Original Article
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Repeated 24-hour recalls versus dietary records for estimating nutrient intakes in a national food consumption survey

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Abstract

Background: The methodology used in the first Belgian food consumption survey followed to a large extent the instructions of the European Food Consumption (EFCOSUM) reports, where repeated 24-hour recalls (24HR) using EPIC-SOFT were recommended.
Objectives: To evaluate the relative validity of two non-consecutive 24HR using the European prospective investigation on nutrition and cancer-(SOFT) (EPIC-SOFT) by comparison with 5-day estimated dietary records (EDR). To assess misreporting in energy for both methods by comparing energy intake with energy expenditure from accelerometery in a subsample.
Design: A total of 175 subjects (aged 15 and over) were recruited to participate in the study. Repeated 24HR were performed with an interval of 2–8 weeks. After completion of the second interview, subjects were instructed to keep an EDR. Dietary intakes were adjusted for within-person variability to reflect usual intakes. A Student's t-test was calculated to assess differences between both methods. Spearman and Kappa correlation coefficients were used to investigate agreement.
Results: In total, 127 subjects completed the required repeated 24HR as well as the five record days. From 76 participants, accelerometer data were available. In both methods, about 35% of participants had ratios of Energy Intake/Total Energy Expenditure (EI/TEE) above or below 95% confidence intervals for EI/TEE, suggesting misreporting of energy. Significant differences between the two dietary intake methods were found for total energy, total fat, fatty acids, cholesterol, alcohol, vitamin C, thiamine, riboflavin and iron. In general, intakes from 24HR were higher compared to EDR. Correlation coefficients for all nutrients ranged from 0.16 for thiamine to 0.70 for water.
Conclusions: The results from this study show that in the context of nutritional surveillance, duplicate 24HR can be used to asses intakes of protein, carbohydrates, starch, sugar, water, potassium and calcium.

Keywords: *estimated dietary record*; *dietary assessment*; *accelerometry*; *relative validity*

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For the planning, implementation and evaluation of national food and health programmes, policy makers need information on dietary habits of the general population (1). National food consumption surveys are essential tools for obtaining this vital information as they provide food intake information at the individual level.

In Belgium, the first national food consumption survey was performed in 2004. The main objectives of the Belgian food consumption survey were to monitor the nutritional adequacy of food and nutrient consumption on one hand, and food safety-related aspects of food intake on the other hand. Information on food intake was collected using two non-consecutive 24h recalls (24HR)

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in combination with a self-administered food frequency questionnaire (2). This method was recommended by the European Food Consumption (EFCOSUM) project as best practice for Europe for estimating usual dietary intakes at the population level (3). To ensure standardisation, a computer-assisted 24HR method, the EPIC-SOFT program was used. This software program was originally developed for use in the European prospective investigation on nutrition and cancer (EPIC) study and has been validated in different European countries (4).

To date, a repeated 24HR has not been validated for use in national food consumption surveys among the Belgian population aged 15 years and over. Moreover, to our knowledge, no literature is available that explores the validity of two independent EPIC-SOFT 24HR compared to an estimated dietary record (EDR). Therefore, the objective of the present study was to investigate the relative validity of the repeated 24HR, using EPIC-SOFT, to assess nutrient intakes, against a 7-day EDR. In addition, energy intake estimation of both methods was externally validated using accelerometry.

Methods

Study design

Using a cross-sectional design, recorded food intake was compared with recalled food intake. Two computer-assisted 24HR interviews were performed in the participant's home with a 2–8 week interval. In the planning of the interviews, an equal distribution of the different days of the week was considered. Both interviews were performed by dietitians trained to use EPIC-SOFT. Between the first and second interview, participants were asked to complete a general questionnaire comprising sociodemographic and anthropometric elements. After the second 24HR interview, participants were instructed on how to complete a pre-structured 7-day EDR. After the 7-day registration, the dietitians visited the participants once more to collect the records and check them for completeness and correctness. A subsample was provided with an accelerometer and instructed on how to wear it. This motion sensor was worn during the 7-day food intake recording. This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the regional Ethics Committee of Ghent University Hospital. Written informed consent was obtained from all subjects.

