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Comparison between optical readable and open-ended weighed food records

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Abstract

Background: A simplified optically readable food record (ORFR) was developed and compared with an open-ended weighed record (WR).

Objective: To compare intake of nutrients and foods using a seven-day ORFR with intake estimated using a seven-day WR. The results from each method were validated against 24-h urine nitrogen excretion and energy intake (EI)/estimated basal metabolic rate (BMR) cut-off values.

Design: The study comprised 73 free-living, healthy 70-year-old Swedish men. Dietary data were collected during seven consecutive days, starting either with WR or ORFR.

Results: Average intakes of energy and several nutrients were significantly lower when estimated using ORFR than when using WR. However, when adjusted for nutrient density, only a few nutrients were still lower with ORFR. Spearman correlation coefficients between the two methods regarding intakes of energy and energy-yielding nutrients were moderate to high, i.e. 0.4–0.6, while figures for most micro-nutrients were in the range 0.3–0.5. A large proportion of subjects under-reported their EIs, a higher proportion doing so when using ORFR. Protein intake obtained using ORFR was 31% lower than the values calculated from the 24-h urine nitrogen excretion, and 22% lower than those obtained from WR. Average intakes of milk, cheese and other milk products as well as coffee, tea and alcohol were significantly higher when estimated using ORFR than when using WR, while intakes of vegetables, meat and meat products, fish, bread and cereal products as well as number of sweet foods were significantly lower with ORFR.

Conclusions: Based on these results, adjustments of some portion sizes in ORFR are suggested. In view of the advantages of ORFR with respect to lower response burden and rapid processing of data, such adjustments would make ORFR a suitable dietary assessment tool for use in dietary surveys, including larger resource-demanding epidemiological investigations.

Keywords: *optically readable food record*; *weighed registration*; *urine nitrogen*; *portion sizes*

Accurate estimates of the dietary intake of free-living individuals are required for nutritional research, epidemiology and clinical medicine. However, all dietary assessment methods in which people report their habitual food intake rely on the information supplied by the subjects. Unfortunately, although methodology and procedures, i.e. computer techniques, have improved in recent years, there is great consensus that no dietary assessment method has been proven to accurately reflect an individual's long-term dietary intake. A large number of trials have shown an apparent underestimation of energy intakes (EIs), not only in overweight subjects, but also in other groups (1–6). This problem has also been discussed in a review by Goldberg and Black (7) and in a study by Willett et al. (8), where the authors suggested routines that should be included in dietary assessment methods to increase the accuracy of EI evaluations.

In the early 1980s, it was suggested that 24-h urine nitrogen (UN) output could be used as a validity test in dietary surveys (9). This is an indirect check of protein intake, but has the advantage of being reliable. Furthermore, the 24-h UN method is inexpensive compared with other biological markers used. Studies using 24-h UN

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excretion have shown that protein intakes estimated with various methods recalling food intake tended to be too low indicating under-reporting (9–13).

Two widely used methods of assessing the dietary intake of free-living persons are the menu book (including recently simplified food records) and open weighed food records. Both methods have been used in large population groups. They are considered rather expensive methods, primarily because they are time-consuming for the investigator (5, 14–16). Therefore, a pre-coded seven-day record book was developed and has been used in several investigations of different population groups in Sweden (5, 15, 16). The record book was compared with an open weighed record (WR) method, and it was found to be very easy to use, but needed further development and improvements (15).

To reduce the time spent on data entry and coding, an optically readable version of the record book was developed. The optically readable food record (ORFR) has the same content of food items/dishes, but data can be entered into the computer automatically by optical reading of each page. This procedure has the advantage of minimising errors that occur at data entry.

Main objective of the present investigation was to evaluate the ORFR for use in a healthy free-living elderly male population. An open WR was used as the reference method. Estimates of the intake of foods as well as energy and some of the main nutrients were compared when using the two methods. In addition, protein intake was validated against 24-h UN excretion in the elderly male population.

