with the EPIC studies. However, because the EPIC countries have not assessed some of the nutrients we found to have poor correlations (e.g. only energy, protein, fat, carbohydrates, alcohol, dietary fibre, retinol, β -carotene, vitamin C and vitamin E were assessed in Dutch EPIC), overall comparisons are not valid. On a nutrient by nutrient basis our results for 63 women compare favourably with the 58 women in the Dutch EPIC validation.¹¹

The German EPIC team reported means from FFQs and 24-hour recalls for a range of macronutrients. In each case, the FFQ calculated a higher intake than the recalls, with differences between 8% and 41%. The differences were greater than we observed for those nutrients in common, except for alcohol and cholesterol.¹² The two FFQs performed similarly in classifying individuals into quintiles of nutrient intakes. In regard to estimates of vitamin intakes, the German EPIC reported correlations between FFQ and recall estimates for total carotenoids, retinol and ascorbic acid,¹³ which were of a similar magnitude to those observed for β -carotene, retinol and vitamin C respectively in the Australian women.

The Women's Health Initiative FFQ is another that has been evaluated recently.¹⁴ This FFQ, in common with the ACCVFFQ, was designed to reflect different ethnic eating patterns. For the 30 nutrients estimated, mean intakes from the FFQ were within 10% of four-day diet records for 21, and within 10% of four-day diet recalls for 22 nutrients, both of which were used as the criterion measures of intake. In our study, 19 of 27 FFQ intake estimates were within 10% of the estimates from weighed records, representing a very similar performance.

On the basis of these comparisons with more recently

Table 4: Comparison of mean nutrient intakes from WFRs and FFQ in 63 women.

Nutrient	Mean from diary	SD	Mean from FFQ	SD	Difference (%)
Energy (kJ)	7221.0	1393.8	6784.4	1801.4	6.0
Protein (g)	77.0	16.7	75.9	23.5	1.4
Fat (g)	55.7	19.1	57.1	21.2	-2.4
Saturated fat (g)	23.4	9.6	22.2	9.8	5.4
Monounsaturated fat (g)	18.4	7.0	20.0	7.8	-8.1
Polyunsaturated fat (g)	8.18	3.0	9.06	4.6	-9.7
Carbohydrate (g)	220.0	49.3	187.1	50.6	17.6
Sugars (g)	98.9	33.3	81.6	28.0	21.2
Starch (g)	115.2	28.6	104.2	30.6	10.6
Alcohol (g)	6.52	8.10	8.57	13.70	-23.9
Fibre (g)	20.1	6.9	20.7	7.4	-2.9
Cholesterol (mg)	199.9	81.6	162.0	74.2	23.4
Retinol (μ g)	538.8	1639.9	236.5	151.7	127.8
β -carotene (μ g)	2825.0	1695.4	2290.5	1077.0	23.8
Total vitamin A (μ g)	1003.3	1647.5	619.1	249.1	62.0
Vitamin C (μ g)	138.8	71.0	142.4	70.2	-2.5
Thiamin (μ g)	1.44	0.45	1.47	0.58	-2.0
Riboflavin (μ g)	2.05	0.66	2.23	0.83	-8.1
Niacin (mg)	20.1	4.6	19.6	6.8	2.6
Niacin equivalents (mg)	33.8	8.2	34.0	10.9	-0.6
Sodium (mg)	2305.2	533.9	2119.3	618.2	-8.8
Potassium (mg)	2741.9	601.1	2658.3	723.8	3.2
Magnesium (mg)	275.5	72.4	270.4	81.8	1.9
Calcium (mg)	835.1	247.2	807.6	306.3	3.4
Phosphorous (mg)	1340.7	305.4	1342.3	403.4	-0.2
Iron (mg)	11.65	3.16	11.88	4.26	-1.9
Zinc (mg)	9.39	2.36	10.22	3.38	-8.1

developed FFQs being used elsewhere in the world, our ACCVFFQ appears to perform acceptably. The independent coding of the FFQ and WFRs in our study could also result in a lower relative validity for our study compared with other published work.

