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Comparison of two dietary assessment methods by food consumption: results of the German National Nutrition Survey II

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Abstract

Purpose To further characterise the performance of the diet history method and the 24-h recalls method, both in an updated version, a comparison was conducted.

Methods The National Nutrition Survey II, representative for Germany, assessed food consumption with both methods. The comparison was conducted in a sample of 9,968 participants aged 14–80. Besides calculating mean differences, statistical agreement measurements encompass Spearman and intraclass correlation coefficients, ranking participants in quartiles and the Bland–Altman method.

Results Mean consumption of 12 out of 18 food groups was higher assessed with the diet history method. Three of these 12 food groups had a medium to large effect size (e.g. raw vegetables) and seven showed at least a small strength while there was basically no difference for coffee/tea or ice cream. Intraclass correlations were strong only for beverages ([0.50) and revealed the least correlation for vegetables (\0.20). Quartile classification of participants exhibited more than two-thirds being ranked in the same or adjacent quartile assessed by both methods. For every food group, Bland–Altman plots showed that the agreement of both methods weakened with increasing consumption.

Conclusions The cognitive effort essential for the diet history method to remember consumption of the past 4 weeks may be a source of inaccurateness, especially for inhomogeneous food groups. Additionally, social desirability gains significance. There is no assessment method without errors and attention to specific food groups is a critical issue with every method. Altogether, the 24-h recalls method applied in the presented study, offers advantages approximating food consumption as compared to the diet history method.

Keywords Diet history method · 24-h recalls · Food consumption · German National Nutrition Survey

Introduction

Accurately reported usual food consumption and nutrient intake are crucial to either investigate the nutritional status of the general population or estimate the association between diet and a particular disease. Despite this essential function, dietary assessment methods appear rather simple against the background of complex human behaviour [38, 48]. With every assessment method, perception of the individual diet and nutrition in general affects the way participants report their food consumption. Food consumption is a challenging variable undergoing enormous changes throughout an individual's lifetime [4, 40, 53]. For many reasons, real consumption will never be known. The goal behind every dietary assessment remains the best possible approximation. The fact that every dietary assessment method has certain strengths and limitations is accompanied by the established advice to carefully choose the appropriate method regarding the specific demand for the respective research focus [38, 40, 51, 53, 55].

A suitable method for assessing usual food consumption either for population studies or target groups of special interest is the diet history method. This method requests the long-term averages of frequency and amount of food consumption. For participants, the estimation of food

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consumption for the considered period of time can be difficult to remember in detail and poses a complex cognitive task [4, 40, 42, 55]. In contrast, 24-h recalls minimise these sources of error by relying on short-term memory delivering detailed information on food consumption of the past day but thereby missing seldom eaten foods and habitual consumption of an individual [3, 40, 55]. The diet history method has been altered considerably since the first proposal in the 1940s and is regarded to provide an estimate of usual food consumption for individuals [51, 55]. The short-term measurement of a 24-h recalls is sufficient in determining mean consumption of groups, while two or more 24-h recalls are recommended to be statistically modelled for estimating usual dietary consumption of individuals [11, 13, 21]. Thereby, the application of the 24-h recalls method for different epidemiological settings improves.

For the German National Nutrition Survey II (NVS II), computer-assisted versions of both methods were used under similar conditions followed by considerable standardisation procedures. There are several statistical analysis methods to apply and interpret the comparison of dietary assessment methods. They offer diverse perspectives and interpretations thereby leading to a differentiated judgement.

The results of the presented comparison should add to the characterisation of strengths and limitations of both methods and support the appropriate use of both dietary assessment methods. In this regard, the study differs from usual validation studies where the comparison with an established method aims at clarifying the quality of an altered method. Thus, the objective of the present study is to compare a diet history method with two 24-h recalls, both in a computer-assisted version, which to our knowledge has not yet been published. Moreover, data of the NVS II of 19,329 participants, representative of the German-speaking population, allowed a sample of 9,968 participants for the analysis of this comparison. The following questions are approached: what are the main differences and the extent of agreement between the applied dietary assessment methods? What are possible underlying reasons for these results? Is it possible to deduce in which instance both methods can be applied interchangeably or when one method should be preferred?

Materials and methods

Study design

The NVS II is a nationwide representative food consumption survey with almost 20,000 participants which took place from November 2005 to January 2007. German-speaking residents aged 14–80 years were selected by local register offices in about 500 randomly chosen municipalities across Germany. At on-site study centres well-trained interviewers (mostly dieticians) conducted computer-assisted diet history interviews to assess usual food consumption of the previous 4 weeks. Additionally, personal interviews for basic socio-demographic information as well as anthropometric measurements were conducted at the study centres [32]. Several times during the survey, quality assurance checks were made by internal and external supervisors. On average, 20 days after the diet history interview participants received an agreed but unannounced telephone call for the first 24-h recalls interview. These interviewers were also trained and controlled for quality assurance. The second 24-h recalls interview was accomplished within a mean of 15 days after the first recall. In total, 9,968 participants completed the diet history interviews and two 24-h recalls.

