Under-reporting of food intake and body fatness in independent older people: a doubly labelled water study

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Abstract

Background: there are no accurate methods for the assessment of food intake in older populations, under-reporting of intake being highly prevalent. There is controversy about which dietary assessment method and what person’s characteristics are associated with greater under-reporting rates.

Objective: to assess the correlation between under-reporting of energy intake (EI) and different percentages of body fat in independent older people.

Design: cross-sectional study.

Setting: area assisted by the Family Health Program of the Ribeirão Preto Medical School, University of São Paulo, Brazil.

Subjects: one hundred volunteers aged 60–70 years.

Methods: all volunteers had their body composition assessed by dual-energy x-ray absorptiometry. In second phase, 41 volunteers were evaluated, representing the four quartiles of fat percentage. Total energy expenditure (TEE) was measured by the doubly labelled water method, and EI was assessed by 24-h recalls and a food frequency questionnaire (FFQ). TEE and EI values, EI-to-TEE ratios and EI–TEE values were compared.

Results: TEE was 2,220 ± 601 kcal, while the EI was 1,919 ± 602 kcal (24-h recall) and 2,119 ± 670 kcal (FFQ). The proportion of under-reporters was 31 and 40.5%, respectively. Under-reporting was more frequent in subjects with higher percentage of body fat and in females (P < 0.05).

Conclusion: under-reporting was more frequent among older persons with higher percentage of body fat in both methods of assessment of food intake. Older persons follow the same profile of under-reporting as younger adults.

Keywords: under-reporting, older people, food intake

Introduction

Under-reporting is one of the most frequent determinants of inaccuracy in the assessment of food intake [1]. Biomarkers of energy intake (EI) have been applied to detect under-reporting, the doubly labelled water (DLW) being the gold-standard method for this purpose. Precision ranges from 4 to 8% or 80–160 kcal day−1 [2].

Although most usually participant’s characteristics are considered the main determinants of under-reporting (i.e. women, obese and older people under-reporting more), the method used for the assessment of intake is also relevant, and some authors have found that the food frequency questionnaire (FFQ) is the least sensitive to under-reporting [3], whereas others have found opposite results [1, 4]. Few studies have verified the patterns of under-reporting in older
people and even fewer have analysed different intake questionnaires in this population, using biomarkers as reference [5, 6]. Although it is known that older people under-report more than younger populations [5], it is not known whether in this age group women still under-report more frequently [5–7] or how much obesity still influences results. Some studies [8] associated a higher under-reporting rate, in older subjects, with higher body mass index (BMI), bigger waist circumference and lower educational level; these studies, however, employed resting energy expenditure (REE) to estimate energy expenditure. Also, in older adults, BMI may not be an accurate marker of obesity or high body fatness, so that the direct measurement of body fatness may be better associated with under-reporting of food intake [9]. This study was aimed to evaluate, using the DLW method as reference, the prevalence of under-reporting of food intake in a free-living, urban, independent older population, comparing two different methods for the assessment of food intake (FFQ and 24-h recall questionnaire) and verifying the influence of body fatness on under-reporting.

Methods

Subjects
One hundred weight-stable persons aged 60–70 years living in the area assisted by the Family Health Program of the Ribeirão Preto Medical School, University of São Paulo, Brazil, participated in this study. That is a medium–low income area, with about 2,000 inhabitants aged 60 years or over. This represents 7.68% of the total population in this age group in the city of Ribeirão Preto. All older persons followed by each of the five Family Health Centres in the area were listed, and 10% of those selected, by draw, to be contacted by phone, which was followed, if agreed, by a visit of the researcher and a local health agent. If the number of participants was not reached after selection, due to refusals or unmet inclusion criteria, another draw was performed. Inclusion criteria were being free-living, independent and aged 60–70 years. The Mini-Mental State Examination [10] was employed to detect cognitive impairment and the Lawton scale to detect dependencies [11]. All volunteers were assessed by a careful clinical and laboratory evaluation (total blood cell count, blood glucose, creatinine and thyroid-stimulating hormone levels). To avoid under-eating, it was required that volunteers were weight-stable (weight not varying over 5%) for the last 6 months (as under-eating is associated with weight loss).

The study was approved by the local Human Research Ethics Committee and all participants signed an informed consent prior to participating.

Initially, the 100 subjects had their body composition assessed by dual-energy x-ray absorptiometry (Hologic QDR4500W®, Hologic Inc., USA). From those, 41 volunteers, representing the four quartiles of percent body fat (five men and five women per quartile, except the highest quartile, where six women were included) were selected by draw within each quartile group, to participate in the DLW study.

Diet assessment

Two dietary assessment methods were used: 24-h diet recall applied on 3 different days and a FFQ. In the 24-h recalls, subjects were asked what they had eaten during the previous day. The interview followed the USDA multiple-pass method [12]. To help estimate portion sizes, life-size pictures and drawings of utensils and portion sizes were used [13]. The FFQ was quantitative, applied by interviewer, and included 120 food items [14, 15].