Methods

Subjects
Dietary data were collected from 73 male subjects, all 70 years of age. The subjects were enrolled in a health survey, which started in 1970–1973 (17). All 50-year-old men living in the Municipality of Uppsala at the time were invited to participate in a health survey on risk factors for coronary heart disease. About 2,000 men have been investigated every tenth year since then. About 20 years later, a follow-up investigation of the 70-year-old 'survivors' was conducted. A total of 855 men have been investigated and a subgroup ($n = 75$) was randomly selected and asked to take part in the present study. The men visited the metabolic clinic at the University Hospital as part of the ongoing health survey. Those who agreed to report their dietary intake during two separate weeks were included in the present study.

Outline of the study
The subjects were recruited throughout November and May and were randomly assigned to start either with the ORFR or with the WR. Each subject was weighed initially and at the end of each dietary recording period including seven consecutive days, with a break of one week between the two periods. Each subject received detailed oral and written instructions from a dietician or nurse on how to record food intake using the WR or the ORFR, as well as instructions on how to use the scales. Information on how to fill in the records correctly was also given in a video film that was shown to each participant. Subjects were instructed to continue their normal eating habits, and to start filling in the dietary record the following day. If further questions arose during the week of reporting, subjects were instructed to contact the dietician or nurse by phone for assistance.

Each subject recorded his intake in the ORFR by marking a horizontal pencil stroke in a 'circel'. Each page of the ORFR contains pre-printed food items or dishes eaten at main meals, and the subject has to mark the amount of food eaten, expressed either in household measurements or as portion sizes. Subjects also indicated where and when foods were consumed. The portion sizes were illustrated in a series of four photographs, as a guide to estimating the portions of the meal components (meat/fish; potatoes/pasta/rice; vegetables/salad, etc.). Use of spreads on sandwiches was also estimated with the help of photographs showing four alternatives for the amounts used. For the other pre-printed foods, the subject indicated the amount consumed in household measures, e.g. glasses, cups, slices, etc. Predefined standard portions were allocated in the data analyses. These portions were mainly derived from Swedish reference publications (*Food Weight Tables. National Food Administration, Uppsala, Sweden,* In Swedish). Food items under the heading 'others' were described by the subjects in free text and were coded into the computer by hand in accordance with the National Food Administration's food composition database (18).

Each page was read by an optical reader (Kaiser OMR 32) using the OMR technique, where the position of the marking on the page constitutes the necessary information. The optical reader is equipped with an extra-sensitive head for reading, which sends out visible light at a reading speed of 3,000 pages/h. The reader is linked to a PC. The Kaiser LEPRON program transfers the data to the PC, where it is accessed and analysed.

The subjects were instructed to weigh all the foods eaten during the seven-day period using a scale (Soehnle, model 8020). As the subjects were retired men, the majority of their meals were eaten at home, according to a regular eating pattern. If for any reason they were to eat away from home, they were asked to bring the scale with them. In some situations where they were unable to weigh their food, they would estimate their food intake using the same set of photographs as for the ORFR. The subjects were instructed to record their intake of food and beverages in a small notebook specially prepared for the

present study. Further, they were instructed to record any intake as soon as possible after consumption of any food or drink.

All subjects were asked to collect a 24-h urine sample during the weighed food record period. Protein intake was validated by comparing the estimated intake from the food records with the protein intake calculated from the 24-h UN excretion (9). Oral and written instructions on the collection technique were given to each subject. The subjects were given a plastic litre measure for collecting the urine, and two-litre plastic bottles for storing the urine collections. Each bottle contained 5 g boric acid as preservative. The first morning urine voided on the collection day was discarded and the time noted. All urine passed in the next 24 h was collected until the same time the next morning. To check the completeness of urine collection, para-amino-benzoic acid (PABA) tables were used (10, 11). The subjects were instructed to take the PABA tablets (380 mg) during the 24-h urine collection. One tablet was taken with each of the three main meals, i.e. breakfast, lunch and dinner. To include all days of the week, the urine collections were spread out over the week. Individual urine specimens for each 24-h period were carefully mixed. Aliquots of the 24-h collections were stored at –20°C prior to analysis. The urine collections containing less than 85% were considered incomplete. UN excretion was converted to grams of protein ingested using the formula gram N/0.81 × 6.25, as suggested by Bingham and Cummings (10), as it was found that, on average, 81% of the nitrogen is excreted with the urine.