Diet history

For the diet history interviews, Diet Interview Software for Health Examination Studies (DISHES) was used as software, a programme developed by the Robert Koch-Institute, Berlin [33, 34]. The programme was slightly modified for the requirements of the NVS II [27]. The face-to-face interview covered food consumption of the past 4 weeks and was open-ended. Portion sizes were quantified by models of tableware (cups, glasses, spoons, plates and bowls) and by a 30 page photo book of different portions of food items (an excerpt of the original EPIC-Soft picture book modified for the NVS II). To increase data quality, high attention was paid to assurance procedures. Amongst others, data controls for plausibility (e.g. for quantities) to identify and correct for input errors were inserted. Also, about 3,400 individual comments made by the interviewers and directly related to single interviews were utilised.

24-h recalls

For the 24-h recalls, the software EPIC-Soft was used. Originally, the programme was developed for the European Prospective Investigation into Cancer and Nutrition by the International Agency for Research on Cancer [43] and adopted to German dietary habits [27]. During the telephone interviews, participants were asked in multiple steps what they had drunk and eaten the previous day. After the initial 'quick list' of all foods and beverages recalled, EPIC-Soft requires further specification of the consumed food regarding level of processing or brand names via so-called facets and a variety of 'descriptors' characterising the description of food in great detail [43, 44]. Besides household measures and standard units, the same picture book as for the diet history interview was applied. The 24-h recalls interviews were open-ended and included probing questions and integrated quality checks. The two 24-h recalls interviews were randomly sampled and about equally distributed over weekdays and weekends with 75 and 25 %, respectively.

Standardisation procedures

Both dietary assessment methods execute the disaggregation of recipes differently, so the level of detail had to be adjusted. Originally, complete recipes in DISHES, for example ‘noodle gratin’, were chosen directly from the integrated German nutrient database (BLS) but the ingredients were not changeable. In contrast, the software EPIC-Soft also includes standard recipes but alterations are possible. DISHES was adapted to this level of detail, which in total required a subsequent disaggregation of about 1,300 recipes into main food components. This way differences resulting from unequal food grouping were eliminated and comparability of both assessment methods was improved essentially. Concurrence of estimation of serving sizes was supported by applying the identical picture book to both methods. The period of time from the diet history interview up to the second 24-h recalls was 5 weeks on average. This time span is regarded as having no seasonal influence on the individual recording. At the group level, influences of seasonality are balanced with the mean of the total 12 months of dietary assessment.

Data processing

While the diet history method individually assesses usual food consumption over the last 4 weeks, the 24-h recalls method, as a short-term method, allows insights into mean and distribution of consumed food groups on the population level. Estimation of the usual intake distribution of individuals or of infrequently eaten food items remains critical [55]. The estimation of the usual food consumption distribution of individuals requires two or more interviews and a statistical modelling [11, 13, 21, 50]. This was realised by applying the MSM method [18, 19, 47].

Statistical analysis

Consumption of food groups is presented as means and standard error as well as the absolute (24-h recalls—diet history) and the relative difference ((24-h recalls—diet history)/(diet history)) between the mean of individual consumption of the two dietary assessment methods. The presentation of the means instead of medians was chosen because, especially for the two assessment days of the 24-h recalls, seldom eaten food groups, like fish or nuts/seeds, were consumed by less than 50 % of the participants, leading to medians with the value ‘0’. This is of restricted use when comparing food consumption. Consumption data showed no normal distribution and could not be normalised by log-transformation, thus nonparametric tests were carried out. Wilcoxon signed-rank test was applied to test for statistically significant differences in food consumption while Cohen’s *d* was added for the estimation of the strength of the obtained differences. Three levels of effect size were taken as a basis to judge the outcome: 0.2 small, 0.5 medium and 0.8 large [15]. Chi-square tests were made to clarify differences between study subjects.

To test the agreement between different methods, two correlation coefficients were calculated. Since Spearman rank order correlation coefficient covers the association, the intraclass correlation coefficient (ICC, two-way mixed) was generated to provide the degree of agreement between the individual food consumption measured by both methods [5].

The agreement of both methods was further tested by classifying participants according to their consumption into quartiles for every food group and for each method. The agreement of that classification was compared, and the quality was determined by the calculation of the weighted kappa coefficient. The quartile cut points were calculated on the basis of the study population distribution for each method. For single gender difference, the calculations were based on gender-specific percentile cut points.

In order to interpret the results, the strengths of agreements were defined as follows: B0.20 weak, 0.21–0.40 fair, 0.41–0.60 moderate, 0.61–0.80 strong and 0.81–1.00 almost perfect [1].