Participants

A different approach for recruiting participants was performed for adolescents, adults and elderly. In adolescents, a multi-stage sampling was performed. Firstly, five secondary schools providing both general education as vocational training were contacted in the region of Ghent. Four schools agreed to participate in the study. Subsequently, parent's permission was asked by written request. Because, selection of classes and communication with parents was performed by the school's administration, the number of invited participants is unknown. Adults invited for participation were acquaintances and family of students and researchers, elderly were recruited via social service centres. Elderly living in a residential care setting were excluded given the more limited freedom in food choices. Equality in gender was pursued at all time. A total of 233 adult men and women were invited accordingly. The subjects did not receive any incentive for their participation.

24h recall and EPIC-SOFT

During a 24HR, the participants need to report the types and quantities of all foods and beverages consumed during the preceding day. Preferably interviews are carried out by a trained dietitian. Due to within-subject variation, a single 24HR is not able to offer a critically valid estimate of one's usual dietary intake (3). Performing two non-consecutive 24HR allows for important correction for within-subject variability in nutrient intake (5–7). Because a 24HR is an open-ended interview, this type of data collection requires standardisation. EPIC-SOFT is a computerised 24HR program suitable for obtaining dietary information in national food consumption surveys (8). The 24HR interview performed with EPIC-SOFT is divided into four main steps: (1) general non-dietary information; (2) quick list (chronological list of consumed foods and recipes); (3) description and quantification of foods and recipes; and (4) quality controls at nutrient level. Entering foods in chronological order of consumption and the use of probing questions supports the respondent's memory (2). Quantification of foods was possible using weights or volumes, food photographs from the EPIC-SOFT picture book (9), household measures, standard units and standard portions from the Belgian household weights and measures manual (10). After data collection, all foods with their characteristics including a food code were exported from EPIC-SOFT for future linking.

Estimated dietary record

Structured open-ended diaries containing predefined food groups (including the option 'other food items') at six food occasions (breakfast, lunch, dinner and three snacks) were provided to all subjects. All participants were informed on how to complete the food record. The diary also contained a written example for future reference. During a 7-day period, all consumed foods and drinks had to be reported with notification of date and place of consumption, estimated consumed quantity expressed as a household measure, unit or weight, specification and if present a brand name. Separate forms were included to report on homemade recipes so name of dish, total quantities of all ingredients and fraction of dish consumed could be stated. Foods reported in the 5-day EDR were entered in the 'Diet Entry & Storage' program (BECEL) (11) using a standardised set of food codes and exported for further linking.

The number of days necessary to estimate true energy intake can be calculated as $n = [(1.96 \times CV_{wEI})/D_0]^2$ where D_0 is the specified % of the true mean and CV_{wEI} is the within-person coefficient of variation (12). Using this calculation, the number of days needed to estimate a person's energy intake to within 20% of his true mean, 95% of the time, would be 4.7 days (CV_{wEI} calculated from the 5-day EDR). Therefore, only participants who completed at least five days of the dietary record were included in the analysis and intakes were calculated from the first five consecutive days available.

Nutrients

Usual intakes of energy, water, 10 macronutrients (protein, fat, saturated fatty acids (SFA), mono-unsaturated fatty acids (MUFA), poly-unsaturated fatty acids (PUFA), carbohydrates, starch, simple sugars, fibres, alcohol) and seven micronutrients (cholesterol, thiamine, riboflavin, ascorbic acid, potassium, calcium, iron) were calculated. Therefore, food codes of the exported files from the 24HR and EDR were linked to food composition databases (FCDB). In total, five FCDB were used: (1) a Belgian database for regular foods (NUBEL) (13); (2) a specific database with only brand foods (www.internubel.be) (14); (3) a database from the Netherlands (NEVO) (15); (4) a UK database (McCance and Widdowson's) (16); and (5) a local FCDB (17). Selection of a FCDB for any given food was based on the best proximate in those food composition databases. However, priority was given to the Belgian FCDB, followed by the database from the Netherlands and the United Kingdom. Finally, for both methods, calculated nutrients of all foods were aggregated on a day level. For both methods (24HR and EDR), use of food supplements was not taken into account.