Calculation of energy and nutrient intakes

The daily intakes of energy and selected nutrients were calculated using a computerised dietary assessment program (19) equipped with a food composition database from the National Food Administration (20). The database includes about 1,500 food items, drinks and standard recipes, and reports data on energy and 47 nutrients. The adequacy of the recorded EI values was evaluated using the cut-off method, according to Goldberg et al. (23). This is based on reported EI divided by estimated BMR (23). A cut-off value below 1.27 for EI/estimated BMR was used to identify subjects with apparent long-term under-reporting. This value is considered as the lower limit for long-term survival (21). In addition, a cut-off value of 1.1 was used to characterise subjects with an 'implausibly low' EI for a seven-day period based on statistical considerations described by Goldberg et al. (23).

Statistical analysis

The Statistical Analysis System (24) for Personal Computers Release 6.04 was used for the statistical analyses.

The results are expressed as means $\pm$ standard deviation. For comparison of means of normally distributed variables, the paired Student's t-test was used. For variables not normally distributed, the Wilcoxon rank sum test was applied. Correlation analysis was performed with Spearman's rank correlation to test for the trend in the different quintiles of the main variables (25). Pearson correlation was used to test the linear relationship among some of the variables.

Results

Subjects

Seventy-three of the 75 men completed both recordings: one week using the optical readable food record and one week using the weighed food registration method. Two subjects failed to complete the recordings adequately. There were no significant differences in body weight from baseline, ORFR 82.7 ± 11.4 kg and WR 82.5 ± 11.4 kg, to the end of either of the two dietary recording periods, ORFR 82.7 ± 11.5 kg and WR 82.7 ± 11.2 kg, or between the two methods used.

Intakes of energy and nutrients

The mean daily intakes of energy and selected nutrients as measured with the two methods are shown in Table 1. Average daily intakes of energy and several nutrients differed significantly between the two methods. Higher average intakes were obtained by the WR for energy and protein, total fat, carbohydrates, ß-carotene, vitamin D, α-tocopherol, thiamin, riboflavin, preformed niacin, vitamin B$_6$, folate, vitamin C, magnesium, iron, zinc, selenium and dietary fibre. However, the proportion of energy (E%) from energy-yielding nutrients was similar, except for a higher E% saturated fatty acids and alcohol, and a lower E% sucrose, with the ORFR method.

When expressed as nutrient density (i.e. amount per MJ), the ORFR yielded lower nutrient density for iron, calcium, ß-carotene, selenium, α- tocopherol and dietary fibre, while a higher nutrient density was found for potassium (Table 2). Lower intakes per MJ were also obtained with the ORFR for the fatty acids 16:1, 18:1 and 18:3 n-3 and the long-chain n-3 fatty acids 20:5 and 22:6 (data not shown).