The individual results were also plotted for each food group using the Bland–Altman method, which proves the agreement of two methods according to the whole range of consumption and generally shows if one method implies a systematic bias compared to a reference method. Bland–Altman plots display the difference between the two methods (24-h recalls—diet history) against the average consumption assessed by the two methods ((24-h recalls ? diet history)/2) [7]. Because consumption data are highly skewed, the decision was made to choose a method that is capable of handling those kinds of data and does not rely on the assumption of normally distributed values. As a consequence 2.5- and 97.5-percentiles were calculated by means of quantile regression [6]. These limits of agreement take into account that the differences in agreement are increased for higher mean consumption, therefore resulting in spreading lines instead of the common parallel lines. Additionally, the median line was integrated to better judge for systematic disagreement. A median line with a slope of zero through the origin would signify a balanced outcome.

All statistical analyses were performed using the Statistical Analysis Systems statistical software package version 9.2 (SAS Institute, Cary, NC, USA) except for ICC, which was calculated with PASW Statistics Version 17.0 (SPSS Inc., Chicago, Illinois, USA).

Results

Sample characteristics

The study includes 9,968 participants, 56 % were women (Table 1). The age range was 14–80 years and reached a mean of 46 years for women and 45 years for men ($p = 0.98$). Also, mean body mass index, marital status, years of education or smoking did not significantly differ between women and men.

Comparison of mean consumption

For the total group, the diet history method showed significantly higher consumption for twelve out of 18 food groups compared to the 24-h recalls in absolute differences, while five food groups were estimated with a higher consumption by the 24-h recalls method (Table 2). All absolute differences reached statistical significance except for the consumption of ice cream in the total group and for (sparkling) wine consumption in men. The highest absolute difference was found for water, followed by fresh fruit and raw vegetables. Low absolute differences were found for the consumption of nuts/seeds and eggs, for sausage/meat products and for coffee/tea. While nuts/seeds and eggs were consumed in small quantities, the food groups sausage/meat products and coffee/tea reached high consumption quantities and correspondingly proved the smallest relative differences. Eleven out of 18 food groups exceeded a level of 20 % differences but as Cohen's *d* indicate, only four food groups reached a medium to large effect size: pastries, raw and cooked vegetables and fruit. A small effect size was found for the differences between further eight food groups. Standard errors from consumption data of the diet history method were higher compared to the ones attained by the 24-h recalls, indicating a higher variability for the results of diet history method (Table 2).

For women, two additional food groups with a higher consumption were found by the 24-h recalls method, ice cream and coffee/tea. These differences disagreed contrariwise between men and women so that for the total group the values were balanced (Table 2).

Table 1 Characteristics of study subjects

		Total ($n = 9{,}968$)	Men ($n = 4{,}427$)	Women ($n = 5{,}541$)
Age (years)	Mean (SE)	46.6 (0.17)	45.4 (0.26)	45.8 (0.23)
Body mass index (kg/m^2)	Mean (SE)	26.1 (0.06)	26.1 (0.09)	26.1 (0.08)
Marital status	% married	59.5	59.1	59.9
Education	% C10 years	59.7	58.9	60.3
Smoking	% smokers	25.9	26.3	25.6

SE standard error

Correlations

Spearman rank order correlation coefficients ranged from 0.19 (weak association) for cooked vegetables to 0.84 (almost perfect association) for beer (Table 3). Intraclass correlation coefficients comprised a range from 0.11 (weak) for cooked vegetables to 0.67 (strong agreement) for coffee/tea (Table 3). For seldom and/or seasonally eaten food groups, like nuts/seeds and ice cream, the high values of the Spearman rank order correlation coefficient (0.78 resp. 0.75) were not confirmed by the intraclass correlation coefficient (0.26 resp. 0.23).

Substantial discrepancies between men and women were only seen for milk/dairy products (Spearman), ice cream (intraclass) and beer (Spearman and intraclass).

Ranking classification

Classification of participants into quartiles of food consumption was compared between both methods to further verify agreement (Table 4). Analysis of quartiles was not performed for food groups for which more than 25 % of participants reported no consumption, which applied to nuts/seeds, ice cream, beer and (sparkling) wine. The agreement (same quartile plus adjacent quartile) between both assessment methods for the total group and also separated by sex was found between 69 and 90 %. The best agreement was reached by coffee/tea (90 %) for the total group and also for women and men. Misclassification in opposite quartiles was highest for cooked vegetables and least for coffee/tea; this finding applied to the total group and also differentiated by sex.

