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Validation of a semi-quantitative FFQ using food records as a reference in older women in the Kuopio Fracture Prevention Study (OSTPRE-FPS)

Arja T Erkkilä[1,]*, Ritva Järvinen[2], Henna Karvonen[2], Linda Keronen[2] and Marjo T Tuppurainen[3]

[1]Institute of Public Health and Clinical Nutrition, Public Health, University of Eastern Finland, PO Box 1627, 70211 Kuopio, Finland: [2]Institute of Public Health and Clinical Nutrition, Clinical Nutrition, University of Eastern Finland, Kuopio, Finland: [3]Department of Obstetrics and Gynecology, Kuopio University Hospital, and Bone and Cartilage Research Unit, Clinical Research Center, University of Eastern Finland, Kuopio, Finland

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Abstract

Objective: To validate an eighty-nine-item semi-quantitative FFQ for measurement of nutrient intakes in elderly women.

Design: FFQ and 3 d food records were filled in by women participating in the Kuopio Fracture Prevention Study (OSTPRE-FPS). Data on intakes of energy, fat, protein, carbohydrate, fibre, Ca, Fe, P, K, Mg, folic acid, vitamin B_{12}, vitamin C, vitamin D and vitamin K from ninety-nine women were available to assess the agreement of the two methods. Validity was assessed using correlation coefficients, cross-classification into quintile categories and Bland–Altman plots. Nutrients relevant to bone health were assessed.

Setting: OSTPRE-FPS in Finland.

Subjects: Elderly women with a mean age 71·3 years.

Results: The FFQ overestimated energy and nutrient intakes as compared with food records by 30–50 %. The highest correlation coefficients of the energy-adjusted nutrient intakes between the methods were observed for fibre (0·60), Mg (0·56) and folic acid (0·49) and the lowest for protein and vitamin D (both 0·19). The cross-classification of energy-adjusted nutrient intakes showed that on average 68 % of the participants (range 62–78 %) were classified into the same or an adjacent quintile category.

Conclusions: The validity of energy and nutrient intakes measured with the FFQ was moderate as compared with 3 d food records in elderly women. The FFQ is a useful tool for the nutrient assessment of elderly women in epidemiological research.

Keywords
FFQ
Food record
Validity
Women
Elderly

Few studies have estimated the use and validity of FFQ in nutrient intake estimation in elderly populations[1–3]. However, determining nutrient intakes is critical in examining the effect of nutrition on health and disease. The FFQ is a useful tool to estimate long-term habitual dietary intake, can be self-administered and is relatively inexpensive. However, an FFQ should be tested in the specified population group before use[4]. Food records are a suitable reference method for assessing the validity of an FFQ because the errors associated with the two methods are independent[5].

The present study examined the nutrient intakes measured in the Kuopio Fracture Prevention Study (OSTPRE-FPS). Therefore, especially the nutrients related to bone health were of interest in the validation. Our aim was to develop a semi-quantitative FFQ for elderly women and to evaluate the relative validity of nutrient intakes estimated by the FFQ as compared with 3 d food records.

Experimental methods

Participants

Participants were recruited from the OSTPRE-FPS[6], which aims to examine the effect of Ca and vitamin D supplements on falls and fractures in women aged over 65 years during a 3-year intervention. The total number of women in the study was 3432, of whom 750 were randomly selected for a subsample participating in detailed examinations including measurement of bone mineral density and dietary records and FFQ. Dietary data used in the present study were collected at study year 3 (between April 2006

*Corresponding author: Email arja.erkkila@uef.fi

and June 2006). The convenience sample in the validation study included 102 women. Three were excluded from the analyses due to high energy intake >14·7 MJ/d (3500 kcal/d) in the FFQ, leaving ninety-nine women with food record and FFQ data.

The mean age of the women was 71·3 years in the validation study (SD 1·7, min 68·5, max 74·3 years). The mean height, weight and BMI of the women were 158 (SD 5) cm, 71·2 (SD 11·6) kg and 28·4 (SD 4·8) kg/m^2, respectively. The participants lived Kuopio Province including rural and urban areas.

