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ORIGINAL CONTRIBUTION

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Validation of a self-administered 3-day estimated dietary record for use in the elderly

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Summary The *aim of this study* was to assess the validity of a 3-day estimated dietary record, especially developed for the longitudinal study on nutrition and health status in an aging population (aged ≥ 60 years) in Giessen, Germany.

Methods The dietary record comprises 146 food items. Portion sizes of the foods consumed were estimated by means of household measures and corresponding dimensions. The validity of the dietary record was evaluated by means of nitrogen excretion in the 24 h urine in 14 women and 9 men, and by comparing energy intake and basal metabolic rate determined by indirect calorimetry in 238 women and 105 men.

Results Neither in women nor in men were any differences found between calculated nitrogen intake (13.4 ± 2.2 g and 15.0 ± 2.0 g, respectively) and nitrogen excretion (12.9 ± 2.1 g and 15.7 ± 3.0 g, respectively). The ratio between reported energy intake and basal metabolic rate was 1.62 ± 0.46 in women and 1.53 ± 0.46 in men. Regarding energy intake, 7.6 % of the females and 16.2 % of the males were classified as underreporters. They show a significantly higher body weight and BMI than the adequate reporters.

Conclusion The results have proved the new 3-day estimated dietary record as suitable to determine energy and nutrient supply of the elderly.

Key words Elderly – validation of 3-day estimated dietary record – 24 h urine nitrogen excretion – ratio of energy intake and basal metabolic rate – underreporting

Introduction

The current demographic trend towards increasing proportion of elderly people in Germany and other western countries (1, 2) indicates a need for more information concerning the relation between nutrition and health of older age groups. Therefore, within the longitudinal study on nutrition and health status in an aging population in Giessen, Germany (GISELA), the nutritional and health status of elderly people has been investigated at annual intervals since 1994. Basal metabolic rate, anthropometrical data, body composition, and various biochemical parameters in blood as well as food intake and corresponding energy and nutrient intake of the study participants have been examined within the scope of this study. In order to estimate food intake, an instrument of nutritional assessment which is able to yield valid measurements of food intake of a large group of elderly people, had to be developed. The instrument should be easily comprehensible and require as little effort as possible for elderly people, but on the other hand it should also ensure a valid determination of the energy and nutrient intake. To do justice to these demands, a closed 3-day estimated dietary record was developed for the GISELA study, in which the participants were asked to record their food intake for three consecutive days. To assess the validity of the dietary food record two independent validation approaches were applied. First, nitrogen excretion in the 24 h urine was used as a marker for protein intake. Second, energy intake which was calculated from the dietary record was compared to basal metabolic rate measured by indirect calorimetry. More subjects with low reported relative energy intake were identified and compared to those with high relative energy intake regarding gender, age, body weight, and BMI.

Subjects and methods

Subjects

The study subjects were recruited by physicians, notices, senior citizens' meetings, advertisements in local newspapers as well as by recruitment of friends through subjects who were already participants. Subjects had to be at least 60 years of age, physically mobile, and available around Giessen for the long term. The study protocol was approved by the Ethical Committee of the faculty of medicine at the Justus-Liebig University and an informed consent form was obtained in writing from each study participant. During the first four years of this longitudinal study (1994–1997), a total of 320 women and 133 men participated in the investigations. Validation of protein intake was carried out in a subsample of the GISELA collective of 14 women (age: 65 ± 4 years; BMI: 25.5 ± 4.1 kg/m^2) and 9 men (age: 66 ± 4 years; BMI: 26.2 ± 2.6 kg/m^2). Validation of energy intake was carried out in 238 women (age: 68 ± 6 years; BMI: 26.8 ± 4.3 kg/m^2) and 105 men (age: 67 ± 5 years; BMI: 26.8 ± 3.2 kg/m^2).

3-day estimated dietary record

To determine the food intake of the subjects of the GISELA study, a 3-day estimated dietary record was developed. The participants were instructed to record their entire food intake on three consecutive days right after consumption, starting with a Sunday. The dietary record consists of 146 food items, subdivided into 16 food groups. Food items were formed considering the eating habits of the elderly people, which were also assessed by a questionnaire in the GISELA study. Foods similar in energy and nutrient content were summarized in one food item. These items were analyzed by taking the average energy and nutrient content of the single foods. For every food item both typical household measures (e.g., slice, cup, spoon) and the appropriate weights were given, so with this information the elderly were supposed to estimate the amount of their food consumption. The food items were compiled in a record booklet including instructions with examples. At the end of the booklet the participants had the possibility to write down any consumed food they were unable to classify under the heading "others".