All answered questionnaires were verified, coded and analysed by registered dietitians, and when an item was not clear, the subject was asked to clarify it. The software Nutrition Data System (USA) was used in the two methods of food intake assessment [16, 17].

Resting and total energy expenditure measurements

REE was measured by indirect calorimetry (Sensormedics, model Vmax29, EUA).

To calculate total energy expenditure (TEE), the two-point DLW method was employed. In the morning of day 1, subjects provided a baseline urine sample after a 10-h overnight fast. DLW was given orally at a dose of 2 g of 10% 18O-labelled and 0.12 g of 99.9% deuterium-labelled water per kilogram of estimated total body water, along with two subsequent 50 ml water rinses of the bottle. Urine samples were collected 3, 4 and 5 h after dose administration. On Days 5 and 10 after dose intake, the subjects had a urine sample collected at home. Enrichment of urine samples was analysed by isotope ratio mass spectrometry (ANCA 20-20, Europe Scientific, UK) at the Mass Spectrometry Laboratory of the Ribeirao Preto Medical School. Isotope dilution spaces and energy expenditure were calculated according to Schoeller [18], by the comparison of the enrichment of the baseline specimen with that of the 3, 4 and 5 h specimens when a plateau of enrichment must have been reached. The enrichment of specimens collected after dosing was used to draw the deuterium and oxygen 18 elimination rate; the difference between the two rates reflect CO2 production, and TEE is, then, calculated by indirect calorimetry formulas [18].

Definition of under-reporters of EI

Subjects were identified as under-reporters of EI based on the 95% confidence limits of the expected EI-to-TEE ratio of 1.0, calculated from the equation [19]:

\[
\pm 2 \times \sqrt{[CV_{EI}^2/D] + (CV_{TEE}^2)}
\]

The variable CV_{EI} is the within-subject coefficient of variation (CV) for EI. These were 32% for the 24-h recall and 18% for the FFQ. The variable CV_{TEE} is the within-subject CV for TEE, which was 8.8% [1]. D is the number of days of dietary assessment which was three for the recall; as the FFQ refers to the habitual intake, the number of days is considered infinite and the expression of CV EI disappears [19].
Under-reporters were defined as subjects who presented EI-to-TEE ratios smaller than 0.69 (24-h recall) and 0.82 (FFQ).

**Statistical analysis**

All statistical analyses were performed using the softwares SPSS version 17.0 (SPSS Institute, USA) and SAS, version 9.0 (SAS Institute, USA). Sample size was calculated from data obtained in a pilot study including 20 volunteers, with the level of significance 0.05 and 80% power. Data from the three 24-h recalls were used to estimate within- and between-subject variances [20, 21] according to the method proposed by the Iowa State University using the Software for Intake Distribution Estimation, PC-Side version 1.0 (USA). The mean EI estimated from the three 24-h recalls was de-attenuated, considering within and between variance ratios [22, 23]. The t-test was employed for gender comparisons, after the verification of normality by the Kolmogorov–Smirnov test. Bland–Altman plots were built for the comparison of the variation of EI-to-TEE ratios and EI-to-TEE values. Data that were not normally distributed were log-transformed before further analysis.

For comparison of different quartiles of EI/TEE, analysis of variance was employed comparing the group with the highest fat quartile with each of the other groups. The Pearson coefficient was employed for the evaluation of correlations between TEE and EI, as assessed by the different methods. The kappa coefficient was used to measure the agreement between the two EI assessment methods in the detection of under-reporters. P values < 0.05 were considered significant.

**Results**

Forty-one volunteers were included (20 men). Mean age was 67 ± 3 years (women) and 68 ± 4 years (men), P = 0.784. Schooling was 6.7 ± 4.7 and 4.4 ± 4.0 years. BMI was 29 ± 5 and 26 ± 4 kg m⁻² (P = 0.042). Socio-economic characteristics and health status are shown in Table 1. No volunteers had cognitive impairment or dependencies detected. All chronic diseases were controlled during the study.

REE was 1,383 ± 87 and 1,594 ± 85 kcal (women and men, respectively, P = 0.001) and TEE was 2,220 ± 563 and 2,627 ± 586 kcal (P = 0.016). EI as measured by the FFQ was 1,883 ± 662 and 2,380 ± 593 kcal (P < 0.005) and as measured by the 24-h recall was 1,616 ± 604 and 2,253 ± 394 kcal, respectively, (P = 0.015).