The ethics committee of Kuopio University Hospital approved OSTPRE-FPS. The trial was registered at Clinicaltrials.gov under identifier NCT00592917 (registration date: 2 January 2008).

Food records

Current diet was assessed using 3 d food records including two consecutive weekdays and one weekend day. The instructions to complete a food record were mailed to the participants beforehand and they returned the records on a research visit at the Bone and Cartilage Research Unit (BCRU) at the University of Kuopio. Participants were instructed to write down everything they ate and drank and to evaluate the amount of food using household measures. The types of fats used on bread, in cooking and in baking were asked separately. In case of uncertainties in the food record, a nutritionist called the participant for more information.

Nutrient intakes were calculated using Diet32 software version 1·40 (Aivo Finland Oy, Turku, Finland). The Finnish food composition database, Fineli, was used in the calculations (National Institute for Health and Welfare, Helsinki, Finland).

FFQ

The FFQ was designed based on previous data on food consumption derived using food records in the same sample of Finnish elderly women at the baseline examination. The contributions of different food groups to energy, fat, vitamin and mineral intakes were evaluated and used to make the food list. Portion sizes for the FFQ were determined based on previous food records and an earlier Finnish FFQ[7]. Previous FFQ from the Finnish Health 2000 study[7], the British Aberdeen Prospective Osteoporosis Screening Study (APOSS)[8] and the Swiss Evaluation of Nutrient Intake and Bone Ultra Sound (EVANIBUS) study[1] were used in developing the questionnaire structures. The FFQ included fourteen pages and eighty-nine food items. The FFQ was designed to measure habitual food intake. The FFQ were given to the participants at the visit to the BCRU and they mailed the filled FFQ back using a prepaid envelope. Again, the nutritionist telephoned the participant if more information was needed.

The eighty-nine food items were classified as cereal products; dairy products; potato, rice and pasta; meat and poultry; fish and egg; food preparation and sauces; vegetables; fruit and berries; drinks; and sweets and snacks. All of the food groups contained an empty line for participants to add foods not listed. There were nine frequency options ranging from 'never or rarely' to 'over 5 times per day'. The type and amount of bread and fat spread were asked in more detail.

Daily nutrient intakes were calculated by multiplying the nutrient content per serving of each food item by the reported frequency of consumption and summing over all foods. Intake from supplements was not included in the calculated nutrient amounts. The nutrient contents were obtained from the Finnish food composition database, Fineli (National Institute for Health and Welfare). Nutrients calculated in the validation included protein, fat, carbohydrate, fibre, K, Ca, P, Mg, Fe, folic acid, and vitamins B_{12}, C, D and K.

Assessment of under-reporting at group level

For evaluation of the plausibility of dietary intake data, the ratio of energy intake (EI) to estimated basal metabolic rate (BMR_{est}) was calculated. BMR_{est} was calculated based on body weight according to equations given by the Department of Health in the UK[9]. The EI:BMR_{est} cut-off value for under-reporting was chosen to be 1·49, as derived from Goldberg *et al.*[10] and Black[11].

Statistical analyses

All data analyses were performed using the SPSS statistical software package version 14·0 (SPSS Inc., Chicago, IL, USA). The nutrient intakes were adjusted for energy intake using the residual method[12]. Normality of the variables was tested by the Kolmogorov–Smirnov test. Pearson correlation coefficients were calculated to compare the two dietary assessments. In calculating the correlations log-transformed nutrient intakes were used to improve normality. The difference between the nutrient intakes from the two methods was tested using the paired-samples *t* test. The women were classified into quintile categories of nutrient intakes and the percentage classified into the same, an adjacent or the opposite quintile category was calculated. Bland–Altman plots were used to determine if the difference in intake between the FFQ and food records varied depending upon the average nutrient intake[13]. The limits of agreement (mean difference ± 1·96 SD of the difference between the methods) indicate whether the agreement is acceptable on an individual level.