The correlation coefficients (Spearman) between the two dietary assessment methods for intakes of energy and nutrients ranged from 0.08 to 0.68 and were all significant ($p < 0.01$). Moderate to high correlation coefficients, $>0.40–0.60$, were obtained for energy and most energy-yielding nutrients (Table 3), while coefficients were between 0.30 and 0.50 for most micro-nutrients (Table 4). Lower figures (<0.30) were obtained for vitamin A, vitamin D, ß-carotene, thiamin, riboflavin, preformed niacin and sodium. A comparison of the

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Table 1. Average daily intakes of energy, nutrients and alcohol as measured by the ORFR and the weighed record (WR); mean and (SD) ($n = 73$)

	ORFR		WR	
Energy (kJ)	7,525***	(2,222)	8,332	(1,690)
Protein (g)	69***	(19)	77	(16)
Protein (E%)	16	(2)	16	(2)
Total fat (g)	72*	(25)	78	(19)
Total fat (E%)	35	(5)	34	(5)
Saturated fat (E%)	15***	(3)	14	(3)
Monounsaturated fat (E%)	12	(2)	12	(2)
Polyunsaturated fat (E%)	5	(1)	5	(1)
Total carbohydrates (g)	210***	(67)	235	(57)
Total carbohydrates (E%)	48	(5)	48	(6)
Alcohol (g)	6.4	(6.3)	6.0	(6.9)
Alcohol (E%)	3**	(3)	2	(2)
Dietary fibre (g)	17.5***	(5.7)	20.4	(5.2)
Vitamin A (RE)	1.52	(0.87)	1.50	(1.03)
Retinol (mg)	1.25	(0.86)	1.06	(0.96)
β-carotene (mg)	1.61**	(1.12)	2.62	(2.22)
Vitamin D (μg)	6.2**	(2.5)	7.1	(2.3)
α-tocopherol (mg)	6.0***	(2.1)	7.2	(1.8)
Thiamin (mg)	1.24***	(0.36)	1.45	(0.38)
Riboflavin (mg)	1.54***	(0.46)	1.66	(0.47)
Niacin (pref.) (mg)	14.1**	(3.7)	15.8	(3.8)
Vitamin B_6 (mg)	1.70*	(0.50)	1.81	(0.40)
Vitamin B_{12} (μg)	7.5	(6.1)	7.7	(7.3)
Folate (μg)	195***	(57)	217	(49)
Vitamin C (mg)	54*	(29)	63	(34)
Calcium (mg)	966	(344)	926	(249)
Potassium (mg)	2,784	(744)	2,960	(569)
Magnesium (mg)	287*	(74)	305	(55)
Iron (mg)	13.0***	(4.0)	15.8	(5.3)
Zinc (mg)	9.7*	(2.8)	10.4	(2.3)
Selenium (μg)	27***	(8)	34	(13)

Values significantly different from weighed record: *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

ranking of the individual intakes of energy and selected nutrients showed that the majority were classified into the same quintile or nearest quintile, i.e. the one below or the one above (Table 4).

Urine nitrogen excretion
All subjects ($n = 73$) collected a 24-h urine sample during the weighed food record period. As we considered urine samples with a recovery of less than 85% incomplete, only 59 samples were used for comparison with the respective dietary records. The daily protein intake estimated using ORFR was 31% lower than the calculated values from the 24-h UN ($p < 0.0667$, $r = 0.59$), while that estimated using the WR was 22% lower ($p < 0.0001$, $r = 0.27$) (Table 5).

Table 2. Nutrient density (per MJ) according to ORFR and WR ($n = 73$)

	ORFR	WR	Mean difference WR–ORFR
β-carotene (mg)	0.22	0.32	−0.11***
α-tocopherol (mg)	0.80	0.87	−0.06***
Iron (mg)	1.74	1.88	−0.14**
Dietary fibre (g)	2.36	2.48	−0.12*
Calcium (mg)	129	112	−16.5***
Potassium (mg)	378	361	17.4*
Selenium (μg)	3.63	4.16	−0.53**

Significant difference between ORFR and WR: *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Food consumption
The average daily consumption of foods (aggregated into major food groups) obtained by the two methods is shown in Table 6. The consumption of cheese, milk and other milk products as well as coffee, tea and alcohol was significantly higher when estimated using the ORFR method than when using the WR method, while the opposite was seen for vegetables, meat and meat products, fish, bread, cereals and pasta, cakes and biscuits, jam, sweet drinks and desserts, chocolate and sugar (Table 6). No differences were seen for spreads, potatoes, fruit, juice and eggs.