Accelerometry

It is well known that, regardless of the method, self-reported food intake underestimates true food and nutrient intake (18, 19). Data on a persons' daily energy expenditure can be used to detect both under-and over-reporting in conditions of energy balance because long-term energy expenditure should correspond to energy intake. Accelerometers are motion sensors which provide objective information on daily physical activity with minimal burden for participants. The motion sensors used in this study are piezo-electric uniaxial accelerometers (the Computer Science and Applications, Inc.; CSA, model 7164) which are able to distinguish between regular body movement and other sources of movement like external vibrations. Subjects were instructed on how to wear the device. Special attention was given to the positioning of the device above the right hip. Participants were instructed to remove the accelerometer for bathing, swimming activities, high contact sports and during sleeping. In addition, participants were requested to keep a diary for registration of duration and type of activity performed when the accelerometer was not worn. Accelerometers had to be worn for a minimum of 10 hours a day during at least four days. Data from participants not meeting these conditions were excluded from analysis.

The CSA data were downloaded from the device using the 'CSA, Inc. reader interface unit'. For adults, classification of 1-min epochs into the following three categories, resting/light, moderate and vigorous intensity categories was performed using cut-offs proposed by Swartz and colleagues (20). These cut-offs were chosen because both type of activity and age of participants resembled best our adult study sample. The categories of intensity of activity correspond to the ratios of work metabolic rate to resting metabolic rate (metabolic equivalents; METs) <3, 3–5.99 and ≥ 6, respectively. The specific count ranges used to classify activity as resting/light, moderate and vigorous intensity, respectively, were in adults and elderly as follows: 0–573, 574–4,944, $\geq$4,945 (20). In adolescents for every age-category (15, 16 and 17 years), the corresponding age specific counts per minute for 3, 6 and 9 METs were calculated using a derivative of the equation proposed by Freedson and colleagues (21). Counts per minute are given by the equation: $\text{counts}\cdot\text{min}^{-1} = (MET – 2.757 + 0.0895 \times A)/(0.0015 – 0.000038 \times A)$ with MET being the MET value for which the corresponding counts per minute need to be calculated and A the age of the respective age category expressed in years.

Activity levels expressed in METs were assigned to all activities reported in the activity log using the Compendium of Physical activities from Ainsworth (22). Then, data from CSA and activity log were summed in such a way that for every participant, total time (expressed per minute) spent at the four different physical activity levels (resting to vigorous) was obtained. Subsequently, total energy expenditure (TEE) per intensity category was calculated using the formula: TEE (kcal) = body weight (kg) $\times$ total minutes of activity (min.) $\times$ MET-value/60. Self-reported body weight was taken from the general questionnaire. Because activity levels only correspond to certain ranges of METs, a mean MET value was used as follows: inactivity, 1 METs; light activity: 2 METs; moderate activity: 4.5 METs and vigorous activity: 7.5 METs.

Underreporting

In weight stable conditions, participants' reported EI should accord to their TEE, thus the ratio of both measures should be equal to 1. Values above or below the 95% confidence limits of the ratio were taken to indicate over- or underreporting, respectively, using the equation from Black & Cole (23). The mean within-person coefficient of variation for daily energy intake (CV_{wEI}) was calculated from the EDR and the 24HR data and number of days (d) was set to 5 and 2 respectively. The within-person coefficient of variation for energy expenditure was taken from an analysis of studies with repeated doubly labelled water (DLW) measurements and set to 8.2% (24). The correlation (r) between EI and EE from accumulated individual DLW data was set at 0.425 (25).

Statistical analysis

Many factors contribute to the variance of food and nutrient intake data. However, from a statistical point of view, three main factors can be identified including between-subject variability, within-subject variability and measurement error (26). Correcting for within-subject variability gives a better estimate of the population distribution for usual intake, especially for episodically consumed foods and nutrients. To estimate usual nutrient intake distributions from short-term dietary intake assessments, C-side (Software for Intake Distribution Estimation) was used to remove within-subject variability and transform the data to an approximately normal distribution (5, 6, 27). During this procedure, dietary intake data was adjusted for day of week, age and gender. The differences between mean intakes of nutrients for both methods were assessed using Student's T-tests. For this, adjusted sample means and standard deviations were used. Agreement of both methods was evaluated using Spearman correlations on unadjusted data. Because the null hypothesis of the Spearman correlation assumes that the ranks of one variable do not co-vary with the ranks of the other variable, which seems unlikely because both methods measure the same variables, weighted Kappa correlations were also calculated. In addition, ratios of estimated nutrients from 24HR over EDR were reported. For all nutrients, Kappa correlations between both methods were compared by gender after Fisher r-to-Z transformation. Comparison of misreporting between genders was performed using the χ^2 test. All statistical tests were performed using SPSS for Windows release 18.0.0 (SPSS Inc., Chicago, IL, USA), two-tailed and $p < 0.05$ was considered as statistically significant.