Bland–Altman plots

The Bland–Altman plots showed that the agreement between the two methods depends on the overall consumption insofar as the agreement between data from the diet history and the 24-h recalls diminishes with increasing consumption. This applied to every food group (data not presented). With rising mean consumption, negative differences increased in most

Table 2 Food consumption (g/d) assessed by diet history method and two 24-h recalls, absolute and relative differences between both methods for the total group and differentiated for men and women

g/d	Total ($n = 9{,}968$)							Men ($n = 4{,}427$)							Women ($n = 5{,}541$)						
	DH		24HR		Diff.	*d*	Diff. %	DH		24HR		Diff.	*d*	Diff. %	DH		24HR		Diff.	*d*	Diff. %
	Mean	SE	Mean	SE				Mean	SE	Mean	SE				Mean	SE	Mean	SE			
Bread	160	0.90	135	0.59	-25*	0.3	-16	187	1.53	160	0.98	-27*	0.3	-14	138	0.98	114	0.60	-24*	0.4	-17
Pastries	38	0.40	60	0.40	22*	0.5	58	44	0.69	64	0.67	20*	0.4	47	33	0.46	56	0.47	23*	0.6	68
Vegetables, raw	136	1.18	61	0.43	-75*	0.7	-55	128	1.70	57	0.66	-71*	0.7	-56	143	1.63	64	0.56	-79*	0.7	-55
Vegetables, cooked	107	0.71	67	0.29	-39*	0.6	-37	108	1.05	71	0.49	-37*	0.5	-34	105	0.96	64	0.35	-41*	0.6	-39
Potatoes	81	0.50	65	0.33	-17*	0.3	-21	92	0.83	73	0.57	-20*	0.3	-21	72	0.58	58	0.38	-14*	0.3	-20
Fruits, fresh	261	2.28	158	1.25	-103*	0.5	-39	236	3.27	137	1.80	-99*	0.5	-42	280	3.14	174	1.70	-106*	0.5	-38
Nuts/seeds	4	0.12	3	0.07	-1*	0.1	-27	5	0.19	3	0.13	-1*	0.1	-29	4	0.14	3	0.08	-1*	0.1	-27
Milk/dairy products	203	2.26	161	1.46	-42*	0.2	-21	211	3.81	161	2.42	-50*	0.2	-24	197	2.68	162	1.80	-35*	0.2	-18
Eggs	14	0.15	11	0.11	-3*	0.2	-19	16	0.26	12	0.19	-4*	0.2	-25	12	0.16	11	0.13	-1*	0.1	-12
Meat	44	0.38	56	0.29	12*	0.3	26	57	0.70	72	0.58	15*	0.3	26	34	0.35	43	0.26	9*	0.3	27
Sausage/meat products	58	0.50	59	0.37	1*	0.0	2	79	0.88	79	0.63	0*	0.0	0	41	0.46	43	0.35	2*	0.1	5
Fish/-products	24	0.25	18	0.18	-6*	0.2	-26	27	0.42	20	0.33	-7*	0.2	-27	22	0.29	16	0.20	-6*	0.2	-26
Sweets	21	0.31	12	0.16	-8*	0.3	-40	21	0.49	12	0.26	-9*	0.3	-42	20	0.40	12	0.19	-8*	0.3	-40
Ice cream	8	0.20	7	0.12	0[t]	0.0	-2	8	0.27	7	0.20	-1*	0.1	-16	7	0.28	8	0.15	1*	0.0	11
Water	1,158	8.42	921	6.50	-238*	0.3	-21	1,143	13.2	855	9.88	-287*	0.4	-25	1,170	10.90	970	8.47	-200*	0.3	-17
Coffee/tea (black/ green)	520	4.68	518	3.69	-2*	0.0	0	550	7.62	533	6.07	-17*	0.0	-3	496	5.78	506	4.54	11*	0.0	2
Beer	132	2.81	152	2.69	20*	0.1	15	246	5.62	287	5.32	41*	0.1	17	41	1.42	46	1.36	6*	0.1	14
(Sparkling) wine	46	0.96	51	0.82	5*	0.1	11	52	1.66	54	1.44	2[t]	0.0	3	41	1.10	48	0.94	8*	0.1	18

DH diet history, *24HR* 24-h recalls, *SE* standard error, *Diff.* absolute difference (24-h recalls minus diet history interviews), *d* Cohen's *d* (effect size), *Diff. %*, percentage difference (diet history interviews = 100 %)

* Wilcoxon signed rank test, *p* \ 0.001, [t] $p = 0.17$, [t] $p = 0.68$

Table 3 Spearman rank order correlation coefficients and intraclass correlation coefficients between diet history method and 24-h recalls for the total group and differentiated for men and women