Cut-off limits for identifying under-reporting
A large proportion of the men under-reported their EI. Use of the cut-off point <1.27 (21) showed a majority of the men reported an EI below this value when using the ORFR and WR, respectively. Further, it was found that a higher percentage had an implausibly low EI according to Goldberg, i.e. cut-off <1.1 (23), when using the ORFR (26%) than when using the WR (12%).

Discussion
The main results from the present study show that estimates of average intakes of energy and several nutrients differed significantly between the two methods, higher figures being obtained when using the WR. However, when expressed as nutrient density, i.e. per MJ, only a few nutrients were still lower when using the ORFR. The mean Spearman correlation coefficients between the intakes of energy and energy-yielding nutrients between the two methods were moderate to high, i.e. 0.4–0.6, while figures for most micro-nutrients were in the range 0.3–0.5. The majority of the subjects' intakes were classified into the same or adjacent quintile.

In a series of dietary surveys earlier performed in Sweden, a pre-coded record book has been used to

Table 3. Cross-classification (quintiles) and correlation of intakes of energy, energy-yielding nutrients and dietary fibre (in absolute and energy-adjusted values), according to ORFR and WR

	Cross-classification, %		Spearman correlation[c]
	WR QI vs ORFR QI+Q2[a]	WRQ5 vs ORFR Q4+Q5[b]	r
Energy (kJ/d)	87	86	0.62**
Protein (g)	67	57	0.33*
Total fat (g)	93	64	0.54
Saturated fat (g)	93	79	0.64**
Monounsaturated fat (g)	80	71	0.47**
Polyunsaturated fat (g)	80	71	0.34*
Cholesterol (mg)	80	79	0.51**
Total carbohydrates (g)	87	86	0.63**
Dietary fibre (g)	80	79	0.51**
Alcohol (g)	73	93	0.64**
Protein (E%)	60	64	0.48**
Total fat (E%)	60	71	0.42**
Saturated fat (E%)	60	79	0.58**
Monounsaturated fat (E%)	67	77	0.33*
Polyunsaturated fat (E%)	60	71	0.37**
Alcohol (E%)	78	93	0.65**

[a]Percent subjects in first quintile WR classified into first and second quintiles in ORFR.
[b]Percent subjects in fifth quintile WR classified into fourth and fifth quintiles in ORFR.
[c]Significance of the Spearman correlation: *$p < 0.01$; **$p < 0.001$.

Table 4. Cross-classification (quintiles) and Spearman correlation for daily intakes of selected nutrients measured by the ORFR and the weighed record (WR) ($n = 73$)

Nutrients	Cross-classification, % in quintiles		Spearman correlation
	WR QI vs ORFR QI+Q2[a]	WR Q5 vs ORFR Q4+Q5[b]	r
Vitamin A (retinol eqv.)	63	57	0.13*
Retinol (mg)	60	64	0.34*
β-carotene (mg)	40	64	0.29*
Vitamin D (μg)	67	43	0.08*
α-tocopherol (mg)	73	57	0.36*
Vitamin C (mg)	73	79	0.42**
Thiamin (mg)	67	57	0.29*
Riboflavin (mg)	80	43	0.38*
Niacin (mg)	53	40	0.20*
Niacin eqv. (mg)	73	57	0.33*
Calcium (mg)	73	71	0.47**
Phosphorus (g)	80	86	0.68**
Magnesium (mg)	73	50	0.41**
Sodium (mg)	60	64	0.38**
Potassium (mg)	53	64	0.30*
Iron (mg)	73	71	0.42**
Zinc (mg)	60	64	0.37**
Selenium (μg)	73	64	0.33**

[a]Percent subjects in first quintile WR classified into first and second quintiles in ORFR.
[b]Percent subjects in fifth quintile WR classified into fourth and fifth quintiles in ORFR.
Significance of the Spearman correlation: *$p < 0.01$; **$p < 0.001$.