Results

In total, 156 subjects agreed to participate in the study, representing a response rate of 55% in the adults and elderly. The response rate for the adolescents could not be calculated because cluster sampling was used and the total number of adolescents eligible for inclusion from all schools was not known. Almost all participants completed both 24HR ($n = 155$); however, only 100 (64%) were able to complete all 7 days of the food record. For the EDR, the first five consecutive days were used. This brings the final total to 127 (56% women). The subsample provided with accelerometers comprised 106 participants. Accelerometer data from 76 participants (50% women) were available for analysis.

Table 1 summarizes age and self-reported anthropometric measures of the participants. According to the three age categories, the number of subjects were 18 (14.2%), 51 (40.2%) and 58 (45.7%) for the adolescents, adults and elderly, respectively.

Total energy intake from foods assessed by both methods was compared to TTE calculated from accelerometer data. TEE and the ratio EI/TEE with the 95% CIs were calculated. For EDR and 24HR the mean within-person coefficient of variation for energy (CV_{wEI}) was 22.0and 21.6% respectively. The lower and upper ratio cut-offs for EDR and 24HR were 0.80 and 1.20; and 0.72 and 1.28, respectively. Fig. 1 summarises classification of participants as underreporter, acceptable reporter or overreporter clustered by method and gender. For both methods, approximately 65% of participants was classified as acceptable reporters. The remaining 35% was more or less distributed over the under- and overreporters categories. For energy intake assessed with the 24HR, the number of underreporters in men was significantly lower compared to women (χ^2 (2) = 6.361, $p < 0.042$). No significant difference was found in misreporting between both methods.

Table 1. Characteristics of the participants

	Total ($n = 127$)				Women ($n = 71$)				Men ($n = 56$)			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Age (years)	50.2	24.7	15.1	91.1	51.7	25.3	15.2	84.7	48.3	23.9	15.1	91.1
Weight (kg)	71.6	13.4	44.0	119.0	65.9	11.2	44.0	98.0	78.9	12.5	55.0	119.0
Height (cm)	170.4	9.1	152.0	190.0	165.3	6.5	152.0	182.0	176.9	7.7	160.0	190.0
BMI (kg/m^2)	21.0	3.6	13.3	33.1	19.9	3.3	13.3	30.1	22.4	3.4	16.0	33.1

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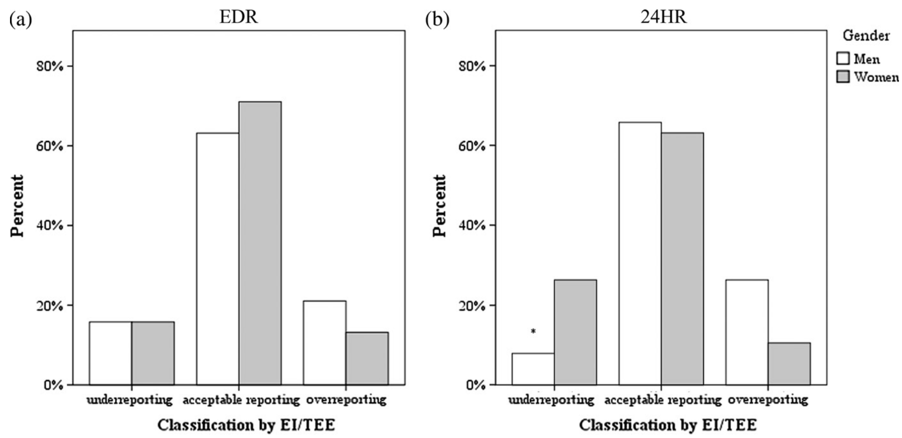

Fig. 1. Percentage of participants ($n=76$) classified as underreporter, acceptable reporter and overreporter by the ratio energy intake over total energy expenditure (EI/TEE) clustered by gender and method (estimated dietary record; EDR (a), 24-hour recall; 24HR (b). The lower and upper ratio cut-offs for EDR and 24HR are 0.80 and 1.20; and 0.72 and 1.28, respectively. *Number of underreporters in men was significantly lower compared to women ($\chi^2(2) = 6.361$, p = 0.042)).