	Total ($n = 9{,}968$)		Men ($n = 4{,}427$)		Women ($n = 5{,}541$)	
	Spearman	Intraclass	Spearman	Intraclass	Spearman	Intraclass
Bread	0.50	0.42	0.48	0.39	0.44	0.36
Pastries	0.34	0.27	0.35	0.29	0.34	0.26
Vegetables, raw	0.36	0.18	0.35	0.17	0.37	0.17
Vegetables, cooked	0.19	0.11	0.20	0.13	0.19	0.10
Potatoes	0.29	0.27	0.29	0.26	0.27	0.25
Fruit, fresh	0.53	0.37	0.55	0.39	0.50	0.34
Nuts/seeds	0.78	0.26	0.78	0.26	0.78	0.25
Milk/dairy products	0.52	0.46	0.56	0.49	0.48	0.43
Eggs	0.31	0.25	0.28	0.26	0.31	0.25
Meat	0.29	0.28	0.26	0.24	0.27	0.24
Sausage/meat products	0.47	0.42	0.41	0.37	0.40	0.33
Fish/-products	0.41	0.27	0.41	0.27	0.40	0.27
Sweets	0.52	0.28	0.55	0.31	0.50	0.25
Ice cream	0.75	0.23	0.78	0.30	0.74	0.19
Water	0.60	0.54	0.60	0.52	0.61	0.57
Coffee/tea (black/green)	0.74	0.67	0.76	0.68	0.72	0.66
Beer	0.84	0.65	0.73	0.61	0.86	0.49
(Sparkling) wine	0.74	0.54	0.75	0.55	0.73	0.53

food groups indicating that the diet history method compared to 24-h recalls results in higher consumption of these food groups. This was the case for raw vegetables, cooked vegetables, fruit, sweets, bread, potatoes, milk/dairy products, eggs, nuts/seeds, fish/-products and water (e.g. cooked vegetables; Fig. 1; other data not presented). Consequently, the corresponding lines of medians have a negative slope. For meat, sausage/meat products, ice cream, coffee/tea, beer and (sparkling) wine the median lines were almost horizontal, indicating no dependence on rising mean consumption for either method (e.g. coffee/tea; Fig. 2; other data not presented). This result corresponds to the outcome of the difference calculations insofar that the least (relative) differences of mean consumption between both methods were found for the same food groups (exception: meat). Pastries was the only food group, identified by the 24-h recalls method, to show a divergence towards a higher consumption with increasing mean consumption, illustrated by a rising slope (Fig. 3). The presented plots were chosen to picture the three different patterns.

The parallel lines originated from predominantly used portion sizes, e.g. ‘‘cup’’ for beverages (Fig. 2) and are also seen for nuts/seeds, eggs, fish, sweets, ice cream and all beverage groups (data not presented).

Discussion

The present study compares individual usual food consumption, assessed by diet history method and two 24-h recalls, statistically modelled by the Multiple Source Method (MSM) in the same study population of 9,968 participants of the NVS II. Consumption of the majority of food groups assessed by the diet history method is higher than that of the 24-h recalls, especially for vegetables and fruit. These food groups are also identifi in this study by the Bland–Altman method visualising the lines of medians with a negative slope and thus indicating the link between higher consumption assessed with the diet history method with rising mean consumption. For sausage/meat products, ice cream, coffee/tea, beer and (sparkling) wine the differences between the two methods are small as well as the discrepancies indicated by the Bland–Altman method. Correlation coeffi as further statistical methods to measure agreement between the two dietary assessment methods, comprise strong correlations only for beverages. The quartile classifi show satisfying results. So, for the beverages coffee/tea, beer and (sparkling) wine and additionally for the food group sausage/meat products, both dietary assessment methods can be used interchangeably either in population-based dietary surveys or in more specifi epidemiological studies on diet and diseases. For other food groups, special considerations will be discussed below.

The NVS II offers favourable conditions for an equalised comparison, e. g the same study population of almost 10.1 participants. Also the assessment technique of an interview in both dietary assessment methods contributes to a basic accordance. A further strength of the study lies in the consistent time frame. All interviews were accomplished

Table 4 Agreement of quartiles for food consumption (*) assessed by diet history method and 24-h recalls for the total group and differentiated for men and women