The nutrients with the greatest differences between means – carbohydrate, sugars, starch, alcohol, cholesterol, retinol, β -carotene and total vitamin A – were not always those with the weakest correlations between methods, nor the poorest cross-quintile classification. Both correlations and cross quintile classification tend to be better for items with a greater range and variability of intake, irrespective of agreement between the measured intakes.⁴ This contributes to the good reproducibility and validity of alcohol intake when assessed by rank, even if actual estimates of intake are not close.^{11,15,16}

The FFQ estimates of retinol and total vitamin A were notably lacking in agreement with results from the WFRs in terms of the 95% limits of agreement, in each case the means from the FFQs were lower than from the WFRs. Closer examination of the data revealed that the high mean intakes of retinol and vitamin A from the WFRs were due to very high intakes by two women in the diet treatment on a single day each, attributable to consumption of

liver. In the 1995 National Nutrition Survey (NNS), organ meats and offal were the single most important source of retinol,¹⁷ but were consumed by a very small proportion of respondents. The exclusion of this group of foods from the FFQ may, however, lead to an under-estimate of retinol intakes. Liver was included on the original FFQ used in the MCCS, however, reproducibility for the frequency of liver intake over 12 months was very low and it was deleted from the version of the FFQ evaluated here.

The women who completed the FFQ and the comparison WFRs were taking part in a study where those who were iron deficient were given diet or supplement treatment, therefore liver may have been emphasised as a source of iron. However, the nutrients for which treatment group appeared to influence the relationship between WFR and FFQ estimates did not include iron or retinol.

There was no evidence that the ACCVFFQ under-estimated iron intake relative to the WFRs, despite the omission of liver. Major iron sources in the NNS, such as meats and cereals¹⁷ are well represented on the FFQ. Similarly, while offal is a cholesterol rich food, it was not important as a source of cholesterol in the NNS.¹⁷ Although cholesterol intake was under-estimated by the

Table 5: Quintile classifications by WFRs and FFQ using energy adjusted log_e-transformed data.

Nutrient	Proportion in same quintile (%)	Proportion in next quintile (%)	Proportion in same or next quintile (%)	Proportion grossly misclassified (%)
Energy (kJ)				
Protein (g)	25.4	41.2	66.6	3.2
Fat (g)	39.7	42.8	82.5	0
Saturated fat (g)	34.9	41.3	76.2	0
Monounsaturated fat (g)	38.1	36.5	74.6	0
Polyunsaturated fat (g)	31.7	34.9	66.6	0
Carbohydrate (g)	34.9	46.0	80.9	1.6
Sugars (g)	30.2	47.6	77.8	1.6
Starch (g)	25.4	38.1	63.5	4.8
Alcohol (g)	31.1	42.2	73.3	0
Fibre (g)	47.6	36.5	84.1	3.2
Cholesterol (mg)	24.2	36.5	60.7	1.6
Retinol (μ g)	38.1	38.1	76.2	1.6
β -carotene (μ g)	30.2	36.5	66.7	1.6
Total vitamin A (μ g)	20.6	42.8	63.4	3.2
Vitamin C (μ g)	34.9	36.5	71.4	1.6
Thiamin (μ g)	36.5	34.9	71.4	1.6
Riboflavin (μ g)	33.3	34.9	68.2	1.6
Niacin (mg)	31.7	30.1	61.8	4.8
Niacin equivalents (mg)	28.6	36.5	65.1	6.4
Sodium (mg)	28.6	33.3	61.9	9.5
Potassium (mg)	28.6	39.7	68.3	3.2
Magnesium (mg)	39.7	30.1	69.8	0
Calcium (mg)	41.3	38.1	79.4	1.6
Phosphorous (mg)	30.2	41.3	71.5	1.6
Iron (mg)	50.8	25.4	76.2	4.8
Zinc (mg)	36.5	31.7	68.2	1.6

FFQ relative to the WFRs, the difference was not as extreme as for retinol and vitamin A.

Data on Vitamin A intakes are associated with poor reproducibility and agreement between methods in other studies. In most cases, FFQs over-estimate intake relative to weighed records. Based on evidence from a study of US men and women who kept records for 365 consecutive days, at least 433 days of dietary records are needed to accurately estimate vitamin A intake compared to 31 days for energy.¹⁸ Because retinol is found in very high concentrations in a limited number of foods, estimates of intake are very sensitive to small variations in estimated consumption of these items.