estimate nutrient and food intake in different groups (5, 15, 26). The record book has proven to be very useful in larger dietary investigations, but has also been found to have some limitations (5, 15). One important advantage of a pre-coded record book, compared with open-ended records, is that considerable time may be saved by not having to code and enter data. Becker et al. (15) suggested that the time reduction was almost 50%: coding and data entry from the pre-coded record took 1.3 h per person as compared to 2.5 h per person for the WR. In a study including 500 participants, this means a saving of four man-months of work (15, 27). In the present study, a pre-coded record book designed for optical scanning was used, which also considerably reduced the time-consuming step of entering the data manually (15).

As reported by others, and shown here, underestimation of food intake seems to be a 'general problem', as shown by various assessment methods (1, 2, 4, 5, 14, 15, 23, 28, 29). The reported EIs obtained here are comparable with those from a number of other large investigations in which seven-day food records were

also employed (5, 15, 28). In the present study, the proportions of energy-providing nutrients did not differ significantly between the two methods, indicating that under-reporting of this aspect was not specific to the method used (Table 3).

However, significantly lower EIs were obtained when using ORFR than when using WR. There may be several reasons for this under-reporting. One plausible reason may be that ORFR includes 'standard' recipes. This means that the fat used for cooking, i.e. included in the recipes, is of the same quality/type (amounts of total fat and fatty acid composition). Thus, if the subject uses other cooking fats with a different fat content or with a different fatty acid composition, this will not be recorded or calculated. The true picture of the dietary fat intake is thus limited when using ORFR. This may explain the significant differences found for some of the individual fatty acids. The same observations have been made earlier (4, 5, 15, 17). However, when using WR, the subjects are more likely to specify the type of cooking fat, as well as the true amounts

Table 5. Intake of protein (g/d) measured by ORFR, WR and 24-h urine nitrogen excretion (UN). The figures are presented as mean and (SD) and their correlation (*n* =59)

Methods	Mean	SD	Difference from UN (%)	Spearman correlation
ORFR (g/d)	68.5*	(19.3)	−31.4	0.59*
WR (g/d)	77.5*	(15.5)	−22.4	0.27**
UN	99.9	(22.9)		

Significance difference from urine protein: *p <0.0001.
Significance of Spearman correlation: **p <0.05.

of spreads they consume, because they actually weigh every single food item and the amount they eat.

In the present investigation, calculations of the adequacy of the reported EI values were made on the basis of estimated BMR values as suggested by FAO/WHO/UNU (21, 22) and the cut-off points suggested by Goldberg et al. (23). Based on these calculations, a large proportion of the subjects were categorised as under-reporters using both methods, though a larger number using the ORFR method. The proportion of subjects with implausibly low reported EIs corresponds well with the findings of other surveys in which a record book (pre-printed, but not optically readable) was used (5, 15, 26). There is some uncertainty in the calculations of under-reporting because physical activity, specific to this study, was not assessed and cut-off limits for the EI:BMR ratio were based on those calculated by Goldberg et al., with a sedentary Physical Activity Level of 1.55 for *n* =1 (4, 23).

It was further found that both assessment methods yielded lower estimates for protein intake compared to estimates based on UN excretion (Table 5). The lowest calculated intakes were obtained by the ORFR. Despite that only a single 24-h urine was collected, correlation coefficient (Spearman) for ORFR was relatively high (0.59), and close to figures reported by Bingham et al. (13) for estimated food records (0.60–0.70) using eight 24-h urine per subject. Further, when we checked our results using PABA, we did not include those who had <85% completeness, as such results obviously indicate significant underestimation. Similar results have been reported by Becker et al. (15), also based on comparison of an open WR with the pre-coded record book. Some of the portion sizes used in the ORFR provide the most probable explanation for the low figures obtained (5, 15, 30). An analysis of the food consumption figures is very much in line with the lower energy findings, as well as with some lower nutrient intake figures, when using the ORFR. Lower consumption of, e.g. meat, milk and fat products can be associated with lower intakes of energy, as well as with lower intakes of the major energy-yielding nutrients such as total fat and protein, and perhaps also with some of the vitamins and minerals. Further, lower consumption of bread and cereal products, as well as vegetables, may explain lower figures for carbohydrates and dietary fibre.