To analyze the 3-day dietary record first, the foods recorded under the heading "others" were classified among given food items according to their energy and nutrient content. Then data were checked with regard to cooking fat, i.e., if the subjects consumed meat or fish usually prepared with fat, such as cutlet or steak, we checked whether the corresponding fat for frying was also recorded. If reported fat quantities were used as bread spreading only and no cooking fat was written down, fat intake was corrected by adding 4 g cooking oil and 4 g butter for each portion of meat or fish. Then energy and nutrient contents of the food items were calculated by means of the nutrient calculation program CALORA version II and the Federal Nutrient Data Base version II.2 (3).

Protein intake calculated from the dietary record was converted into nitrogen intake according to Isaksson: nitrogen intake = protein intake / 6.25 (4).

24 h urinary nitrogen

The subjects selected were asked to collect their 24 h urine, on the third day of recording dietary intake, after being informed orally and in writing how to collect a 24 h urine. After the urine volume was determined, samples were stored at –20 °C until analyzed. Urinary creatinine was measured colorimetrically by the Jaffé reaction (5). Urinary nitrogen was analyzed with an automated chemiluminescence nitrogen analyzer (703 C, Antek Instruments, Inc., Houston, Texas) (6). Total nitrogen excretion was calculated applying the equation of Isaksson: nitrogen content in 24 h urine + 2 g for extrarenal nitrogen losses (4). To determine the completeness of the 24 h urine collections, 24 h creatinine excretion was compared with the creatinine ratio according to Joossens and Geboers (7). According to this procedure, one urine sample had to be considered as incomplete and therefore was excluded from further consideration.

Basal metabolic rate

Basal metabolic rate was measured for 35 min in the morning after an overnight fast by respiratory gas analysis using a ventilated-hood system (Deltatrac™ MBM-100, Hoyer, Bremen, Germany). Data collected during the initial 10 min of the measurements were discarded. Basal metabolic rate was calculated by using the equation of Weir (8). As measurements were made on an outpatient basis, inpatient basal metabolic rate was calculated according to Berke et al. (9) by multiplying measured basal metabolic rate by 0.93.

Cut-off limits for energy intake

The cut-off 2 derived from Goldberg et al. (10), assuming basal metabolic rate measured with 95 % confidence limits, was used to assess reported energy intake of the subjects. The cut-off limit is based on sample size and number of days recorded by the dietary record. Cut-off values were 1.51 for females, 1.50 for males, and 1.52 for the whole study group. To classify individuals (sample size = 1), the cut-off value of 1.073 was used. Participants with a ratio of energy intake and basal metabolic rate < 1.073 were considered to be underreporters, and those with a ratio ≥ 1.073 were classified as adequate reporters.

Statistical analysis

Statistical analyses were carried out with the SPSS/PC Statistical Package version 6.1.3. Nitrogen intake and excretion were compared by using nonparametric Wilcoxon's matched-pair signed rank test. The relationship between nitrogen intake and excretion was examined using Spearman's rank correlation test. The unpaired Mann-Whitney rank sum test (two-tailed) was employed to evaluate differences between underreporters and adequate reporters. Results were considered statistically significant if P values were less than 0.05.

Results

Nitrogen intake

There were no significant differences between nitrogen intake calculated from the dietary record and nitrogen excretion (Table 1). Spearman's correlation coefficient between nitrogen intake and nitrogen excretion was R = 0.57, P < 0.01 (Fig. 1). According to the crosstable, 47.8 % of the subjects were classified into the same tertile and only 8.7 % were extremely misclassified with regard to nitrogen intake and excretion (Table 2).

Table 1 Reported nitrogen intake and nitrogen excretion (Mean ± SD)

	Females (n = 14)	Males (n = 9)	Total (n = 23)
Nitrogen excretion in 24 h urine [g/d]	10.9 ± 2.1	13.7 ± 3.0	12.0 ± 2.8
Total nitrogen excretion [g/d]	12.9 ± 2.1	15.7 ± 3.0	14.0 ± 2.8
Reported nitrogen intake [g/d]	13.4 ± 2.2	15.0 ± 2.0	14.0 ± 2.2
P	NS	NS	NS

Table 2 Classification of the subjects into tertile of distribution according to reported nitrogen intake and total nitrogen excretion

	Reported nitrogen intake		
Total nitrogen excretion	Lower tertile	Medium tertile	Top tertile
Lower tertile	3	3	1
Medium tertile	3	4	2
Top tertile	1	2	4

Energy intake

Table 3 shows the basal metabolic rate and the energy intake of the subjects. The ratio between calculated energy intake and basal metabolic rate was 1.62 in females and 1.53 in males, which was 7.3 % and 2.0 % above the cut-off limit, respectively.