Where significant interactions between treatment and the association of FFQ and WFR intakes were observed, correlations were computed within treatment groups. Being in the diet group was associated with stronger correlations between WFRs and FFQs for fat, monounsaturated fat and phosphorous intakes. Women in the iron supplement group showed a stronger correlation between FFQ and WFRs for niacin equivalent. There is no obvious explanation for these effects and it is most likely that chance alone is responsible for four significant interactions out of 26 relationships.

The original ACCVFFQ was developed specifically for use in an older population of Australian, Italian and Greek men and women. However, given the lack of other suitable optically scannable dietary instruments in Australia, the current ACCVFFQ has been used in a number of studies of different population groups. Typically, validation studies are conducted in populations similar to those in which the questionnaire is to be used. The current evaluation of the ACCVFFQ in a group of younger, Anglo-Celtic women indicates that it performs adequately, even in a population group other than that for which it was developed. The validity of the ACCVFFQ has not been demonstrated in other ethnic groups or younger people. For use with other groups, different food items would be important, but the format using the fruit and vegetable calibrators and portion size factors could provide the basis for a modified instrument.

Current interest in nutritional epidemiology is high, as the importance of diet in relation to chronic diseases, especially cancer, is widely recognised. However, the methodology for measuring and analysing diet is still being developed. Better methods, including biomarkers, will eventually replace questionnaires and dietary records. However, the FFQ is the method most commonly

Table 6: 95% limits of agreement between WFRs and FFQ according to Bland and Altman.⁴

Nutrient	Mean difference	95% limits of agreement in crude data	Log _e transformed energy-adjusted data
Energy (kj)	436.6	-3458.3-4331.4	
Protein (g)	1.08	-45.6-47.7	-21.9-40.2
Fat (g)	-1.35	-45.2-42.5	-17.5-25.2
Saturated fat (g)	1.22	-21.0-23.4	-8.2-18.1
Monounsaturated fat (g)	-1.72	-17.4-14.0	-8.4-10.7
Polyunsaturated fat (g)	-0.88	-8.8-7.0	-4.1-8.0
Carbohydrate (g)	32.9	-76.4-142.2	-7.1-85.9
Sugars (g)	17.4	-46.9-81.6	-18.0-71.2
Starch (g)	11.0	-53.7-75.6	-25.5-70.0
Alcohol (g)	-2.05	-23.5-19.4	-5.37-31.1
Fibre (g)	-0.61	-14.8-13.5	-2.1-11.2
Cholesterol (mg)	37.9	-126.4-202.2	-55.7-242.8
Retinol (µg)	302.4	-2883.9-3488.7	-133.1-1074.7
β-carotene (µg)	533.5	-2608.3-3675.4	-1270.4-511.5
Total vitamin A (µg)	384.2	-2816.0-3585.3	-340.4-1775.6
Vitamin C (µg)	-3.60	-155.8-148.5	-79.5-192.0
Thiamin (µg)	-0.03	-1.2-1.1	-0.52-0.86
Riboflavin (µg)	-0.18	-1.6-1.2	-1.0-1.2
Niacin (mg)	0.52	-12.0-13.1	-5.9-11.9
Niacin equivalents (mg)	-0.17	-20.8-20.4	-11.1-18.4
Sodium (mg)	185.8	-1190.0-1561.7	-506.5-1306.1
Potassium (mg)	83.6	-1564.4-1731.5	-703.9-1297.5
Magnesium (mg)	5.10	-160.4-170.6	-68.3-113.3
Calcium (mg)	27.5	-596.7-651.7	-291.6-615.5
Phosphorous (mg)	-1.57	-804.3-801.1	-354.2-552.0
Iron (mg)	-0.22	-8.1-7.7	-4.0-6.3
Zinc (mg)	-0.82	-7.2-5.6	-3.9-4.5

used for large epidemiological studies at present and we have demonstrated that the ACCVFFQ performs as well as others currently in use.

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