Tables 2 and 3 show the usual mean daily macro- and micronutrient intakes assessed using both methods. Also ratios of 24HR/EDR, p-values for differences using t-tests and Spearman correlation coefficients are presented. Ratios vary over nutrients and gender; however, in general positive ratios were found indicating higher intake estimates in the 24HR compared to the EDR. Negative ratios were found for fibre in the total sample and both genders, for protein and potassium in women only, for simple sugars in men only and for water and riboflavin in the total sample and women only.

For the macronutrients, there is a significant difference between the two methods for fat, fatty acids, cholesterol and alcohol, for the micronutrients the difference was significant for vitamin C, thiamine, riboflavin and iron. The Spearman correlation coefficients range from 0.35 to 0.70 for macronutrients and from 0.16 to 0.56 for micronutrients.

Table 4 shows weighted Kappa correlations between both methods based on correct ranking of participants into tertiles. The strength of agreement, as proposed by Altman (28), was moderate for carbohydrates and water (0.42 and 0.54, respectively), to fair for protein, fat and alcohol (0.29, 0.36 and 0.31, respectively). For micronutrients, a moderate agreement was found for iron (0.43). Agreement for thiamine and calcium was found to be poor (0.10 and 0.17, respectively). Kappa correlations were significantly higher in men compared to women for total energy, MUFA, carbohydrates, simple sugars and alcohol.

Discussion

The objective of this study was to compare nutrient intakes collected by two non-consecutive 24HR using EPIC-SOFT against a 5-day EDR to assess its relative validity for use in Belgian food consumption surveys.

Main results and comparison with the literature

Only 100 participants completed all 7 days of the estimated dietary record. Decreasing the number of days from seven to five increased the number of available records to 127. The authors decided to use the first five consecutive days from the EDR in the analysis. Total energy intake from all 7 days was compared, and although the median from day 7 was the lowest, no significant differences between days were found (unpublished observations).

Looking at the estimates of nutrient intakes obtained by both methods, some differences can be found. In general, there is a tendency of higher estimates by the 24HR compared to the EDR. Positive 24HR/EDR ratios were also found in other studies comparing 24HR and EDR (29, 30). Other studies found negative ratios which were attributed to the omission of foods and errors in portion size estimations related to recalled intake (31).

Strengths and limitations of the study

The EDR was chosen as a relative reference method because of its acceptable level of accuracy when validated for assessing dietary intake compared to other methods (32). Moreover, the measurement errors of the EDR and the 24HR are independent, because unlike the 24HR method, the EDR does not depend on memory and involves immediate estimation of portion size. However, like any dietary assessment method, the EDR is subject to some degree of misreporting. The degree of under- and/or overreporting in this study was assessed in a sub-sample ($n=76$) by comparison of energy intake in both methods against TEE calculated from accelerometer data. The type of accelerometer (CSA) used in this study has repeatedly been tested (21, 33, 34) and has shown to correlate significantly with doubly labelled water-derived energy expenditure estimations (35, 36). Nevertheless, not

Table 2. Mean usual intakes, *p*-values for t-tests, ratios and Spearman correlations of macronutrients by both methods. All data are adjusted for day of week and age (in years). Figures representing total sample are additionally adjusted for gender