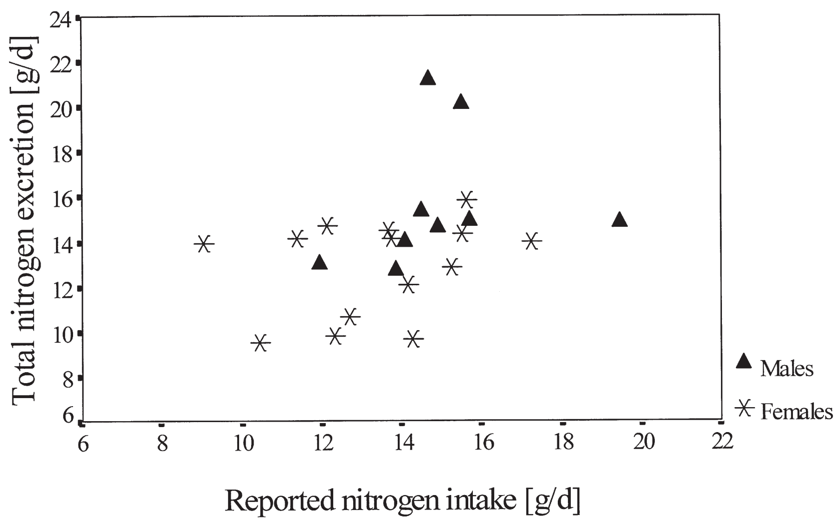

Fig. 1 The relationship between reported nitrogen intake and total nitrogen excretion.

Table 3 Reported energy intake and basal metabolic rate (Mean ± SD)

	Females (n = 238)	Males (n = 105)	Total (n = 343)
Reported energy intake [kJ/d]	8311 ± 2186	9705 ± 2579	8738 ± 2398
Basal metabolic rate [kJ/d]	5212 ± 659	6434 ± 836	5586 ± 912
Ratio of reported energy intake and basal metabolic rate	1.62 ± 0.46	1.53 ± 0.46	1.59 ± 0.46
Cut-off 2 (10)	1.51	1.50	1.52

According to cut-off 2 derived from Goldberg et al. (9), 7.6 % of the females, 16.2 % of the males, and 10.2 % of the total study group were classified as underreporters. The underreporters show a significantly higher body weight and BMI than the adequate reporters (Table 4).

Discussion

The aim of the present study was to evaluate the validity of a newly developed 3-day estimated dietary record for use in the elderly. As a marker for reported protein intake, nitrogen excretion of 24 h urine was used. The ratio between reported energy intake and basal metabolic rate served as a marker for reported energy intake. The advantage of these two methods is their independency from the dietary method regarding errors (11).

One of the best biological markers for validation nutritional assessment methods is the 24 h urinary nitrogen for estimation protein intake (4, 12, 13). In healthy individuals consuming normal western diets, 24 h urinary nitrogen excretion runs up to 81 ± 5 % of the habitual dietary nitrogen intake (12). In our study, mean 24 h urinary nitrogen amounted to 85.7 % of the reported nitrogen intake. Furthermore, mean total nitrogen excretion as calculated by Isaksson (4) is identical with nitrogen intake. The correlation between nitrogen intake and excretion ($R = 0.57$) is comparable to that observed in other studies using 24 h urinary nitrogen to validate protein intake ($R = 0.4–0.7$) (14–16). The dietary record is also able to rank subjects adequately according to their nitrogen intake and excretion, because in the crosstable only 8.7 % of the subjects were extremely misclassified. These results indicate that the 3-day estimated dietary record reflects the protein intake of the elderly subjects well.