Results

The mean nutrient intakes were higher when measured with the FFQ than with food records (Table 1). The least overestimation was observed for fat intake, 28 %, and most of the nutrients were overestimated by 30–50 %. Intakes of vitamins C and K were overestimated the most. The differences in the intakes of energy and energy-adjusted nutrients

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Table 1 Comparison of daily nutrient intakes as measured by the FFQ and food records and correlation between the two methods (*n* 99): elderly women (mean age 71·3 years) in the Kuopio Fracture Prevention Study (OSTPRE-FPS), Finland

Nutrient	FFQ				Food record				FFQ to food record (%)†	Pearson correlation coefficient between FFQ and food record*	
	Unadjusted intake		Energy-adjusted intake		Unadjusted intake		Energy-adjusted intake				
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		Unadjusted (log)	Energy-adjusted (log)
Energy (kJ)	8965	2255	N/A	N/A	6874	1601	N/A	N/A	134	0·39	N/A
Protein (g)	91	27	91	16	69	18	69	13	136	0·26	0·19
Fat (g)	73	25	73	13	58	19	58	11	128	0·32	0·34
Carbohydrate (g)	271	67	271	28	204	55	204	27	135	0·48	0·33
Fibre (g)	33	10	33	8	22	7	22	5	155	0·55	0·60
K (mg)	4823	1250	4823	775	3421	820	3420	590	144	0·44	0·44
Ca (mg)	1334	439	1334	382	1020	356	1020	279	137	0·40	0·48
P (mg)	1941	484	1941	284	1497	380	1497	253	132	0·36	0·46
Mg (mg)	461	107	461	60	334	80	334	52	140	0·56	0·56
Fe (mg)	14·7	4·2	14·7	2·6	10·9	3·5	10·9	2·8	141	0·35	0·40
Folic acid (µg)	353	113	353	80	279	97	279	83	132	0·49	0·49
Vitamin B_{12} (µg)	8·3	4·9	8·3	4·4	6·0	4·1	6·0	3·8	152	0·39	0·39
Vitamin C (mg)	130	95	130	91	97	63	97	63	173	0·32	0·28
Vitamin D (µg)	10·0	4·1	10·0	3·4	8·8	6·1	8·8	5·6	140	0·29	0·19
Vitamin K (µg)	162	84	162	67	79	41	79	40	228	0·36	0·37

N/A, not applicable.
*Pearson correlation coefficients calculated for log-transformed energy-unadjusted and -adjusted values were significant for all nutrients ($P \leq 0·01$), except for energy-adjusted protein and vitamin D intakes ($P = 0·055$ and $P = 0·056$, respectively).
†Calculated from energy-adjusted values.

between the two methods were statistically significant for all of the nutrients (paired-samples *t* test, $P < 0·05$).

Using the energy-unadjusted intakes, the lowest Pearson correlation coefficients were observed for protein ($r = 0·26$) and vitamin D ($r = 0·29$), whereas the highest correlations were found for Mg ($r = 0·56$) and fibre ($r = 0·55$; Table 1). Energy adjustment worsened the correlations for protein and vitamin D intakes ($r = 0·19$ for both). The correlations improved for fibre, P and Ca with energy adjustment. When using the energy-adjusted nutrient intakes, the highest correlation coefficients were observed for fibre ($r = 0·60$), Mg ($r = 0·56$) and folic acid ($r = 0·49$).

The participants were divided into quintile categories of energy and energy-adjusted nutrient intakes as measured by the FFQ and food records to evaluate the ability of the methods to classify participants similarly. The average proportion of participants classified into the same quintile category was 31 % (Table 2). When the classification into the same or an adjacent quintile category was considered the average proportion of participants was 68 %. The highest proportion of women classified into the same or an adjacent quintile category was observed for fibre, K, Mg, Fe and folic acid intakes. The highest proportion of grossly misclassified participants was observed for vitamin D and protein intakes.

The Bland–Altman plots show the average and agreement limits of the difference in energy and energy-adjusted nutrient intakes plotted against their mean (Fig. 1). For most of the nutrients the differences in intake were quite well within the 95 % agreement limits. For energy and vitamin D, the agreement was poorer when the average intake was higher.

Discussion

We evaluated the relative validity of energy and nutrient intakes estimated by a semi-quantitative FFQ as compared with a 3 d food record in free-living elderly Finnish women. We included especially nutrients relevant to bone health in the validation. We are not aware of any other FFQ specifically validated to be used in elderly subjects in Finland.