	EDR						24HR						p[a]			Ratio 24HR/EDR			r[b]		
	All (*n* = 127)		Women (*n* = 71)		Men (*n* = 56)		All (*n* = 127)		Women (*n* = 71)		Men (*n* = 56)										
Macronutrient	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	All	♀	♂	All	♀	♂	All	♀	♂
Energy (MJ/d)	8.1	1.5	6.9	1.1	9.7	1.9	9.0	2.1	7.8	1.8	10.7	2.1	<0.01	<0.01	0.01	1.12	1.12	1.11	0.56**	0.28*	0.63**
Energy including alcohol (MJ/d)	8.4	1.5	7.0	1.1	10.3	2.0	9.4	2.2	7.9	1.8	11.5	2.5	<0.01	<0.01	0.01	1.12	1.12	1.12	0.59**	0.29*	0.63**
Protein (g/d)	76.0	12.0	66.9	9.6	87.3	14.1	78.7	15.6	66.0	11.8	96.5	18.3	0.12	0.61	<0.01	1.04	0.99	1.10	0.47**	0.26**	0.41**
Fat (g/d)	76.7	17.4	64.0	13.9	94.2	21.8	96.6	28.4	84.4	24.3	113.0	29.9	<0.01	<0.01	<0.01	1.26	1.32	1.20	0.50**	0.33**	0.58**
SFA (g/d)	31.0	7.8	27.2	6.2	35.9	9.7	38.6	13.1	33.4	10.1	45.5	16.2	<0.01	<0.01	<0.01	1.24	1.23	1.27	0.45**	0.28**	0.52**
MUFA (g/d)	29.5	6.8	23.9	5.3	37.7	8.4	34.7	9.9	30.1	7.7	40.9	10.8	<0.01	<0.01	0.08	1.18	1.26	1.09	0.50**	0.34**	0.57**
PUFA (g/d)	12.9	3.5	10.4	3.1	16.7	3.9	19.1	6.2	17.5	5.6	21.1	5.9	<0.01	<0.01	<0.01	1.48	1.68	1.26	0.46**	0.37**	0.46**
LA (g/d)	10.1	3.3	8.0	2.9	13.5	3.8	11.4	3.6	9.7	2.9	13.7	4.0	<0.01	<0.01	0.73	1.12	1.22	1.02	0.35**	0.30**	0.27*
Cholesterol (mg/d)	275.7	54.1	244.1	43.8	316.5	67.9	296.5	87.1	256.6	96.7	350.7	54.9	0.02	0.32	<0.01	1.08	1.05	1.11	0.39**	0.17**	0.50**
Carbohydrates (g/d)	233.4	56.0	202.6	42.9	277.1	73.7	239.5	57.9	206.5	46.3	287.3	74.4	0.39	0.60	0.47	1.03	1.02	1.04	0.62**	0.49**	0.68**
Starch (g/d)	126.3	28.0	113.1	25.8	145.2	31.6	131.0	39.3	112.6	37.5	157.1	41.7	0.27	0.93	0.09	1.04	1.00	1.08	0.61**	0.57**	0.55**
Simple sugars (g/d)	104.1	38.8	85.8	27.6	130.0	51.9	107.1	35.8	91.6	19.9	126.5	49.4	0.52	0.15	0.71	1.03	1.07	0.97	0.58**	0.38**	0.72**
Fibre (g/d)	22.5	5.6	21.5	5.5	23.9	5.9	21.3	4.9	19.8	4.1	23.2	6.0	0.06	0.05	0.56	0.95	0.92	0.97	0.47**	0.50**	0.39**
Alcohol (g/d)	12.6	13.1	5.0	6.3	22.1	17.5	15.1	15.3	5.9	6.6	26.9	25.4	0.17	0.44	0.25	1.20	1.17	1.22	0.60**	0.45**	0.67**
Alcohol (g/d)[c]	34.1	16.1	19.1	11.5	44.2	16.3	38.7	17.1	19.8	8.1	53.1	29.8	0.03	0.68	0.05	1.13	1.04	1.20	0.55**	0.14	0.61**
Water (ml/d)	2235.1	583.8	2128.2	583.7	2359.8	576.4	2180.2	501.4	2005.5	436.5	2408.3	562.7	0.42	0.16	0.65	0.98	0.94	1.02	0.70**	0.66**	0.73**
	Nob = 236/ Nind = 90[c]		Nob = 95/ Nind = 44[c]		Nob = 141/ Nind = 46[c]		Nob = 99/ Nind = 66[c]		Nob = 42/ Nind = 30[c]		Nob = 57/ Nind = 33[c]								Nind = 56[d]	Nind = 23[d]	Nind = 33[d]

Note: EDR, 5-day estimated dietary record; 24HR, 2-day 24-hour recall.
[a]Student's *T*-test.
[b]Spearman correlation coefficient.
[c]On consumption days only (Nob, number of observations, Nind, number of individuals).
[d]Positive alcohol consumption in both methods only.
*Significant at the 0.05 level (2-sided).
**Significant at the 0.001 level (2-sided).