The validity of reported energy intake was evaluated by comparing the mean ratio between reported energy intake and measured basal metabolic rate with the cut-off 2 derived from Goldberg et al. (10). These cut-off limits test whether reported energy intake was a plausible measure of food consumption during the current measurement period. In the present study, mean ratio between energy intake and basal metabolic rate is 1.62 for females and 1.53 for males and therefore over the cut-off limits. So the 3-day estimated dietary record appears suitable to assess energy intake validly. Results from other studies measuring total energy expenditure by doubly labeled

Table 4 Characteristics of underreporters and adequate reporters (Mean ± SD)

		Underreporters (n = 18 F, 17 M)	Adequate reporters (n = 220 F, 88 M)	P
Age	F	65.9 ± 5.4	67.6 ± 5.5	NS
[y]	M	66.5 ± 4.8	67.1 ± 4.8	NS
	T	66.2 ± 5.1	67.5 ± 5.3	NS
Body height	F	160.9 ± 5.4	160.5 ± 5.6	NS
[cm]	M	175.4 ± 6.8	172.9 ± 6.3	NS
	T	168.0 ± 9.5	164.1 ± 8.1	< 0.05
Body weight	F	75.2 ± 13.4	68.5 ± 11.6	< 0.05
[kg]	M	88.1 ± 11.7	78.9 ± 9.4	< 0.01
	T	81.5 ± 14.1	71.4 ± 12.0	< 0.001
BMI	F	29.0 ± 4.8	26.6 ± 4.2	< 0.05
[kg/m^2]	M	28.7 ± 3.9	26.4 ± 2.9	< 0.05
	T	28.9 ± 4.3	26.5 ± 3.9	< 0.01

F = Females, M = Males, T = Total study group water as well as basal metabolic rate by indirect calorimetry in Caucasian elderly subjects are in accordance with our data. In a study performed by Pannemans and Westerterp (17), the ratio between total energy expenditure and basal metabolic rate was 1.66 for females and 1.52 for males. Goran and Poehlman (18) found a mean ratio of 1.42 in women and 1.56 in men. In the report of Carpenter et al. (19) total energy expenditure was 1.52-fold of the basal metabolic rate in females and 1.63-fold in males, respectively.

The proportion of underreporters of energy intake on the individual level was also investigated. In our sample 7.6 % of the females and 16.2 % of the males were classified as underreporters. Compared to other studies with different age groups (20–23), the proportion of underreporters is very low, especially in women. The male subjects were more likely to underreport their usual energy intake than women, in contrast to other studies (20–23). In the third National Health and Nutrition Examination Survey, 28 % of the adult women and 18 % of the adult men were classified as underreporters according to the cut-off limit 0.9 for the ratio between energy intake and basal metabolic rate (20). In a study of Pryer et al. (21) 46 % of the women and 29 % of the men, aged 16–64 years, showed a ratio below 1.2 of energy intake and basal metabolic rate. Rothenberg et al. (22) classified 28 % of the elderly women and 22 % of the elderly men as underreporters by means of the cut-off limit 1.2. Price et al. (23) determined that 22.7 % of the females and 18.5 % of the males underestimated their usual energy intake by using a cut-off limit 1.1. The reason for the low proportion of underreporters in our study might be that the subjects were self-selected, highly motivated, and compliant volunteers. An explanation for the low proportion of underreporters in females can be that they were more motivated and willing to record their dietary intake than males.

In the present study women and men who underreported their energy intake were heavier and had a higher BMI than the adequate reporters. The association between a high body weight and BMI, respectively, and underreporting is well known from previous studies with young and middle aged individuals (23–28). In studies with older people findings are inconsistent. Rothenberg et al. (22) showed a higher body weight for elderly women and men who underreported their energy intake in comparison to the adequate reporters as well as a positive correlation between BMI and underreporting. In the reports of Johnson et al. (29) and Visser et al. (30) no relationship between underreporting and body weight or BMI could be detected in the elderly.

The underlying reasons for the observation of a higher body weight and BMI of the underreporters are unknown. It is possible that those subjects either pretend to eat less or they might use the days of recording for weight reduction and therefore reduce their typical level of food intake consciously. Another reason could be that persons with high BMI are more conscious of the body shape and diet which can result in eating patterns oscillating between restrained and unlimited periods (23). These persons probably restrain and consequently underreport their food consumption unconsciously if they have to protocol their food intake.

In our study we were not able to evaluate the validity of the reported intake of other nutrients. However, the intake of most nutrients is positively associated with energy intake (11). Therefore, it can be assumed that the 3-day estimated dietary record will neither underestimate nor overestimate dietary intake of other nutrients on a large scale.

In summary it can be concluded that the newly developed 3-day estimated dietary record is suitable to determine energy and nutrient intake in the elderly. Nevertheless we have to take into account that about 10 % of the study subjects, especially volunteers with a high body weight and BMI, underreported their energy intake.

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