The FFQ overestimated energy and nutrient intakes as compared with the food records. Overestimation of energy and nutrient intakes is common when using FFQ and has been reported earlier in Finnish adult populations[7,14] and in a Dutch elderly population[3]. Two other studies in postmenopausal or elderly women have reported no significant differences in nutrient intakes measured with food records and FFQ[1,2]. It is also noteworthy that food records are prone to under-reporting, which was indicated by the mean ratio of EI:BMR_{est} being 1·23 for food records, below the cut-off value (1·49). It has been suggested that a cut-off value of 1·2 is suitable for chair-bound or bed-bound individuals[11], which was barely met by the food record estimates. For the FFQ, the mean ratio of EI:BMR_{est} (1·60) was above the cut-off value. A slightly lower ratio (1·46) was reported earlier in 55- to 75-year-old women[3] and even lower (1·24) in 75- to 87-year-old women[1].

The validation correlation coefficients are similar to those reported earlier in elderly[1,2,15] and in Finnish studies[7,14]. In agreement with our results the correlation coefficients have been low for protein[7,15] and vitamin D[1] in previous studies. Portion size estimation in food records and FFQ is difficult for non-countable protein-containing foods like meat and fish. This might have affected the low correlation of protein intakes even though its overestimation with the FFQ was similar to that of other nutrients. Fish, which is a major dietary source of vitamin D[16], is consumed once or twice weekly. Thus the 3 d food record is not optimal for capturing the habitual fish intake and the validity is likely to be lower than for nutrients derived from multiple sources daily. The FFQ has been suggested to be a valid tool to estimate the intake of occasionally or episodically consumed foods[7]. According to the FFQ, almost half of the vitamin D came from fish and fish products (4·7 μg/d).

The validity of measuring fibre intake was good as indicated by correlation coefficients and cross-classification. Similarly, earlier studies have reported good agreement between the two methods for assessment of fibre intake[1,2,7,14,15]. Questions asking about the type and amount of bread were detailed, which could have contributed to the strong correlation of fibre intakes. Bread contributes a significant proportion of fibre intake in Finland (approximately 40 % from bread in 65- to 74-year-old women)[16]. Furthermore, significant proportions of Mg and P are derived from cereal products and the validity of their intake was good in the present study.

In estimation of diet and disease associations ranking of individuals according to their nutrient intakes is critical. We observed that ranking of individuals was adequate

Table 2 Classification of energy intake and energy-adjusted nutrient intakes into the same, adjacent or opposite quintile categories (*n* 99): elderly women (mean age 71·3 years) in the Kuopio Fracture Prevention Study (OSTPRE-FPS), Finland

Nutrient	Same quintile category (%)	Adjacent quintile category (%)	Opposite quintile category (%)
Energy	23	45	0
Protein	29	30	6
Fat	27	41	5
Carbohydrate	33	34	4
Fibre	39	39	0
K	31	41	1
Ca	29	34	1
P	34	33	2
Mg	33	42	2
Fe	40	34	3
Folic acid	31	39	0
Vitamin B_{12}	26	37	4
Vitamin C	28	33	3
Vitamin D	34	30	8
Vitamin K	26	42	3