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Table 3. Mean usual intakes, *p*-values for t-tests, ratios and Spearman correlations of micronutrients by both methods. All data are adjusted for day of week and age (in years). Figures representing total sample are additionally adjusted for gender

	EDR						24HR														
	All (*n* = 127)		Women (*n* = 71)		Men (*n* = 56)		All (*n* = 127)		Women (*n* = 71)		Men (*n* = 56)		p[a]			ratio 24HR/EDR			r[b]		
Micronutrient	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	All	♀	♂	All	♀	♂	All	♀	♂
Vitamin C (mg/d)	79.4	32.0	92.9	41.0	63.2	23.4	98.8	34.8	90.3	31.5	110.7	39.6	<0.01	0.67	<0.01	1.2	1.0	1.8	0.42**	0.38**	0.48**
Thiamin (mg/d)	1.4	0.4	1.3	0.3	1.5	0.3	4.0	2.1	3.9	2.2	4.1	1.7	<0.01	<0.01	<0.01	2.9	3.0	2.8	0.16	0.19	−0.03
Riboflavin (mg/d)	1.5	0.5	1.4	0.4	1.7	0.5	1.7	0.4	1.5	0.4	1.9	0.2	<0.01	0.12	<0.01	1.1	1.1	1.1	0.43**	0.35**	0.41**
Potassium (mg/d)	3,252.8	569.3	2,959.9	495.7	3,628.5	640.5	3,130.0	681.1	2,683.5	597.2	3,755.7	718.8	0.12	<0.01	0.32	1.0	0.9	1.0	0.47**	0.32**	0.48**
Calcium (mg/d)	807.7	217.8	746.1	179.4	871.7	251.1	814.5	250.3	755.6	231.7	891.8	268.9	0.82	0.79	0.68	1.0	1.0	1.0	0.26**	0.19	0.34**
Iron (mg/d)	10.9	2.5	9.4	2.3	13.0	2.6	11.8	2.2	10.1	1.9	14.0	2.1	<0.01	0.06	0.02	1.1	1.1	1.1	0.56**	0.44**	0.47**

EDR, 5-day estimated dietary record; 24HR, 2-day 24-hour recall.

[a]Student's *T*-test.

[b]Spearman correlation coefficient.

*Significant at the 0.05 level (2-sided).

**Significant at the 0.001 level (2-sided).

Table 4. Agreement between EDR and 24HR by ranking of participants in tertiles expressed as weighted Kappa coefficients with 95% confidence intervals

	Weighted Kappa (95% CI)		
Nutrient	All	♀	♂
Energy (MJ/d)	0.31 (0.19–0.43)	0.17 (0.01–0.34)	0.45 (0.26–0.63)[a]
Energy including alcohol (MJ/d)	0.40 (0.28–0.52)	0.24 (0.07–0.40)	0.39 (0.21–0.58)[a]
Protein (g/d)	0.29 (0.17–0.42)	0.14 (−0.02–0.31)	0.23 (0.05–0.42)
Fat (g/d)	0.36 (0.24–0.49)	0.30 (0.14–0.46)	0.35 (0.17–0.54)
SFA (g/d)	0.33 (0.21–0.45)	0.11 (−0.06–0.27)	0.27 (0.09–0.46)
MUFA (g/d)	0.33 (0.21–0.45)	0.24 (0.07–0.40)	0.48 (0.29–0.66)
PUFA (g/d)	0.31 (0.19–0.43)	0.33 (0.17–0.50)	0.31 (0.13–0.50)
LA (g/d)	0.20 (0.08–0.33)	0.17 (0.01–0.34)	0.11 (−0.07–0.30)
Cholesterol (mg/d)	0.27 (0.15–0.40)	0.14 (−0.02–031)	0.27 (0.09–0.46)
Carbohydrates (g/d)	0.42 (0.29–0.54)	0.30 (0.14–0.46)	0.56 (0.37–0.74)[a]
Starch (g/d)	0.43 (0.31–0.56)	0.36 (0.20–0.53)	0.35 (0.17–0.54)
Simple sugars (g/d)	0.42 (0.29–0.54)	0.24 (0.07–0.40)	0.52 (0.33–0.70)[a]
Fibre (g/d)	0.27 (0.15–0.40)	0.33 (0.17–0.50)	0.31 (0.13–0.50)
Alcohol (g/d)[b]	0.31 (0.13–0.50)	0.01 (−0.28–0.30)	0.37 (0.09–0.64)[a]
Water (ml/d)	0.54 (0.42–0.66)	0.52 (0.36–0.69)	0.60 (0.41–0.78)
Vitamin C (mg/d)	0.29 (0.17–0.42)	0.20 (0.04–0.37)	0.31 (0.13–0.50)
Thiamin (mg/d)	0.06 (−0.06–0.19)	0.11 (−0.06–0.27)	0.00 (−0.19–0.18)
Riboflavin (mg/d)	0.33 (0.21–0.45)	0.33 (0.17–0.50)	0.27 (0.09–0.46)
Potassium (mg/d)	0.33 (0.21–0.45)	0.20 (0.04–0.37)	0.31 (0.13–0.50)
Calcium (mg/d)	0.17 (0.05–0.29)	0.14 (−0.02–0.31)	0.19 (0.01–0.38)
Iron (mg/d)	0.43 (0.31–0.56)	0.24 (0.07–0.40)	0.35 (0.17–0.54)
	Nind = 56[b]	Nind = 23[b]	Nind = 33[b]