	Total (n = 9,968)					Men (n = 4,427)					Women (n = 5,541)				
	Same quartile %	Adjacent quartile %	Opposite quartile %	*K*	95 % CI	Same quartile %	Adjacent quartile %	Opposite quartile %	*K*	95 % CI	Same quartile %	Adjacent quartile %	Opposite quartile %	*K*	95 % CI
Bread	40.6	40.3	3.8	0.34	0.33–0.36	40.4	39.8	4.0	0.33	0.31–0.35	37.9	40.6	4.7	0.29	0.27–0.31
Pastries	34.9	39.1	6.6	0.22	0.20–0.23	36.1	38.1	6.7	0.23	0.21–0.25	34.5	38.9	6.2	0.21	0.19–0.23
Vegetables, raw	34.7	40.7	5.7	0.23	0.22–0.25	35.0	39.4	5.8	0.23	0.21–0.25	35.7	39.9	5.8	0.24	0.22–0.26
Vegetables, cooked	30.1	38.8	8.9	0.12	0.11–0.13	30.8	38.6	9.1	0.13	0.11–0.15	29.9	38.9	8.6	0.12	0.10–0.14
Potatoes	33.6	39.1	7.3	0.19	0.18–0.21	32.3	40.8	6.5	0.18	0.16–0.21	32.2	39.4	7.5	0.17	0.15–0.19
Fruit, fresh	41.9	40.4	3.4	0.37	0.35–0.38	42.7	40.3	3.3	0.38	0.36–0.40	40.6	40.4	4.0	0.34	0.33–0.36
Milk/dairy products	42.4	40.2	4.0	0.37	0.35–0.38	44.3	39.9	3.1	0.40	0.38–0.42	40.9	40.2	4.6	0.34	0.32–0.36
Eggs	34.4	36.9	7.4	0.19	0.17–0.20	33.3	36.1	7.8	0.16	0.14–0.18	33.8	38.1	7.2	0.18	0.16–0.20
Meat	32.5	39.6	7.2	0.18	0.16–0.19	31.8	38.5	7.9	0.15	0.13–0.18	32.2	39.1	7.4	0.16	0.15–0.18
Sausage/meat products	38.6	40.3	4.3	0.31	0.29–0.32	35.7	41.2	5.5	0.26	0.23–0.28	37.8	39.1	5.2	0.28	0.26–0.30
Fish	39.2	35.9	6.1	0.27	0.25–0.28	39.2	35.6	5.7	0.27	0.24–0.29	40.6	34.5	6.3	0.28	0.26–0.30
Sweets	46.4	34.8	4.2	0.39	0.37–0.40	49.7	32.9	3.6	0.43	0.41–0.45	44.3	35.1	4.8	0.35	0.33–0.37
Water	45.5	39.6	2.4	0.42	0.41–0.44	44.7	40.1	2.5	0.41	0.40–0.43	45.3	40.1	2.3	0.43	0.41–0.44
Coffee/tea (black/green)	55.4	34.9	1.4	0.55	0.54–0.57	55.7	35.8	1.2	0.57	0.55–0.59	54.3	35.7	1.6	0.54	0.53–0.56

K weighted j, *CI* confidence interval

* Analysis only performed when more than 25 % of participants consumed the food group

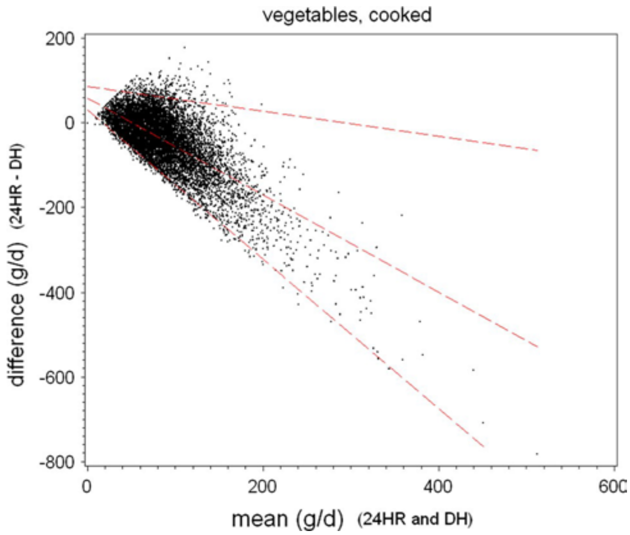

Fig. 1 Bland–Altman plots of mean cooked vegetable consumption from 24HR and DH against the difference in cooked vegetable consumption (24HR–DH) (n = 9,968)

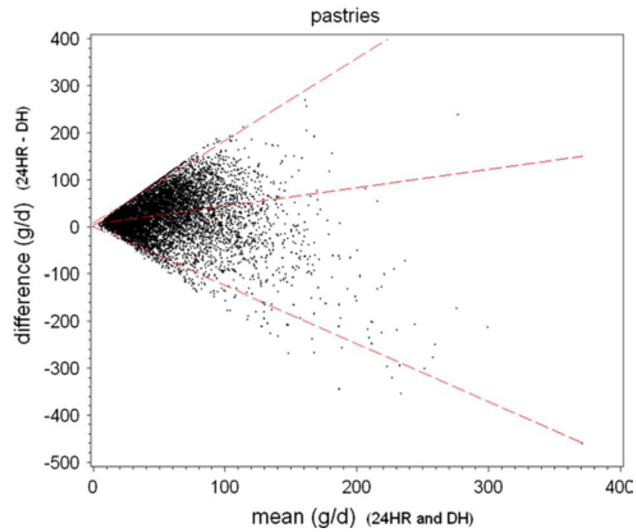

Fig. 3 Bland–Altman plots of mean pastry consumption from 24HR and DH against the difference in pastry consumption (24HR–DH) (n = 9,968)