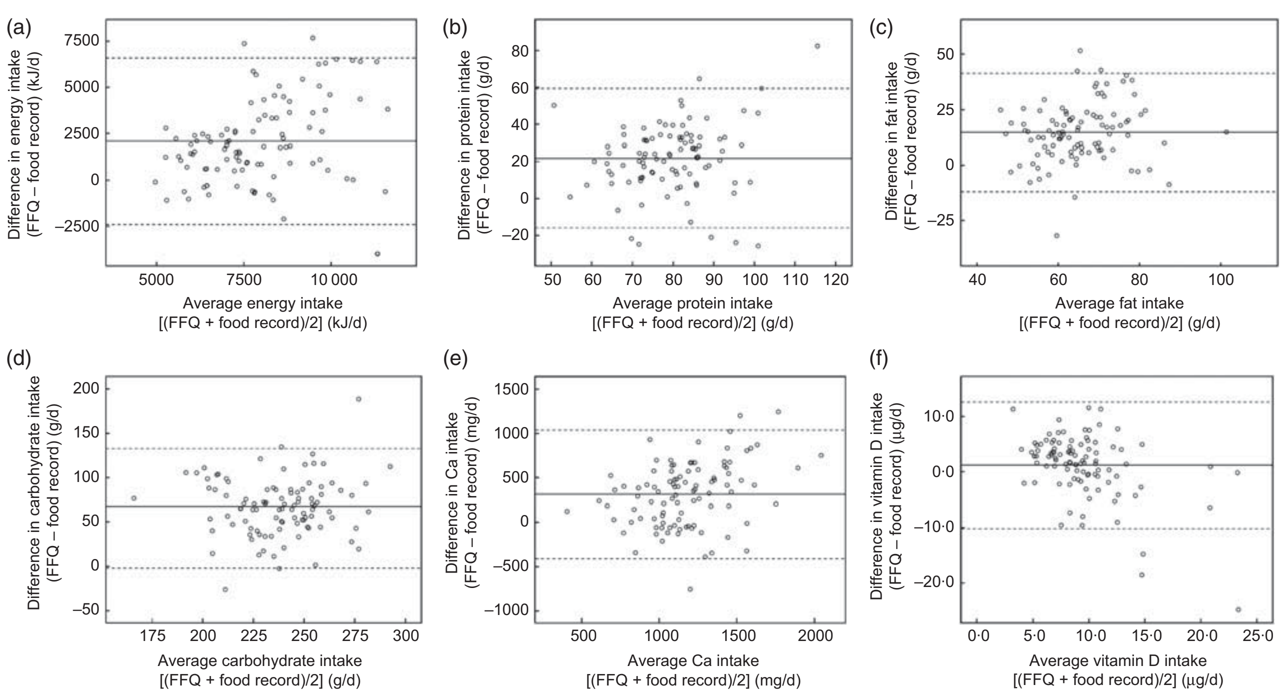

Fig. 1 Bland–Altman plots for intake of (a) energy, (b) protein, (c) fat, (d) carbohydrate, (e) calcium and (f) vitamin D measured with the FFQ and the 3 d food record, showing the difference in the energy or energy-adjusted nutrient intake between the methods plotted against the average energy or energy-adjusted nutrient intake based on both methods, among elderly women (mean age 71·3 years) in the Kuopio Fracture Prevention Study (OSTPRE-FPS), Finland. The mean (——) and the limits of agreement (- - - -) for the differences are shown

based on the cross-classification for the majority of the nutrients. Substantial gross misclassification occurred only for vitamin D and protein intakes. The poor classification of vitamin D and protein was also apparent by values not meeting the agreement limits in Bland–Altman plots. Of note is that also for vitamin K intake the ranking was valid, even though the absolute intakes poorly agreed. This has also been reported earlier[17]. Green salads, chicken and vegetable soups were the most important sources of vitamin K in the FFQ. It is likely that vegetable use is overestimated by the FFQ, and episodically consumed vegetables are poorly accounted for in food records[7,17].

The number of women in the validation study can be considered reasonable[5]. Furthermore, many elderly women have regular dietary habits, which facilitates filling out an FFQ[7]. Portion sizes are typically smaller in elderly women than in adults. Portion sizes in our FFQ were smaller than the average adult portion sizes[18]. Nevertheless, we cannot exclude the possibility that the portion sizes were too big for the population and contributed to the overestimation of nutrient intakes. Furthermore, repeating the food records could have improved the agreement between the two methods. Food records and FFQ were collected in spring and early summer. Thus, we were not able to estimate the seasonal variation in dietary intake. Earlier it has been reported that consumption of leafy vegetables and vegetable fruits is higher in spring and summer in Finland[19].

In conclusion, the FFQ overestimated absolute nutrient intakes. However, the FFQ is a valid tool for ranking individuals according to their nutrient intakes. The FFQ can be used to classify elderly women according to their nutrient intakes for research purposes in Finland.

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