Note: EDR, 5-day estimated dietary record; 24HR, 2-day 24-hour recall.
[a]Kappa correlation coefficient significantly different from women (Fisher r-to-*Z* test, 1-sided).
[b]Positive alcohol consumption in both methods only (Nind: number of individuals).

all physical activity can be translated into acceleration or deceleration resulting in errors in predicted energy expenditure especially in high intensity activity (35). In addition, some literature suggests that CSA sensors are not sufficiently sensitive to quantify energy expenditure in free-living individuals (37).

Participating in a study with a large battery of methods tested is very demanding and needs motivation. Therefore, it is likely that characteristics of participants are different than those from non-participants. When comparing body mass index (BMI) of the participants in the present sample with the BMI of those recruited during the Belgian food consumption survey, a lower BMI is found in the present sample. Consequently, this observation may indicate that a sampling bias is present weakening the generalisability of the instrument's performance in a national nutrition survey context.

In spite of these limitations, prevalence of underreporting for both the 24HR and EDR has shown to be quite similar to those available in the literature (19). Also, the higher prevalence of underreporting in women versus men, found in other published studies was confirmed in this study (38–40). A possible explanation for the fact that in the 24HR, prevalence of underreporting in men was significantly lower than in women could be that an interviewer-guided recall in men provides more complete daily intakes than those based on self-reported food records. Underreporting and overreporting were both found in the two methods. Compared to DLW measurements, underestimation of TEE assessed using CSA devices has been found, even though rather small (25–368 kJ/day) (41). Consequently, if underestimation of TEE is the case, it also implies underestimation of underreporting and overestimation of overreporting of the dietary intake assessment instruments under study.

A major strength of this study is that nutrient intake data have been corrected for within-person day-to-day variability using a statistical model. Other studies have used the arithmetic mean of daily intakes to estimate a persons' usual intake; however, this approach is likely to be inaccurate because the presence of the day-to-day variability can greatly inflate the variance of the distribution of individual means (42). Correcting for within-person day-to-day variability using statistical models produces comparable means for nutrient intake compared to unadjusted data; however, the distributions of intakes show smaller standard deviations which in turn decrease the odds of finding a different mean intake between both methods by chance alone.

With respect to the positive recall/record ratio of total fat (1.26) and, by extension, fatty acids and energy, it should be mentioned that during the EPIC-SOFT-guided 24HR, participants are frequently prompted for missing ingredients such as fats or sauces. Also, because of the presence of facets and descriptors in the EPIC-SOFT program (43), for instance related to facets such as 'cooking method', 'fat content' and 'type of fat used', the 24HR are more likely to yield higher intakes of fat compared to EDRs where this information could be omitted by the participant. On the other hand, using standard factors for fat added during cooking could, in some participants, also result in an overestimation of fat consumption.

Another factor which could explain the differences in mean usual intake between the two methods is related to portion size estimation. During the 24HR interview, food photographs were used in addition to other quantification methods. Using two-dimensional models for portion size estimation can result in errors due to poor conceptualisation and perception. In a recent study, participants' capability in estimating portion sizes of fat on bread using the EPIC-SOFT picture book was evaluated and showed high overestimation of portion sizes by both genders during perception testing (prevalence of overestimation was 90%) (44).

Conclusions

The present study shows a similar degree of energy misreporting in 2-day 24HR and 5-day EDRs. For national consumption surveys among the Belgian population, group-level intakes of protein, carbohydrates, starch, sugar, water, potassium and calcium from duplicate 24HR do not differ from those obtained by 5-day EDRs.

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