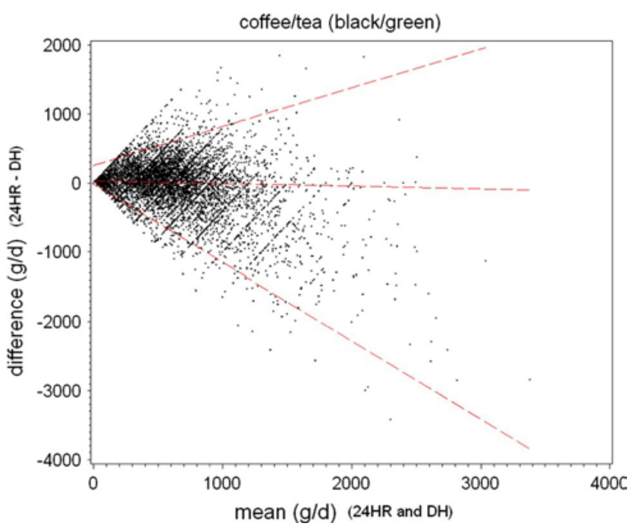

Fig. 2 Bland–Altman plots of mean coffee/tea (*black/green*) consumption from 24HR and DH against the difference in coffee/tea (*black/green*) consumption (24HR–DH) (n = 9,968)

within 35 days for each participant. This fact is regarded as not having a seasonal influence on the individual reporting. As the study encompasses an entire year, the impact of seasonal consumption on the group level is balanced. Both dietary assessment methods used the same picture book for portion sizes.

For further standardisation, some additional basic conditions were equalised. Classification and coding of mixed dishes in food groups was challenging, because originally, the two methods differed in procedures to capture recipes. About 1,300 recipes were disaggregated in the diet history method, resulting in a higher accordance of food group categorisation for both methods, so that comparability of the two assessment methods was further optimised [14, 56]. The statistical modelling with the MSM method is also seen under a standardisation aspect for the estimation of individual usual consumption through the two 24-h recalls. On the whole, several steps to align basic conditions were taken to minimise the influence of methodological framework aspects. Consequently, the results of the comparison may be tracked on the methods itself instead on external factors.

These standardisation efforts are regarded as an actual strength of the study, but in fact, they also create a limitation. Both methods share methodological errors. This includes for example difficulties in portion size estimation and/or social desirability. The effort to standardise conditions and methods for comparison may strengthen those errors resulting in an apparent agreement between both assessment methods, which may be greater than is actually the case. Nevertheless, in this situation, it was decided to avoid obvious errors in framework conditions. This decision was judged to be a greater advantage for the comparison of the two assessment methods.

Higher food consumption measured with a diet history method is found in the present study and was also the result in a validation study by van Liere et al. [54]. A self-administered diet history questionnaire more often (11 out of 18 food groups) led to higher food consumption compared to the average of 9–12 monthly 24-h recalls carried out over 1 year with 115 adult women. Results from a comparison between a diet history questionnaire, followed by a clarifying personal interview and an estimated 7-day record of a total of 51 girls aged 15–16 years reveal that for most food groups (14 out of 20) consumption assessed by the diet history method resulted in higher values [42]. While earlier studies more often reported higher intakes (foods and nutrients) assessed by diet history in comparison to food records and FFQ [17, 24, 37, 39], more recent studies do not support this, possibly reflecting the changes the diet history method experienced [4, 10, 22, 34]. Recently, a diet history interview, administered with the same software (DISHES) as applied in the present study, was used to validate a self-administered FFQ in 1,213 children and adolescents aged 12–17 years. Both dietary assessment methods showed similar results [52].

The 24-h recalls are even more often used as a reference method in validation studies than diet history interviews. Compared to FFQs, the published studies showed no major differences between these methods and thus acceptable relative validities [16, 20, 23, 41].

Beverages are often found with the best agreement in comparison studies [9, 16, 20, 52]. In the present study, the ICC coefficients show the highest agreements between the two methods for beverages (Table 3). These results may be explained by a small variance in units of measurements like glasses, cups or bottles, and additionally regularity in habits (especially for coffee/tea). Furthermore, a limited variety of food items and preparation methods within these food groups facilitates the assessment.

In general, correlations between two methods are higher for frequently consumed foods [2, 20, 24, 25, 54], a finding which is supported by the present results for beverages, milk/dairy products, bread and sausage/meat products while other food groups only indicate a fair agreement independent of their high consumption frequency (Table 3). For example, the lowest ICC agreement is found for raw and cooked vegetables. In other studies, low agreement coefficients (Spearman) for vegetables are often found as well as wide ranges of other frequently consumed foods like cakes/pastries and snacks [12, 16, 20, 30, 35, 52]. Obviously, agreement measurements for inhomogeneous food groups result in lower accordance, independent of the frequency of consumption.

In the present study, the rarely consumed and highly skewed food groups ice cream, nuts/seeds, sweets and fish/-products show strong correlation coefficients calculated by Spearman, indicating a good association between both methods but only fair intraclass correlation coefficients (ICC). As the intraclass correlation quantifies the degree of agreement, the results favour the use of ICC coefficients rather than Spearman correlations at least for the interpretation of seasonally and/or rarely consumed foods.

Ranking participants in categories often results in a range of 70–90 % for the same and adjacent quartile as the presented outcomes also confirm which has to be judged an acceptable agreement between the diet history and the 24-h recalls. The exact agreement (classification in the same quartile) ranges from 30 % (cooked vegetables) to 55 % (coffee/tea), results comparable to those reported in other food-based studies [12, 16, 41, 52]. Cooked vegetables display the highest misclassification in opposite quartiles with 9 % of all food groups.