Table 6. Average consumed amounts, mean and (SD) of food among healthy, elderly men according to the optically readable food record (ORFR) and the weighed record (WR) (*n* =73)

Food group	ORFR		WR		p-Value
Spreads	30	(19)	31	(15)	0.69
Cheese	32	(22)	27	(19)	0.02
Milk	314	(163)	270	(139)	<0.01
Potatoes	154	(70)	158	(65)	0.62
Vegetables	79	(55)	105	(65)	<0.01
Fruit and berries	114	(85)	116	(95)	0.91
Juice	18	(39)	22	(55)	0.48
Bread, cereals and pasta	231	(95)	258	(112)	0.01
Cakes and biscuits	62	(55)	71	(48)	0.02
Meat and meat products	103	(43)	120	(47)	0.01
Fish	31	(22)	53	(35)	<0.001
Egg	17	(20)	17	(17)	0.61
Ice cream	5	(5)	6	(10)	0.42
Jam, sweet drinks and desserts	64	(93)	89	(89)	0.04
Chocolate, sweets and sugar	8	(12)	12	(14)	<0.01
Coffee	492	(206)	348	(169)	<0.001
Tea	135	(165)	113	(145)	0.03
Alcoholic beverages	178	(168)	136	(12)	<0.001

In general, the portion sizes used in our ORFR may have been too small for various food items and dishes. 'Flat slope syndrome' is another explanation, suggested by Gibson (31), for the tendency to overestimate low intakes and underestimate high intakes, and this explanation may also apply to the subjects in the present investigation. In an evaluation of portion sizes, Håglin and co-workers (30) showed that choosing incorrect pictures may result in both under- and over-estimations.

Although most elderly people are thought to have a regular meal pattern and eat most of their food at home, they may forget to weigh everything. This could explain the low protein intakes estimated when using the WR. As stated by Bingham (12), energy and protein intakes have been found to be under-estimated by as much as 20% according to various dietary surveys (12, 33). Our results, as well as those of others (32), suggest that improvement of methods for estimating portion sizes should be a priority in future dietary assessment methodology.

After the present study was performed, the ORFR was also investigated by Rosell et al. (34). The aim of their study was to investigate how much of the energy and nutrients contributed by foods that has to be reported in free text. The authors concluded that to reduce the level of under-reporting, emphasis should be placed on improving the recording of between-meal eating. However, we would like to emphasise the two important advantages of a pre-coded, ORFR: the recorder and the experimenter save a considerable amount of time and the accuracy of coding and data entry is increased. In a pilot study comprising 35 subjects, time savings in data entering, data checks and nutrient analysis were on average 30 min for the ORFR compared with the manual pre-printed record book (Carlsson & Johansson, unpublished data). Therefore, after the suggested adjustments especially in, portion sizes, the ORFR could be seen as a useful tool in a variety of food and nutrition studies.

Conclusions

The above findings indicate that when a pre-coded food record is used this is designed for scanning, the following advantages ensue:

1) It is less time-consuming for subjects to record their food intake because there is no need for weighing and writing.
2) It allows more efficient data processing, e.g. by limiting time spent on data entry.
3) A pre-coded and ORFR is less expensive to process than a manual version is.
4) Emphasis should be put on estimations of the type and amount of fat used in order to obtain a valid assessment of total fat and fat quality.
5) The portion sizes should be estimated carefully measured to reflect the actual portion sizes in the study population.

Conflict of interest and funding

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