Ranking individuals in quartiles (tertiles or quintiles) is a preferred method for epidemiological studies on diet and disease, like case–control studies. The results of quartile classification prove both assessment methods to rank participants satisfyingly good for most food groups.

The food groups raw and cooked vegetables show great differences between the methods and the poorest agreement in the presented study as well as in others [12, 16, 28, 30, 35]. This may be explained by the great botanical diversity of vegetables, a multitude of processed options in recipes and additionally, a great variety of serving size possibilities. Therefore, assessing the consumption of vegetables is more complex compared to the consumption of coffee or tea, for example [26, 45, 57]. Every assessment method has to deal with the inhomogeneity of food groups. But comparing the memorisation of the composition of a meal the day before with the estimated average of (all) meals of 28 days gives an idea of the amount of effort and sources of misjudgement for quantities as well as for frequencies with the diet history method. Nevertheless, special attention has to be given to the data collection of inhomogeneous food groups like vegetables, fruit or pastries in every method [26, 46, 51, 57].

In particular for complex food groups, but also in general, the ability to remember remains of essential importance for the accuracy of the reported information for the diet history method compared to the 24-h recalls. The interviewees have to render comprehensive memorisation of the exact foods eaten and calculate the average quantities for that time period. Subjective influences are almost inevitable [4, 40, 42, 55]. Perceptions of nutrition in general and foods in particular can gain great importance, regarding health- and/or gender-related aspects of social desirability. Although 24-h recalls are susceptible to socially desirable answers too [36], there might be a smaller effect when describing the foods eaten the previous day compared to 4 weeks for the diet history method [29, 42]. These basic differences are seen to account for the higher consumption data of most food groups by the diet history method. Small differences in mean consumption, moderate to strong correlation coefficients and the interpretation of the Bland–Altman plots are reasons for the food groups sausage/meat products, coffee/tea, beer and (sparkling) wine to be assessed interchangeable by both methods.

Another aspect concerns the different focus of both assessment methods during the interview. While the diet history method directly targets usual consumption, the 24-h recalls interview concentrates on actual consumption on single days. Food groups perceived as undesirable are even more omitted if asked as a dietary habit. The question of habitual alcoholic consumption in the diet history interview compared to the possible answer: 'one drink last evening' during a 24-h recalls interview reveals this effect. In general, for most participants, stating the exact amount of alcohol consumption is unlikely and underestimation is a well-known problem [31, 49, 55]. In the presented study, the consumption of alcoholic beverages assessed by the 24-h recalls is higher than the corresponding results of the diet history method. The aspect of undervaluing foods perceived as undesirable as dietary habit with the diet history method may also apply to the food group 'pastries' (including cakes, cookies, pies, spicy snacks) in the presented results. The great inhomogeneity of that food group may contribute to the difference, too. Other studies revealed a higher consumption of pastries for 24-h recalls [8, 20, 54] as well as a lower consumption for diet history interviews, all comparisons with FFQ or 7-d records [42, 52].

The results comparing both assessment methods according to sex show that difference and agreement measurements separated for women and men are in good accordance with the results of the total group. So, the general implications of the study are thus relevant with minor modifications for male and female participants analysed separately.

Conclusion

The German National Nutrition Survey II allowed the execution of a diet history method and two 24-h recalls in a large and representative population sample. For the comparison, framework conditions of both computer-assisted assessment methods were adapted with standardisation procedures amongst others, the statistical modelling of the 24-h recalls. Measurements for differences as well as for agreements show higher consumptions of most food groups for the diet history method with good agreement results only for beverages.

The higher cognitive effort essential for the diet history method to remember quantity and frequency of consumption for the last 4 weeks is judged as one source of inaccurateness. Also, social desirability gains influence more easily. Inhomogeneous foods like vegetables are more affected by these occurrences than less complex food groups like beverages. Additionally, reporting dietary habits perceived as undesirable, such as alcoholic beverages and pastries, seems more difficult with the diet history method.

The outcome of the present comparison does not allow a final conclusion as to which method provides data closer to the 'real' consumption since there is no method without error. Both assessment methods principally apply for the use in either public health studies at population level or for more individual-based epidemiologic studies but with a distinct differentiation for special food groups. Totalling, the results show advantages of the 24-h recalls because the method is less burdened in respect of the extent of memorisation which is also seen as a benefit regarding compliance and response rates. But results on individual usual consumption for occasionally or rarely eaten food groups are obtained only after at least two interviews and after applying a statistical modelling technique. Nevertheless, food groups which tend to either positively or negatively influence the answers regarding a higher or lower consumption, e.g. of fruit, vegetables, pastries or alcoholic beverages as well as rarely consumed food groups, need special attention no matter which method is applied.

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Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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