The differences between EI and TEE were −293 kcal (FFQ) and −491 kcal (24-h recall). The ratios between TEE and EI were 0.92 and 0.83, respectively. Although there was a moderate correlation between EIs as measured by both instruments (r = 0.70, P < 0.005), there was no correlation between TEE and EI measured by the 24-h recall (r = 0.25, P = 0.112) and the FFQ (r = 0.19, P = 0.221). Also, the EI estimated by the 24-h recall and the FFQ differed considerably from TEE, the mean difference being wide and negative. The minimum values of EI were always smaller than the minimum TEE value. (This discrepancy was greater for the 24-h recall.) The minimum values of the ratio between EI and TEE were also very low. The number of under-reporters was 13 (31%) for the 24-h recall and 17 (40.5%) for the FFQ, with a kappa coefficient of 0.65 (P < 0.05).

Bland and Altman plots representing the difference between EI and TEE plotted against the mean of EI and TEE are shown in Figure 1. The 95% confidence limits of agreement were too wide, indicating a poor individual agreement between EI and TEE. Also, there was a high dispersion, showing that the difference between the measurements varied considerably. This effect of dispersion seemed to be slightly more accentuated for the FFQ. There were no outliers.

The body fat percentage of the four quartile groups was 31 ± 7.3% (Group A), 37 ± 7.5% (group B), 42 ± 7.3% (group C) and 45 ± 7.2% (group D).

The ratio between EI and TEE of the different body fatness groups and genders is shown in Figure 2. Differences remained significant among women when the 24-h recall (Group A and D—P = 0.001—and Groups B and D—P = 0.004) and the FFQ were applied (between Groups B and D—P = 0.020). Differences were not significant among men.

**Discussion**

This study confirmed the hypothesis that under-reporting is a prevalent bias in the assessment of dietary intake in a sample of urban, free-living, older people. There was a lack of agreement in the under-reporting of food intake and body fatness in independent older people.
between EI and TEE with systematic errors and large underestimation of EI. The rates of under-reporting were dependent on the method of EI assessment and on body fatness. The accurate measurement of EI of older adults is of great importance in different clinical conditions, so that nutritional interventions may be well designed and effective. Under-nutrition is highly prevalent in the presence of chronic diseases and is frequently caused by the intake of lower amounts of calories compared with needs (under-eating). Our study included only weight-stable, healthy older people, so that actual under-eating is highly improbable to have occurred. As the volunteers with lower body fat were less likely to be under-reporters, it is possible that undernourished older patients may also be reporting more accurately their EI. This hypothesis deserves further researching, as almost all studies on the accuracy of assessments of intake are performed in weight-stable, well-nourished volunteers [5, 24, 25].

Few studies have been published comparing estimated EI with energy expenditure measured by the DLW method in developing countries [1]. To identify under-reporting, most authors use the estimation of REE by equations [26, 27], which may lead to bias. In a previous manuscript with partial data of this study (published in the annals of a research meeting), we showed that the mean percentage of reported intake in relation to TEE was \(-17.7\%\), but under-reporters were not identified [2].

We expected that the 24-h recall would show a better performance than it actually did. Subar and colleagues [4] showed that when a 24-h recall was used to assess dietary intake, there was a lower prevalence of under-reporting than when a FFQ was used. Moshfegh and colleagues [27] also showed a high prevalence of under-reporting of EI with the application of the 24-h recall, but in a population with lower mean age and using BMI as a surrogate for body fatness. In our research, the 24-h recall led to a lower rate of under-reporting than the FFQ, but there was still a considerable bias, which would certainly affect inferences about diet and health. Our results agree with those of Scagliusi et al. [1], who employed the same procedure for data collection and also found a lower rate of under-reporting using the 24-h recall.

Figure 1. Bland and Altman plots of EI (kcal) measured by 24-h diet recall (a) and by the FFQ (b) and TEE (kcal) measured by the doubly labelled water method (n = 41). The solid line represents the mean difference between EI and TEE; the dotted line represents 1.96 SD of the mean (limits of agreement).

Figure 2. Box plots showing the ratio EI/TEE according to the different body fat percentage and gender when intake was assessed by the 24-h recall and the FFQ. Each group represents one of the four quartiles of per cent body fat (Group A: 20th percentile; Group B: 40th percentile, Group C: 60th percentile; Group D: 80th percentile).
recall compared with the FFQ and with those of Blanton et al. [28]. Similar under-reporting rates have been reported in other countries [2, 29]. The adjustment of the 24-h recall for inter- and intra-individual variation may have improved the results of this method.

In the literature, obese people are more frequently under-reporters [6]. Our hypothesis was that this could not be the case in older people, as age itself is related to a higher proportion of under-reporting. However, our results show that higher body fatness is also associated, in older people, with higher rates of under-reporting, especially among women.

Some limitations of our study need to be mentioned. The sample size was relatively small, but it reached the calculated sample size. The population studied (urban, independent) may not represent the Brazilian older population of other regions and social status. However, most of the Brazilian older people as well as older populations of other countries live, nowadays, in urban areas (87% in Brazil, according to the 2010 Census) and are independent [30]. Seventy-two per cent of the Brazilian older population has a family income of up to three minimum wages (US$800) and 82% has up to eight years of study, characteristics that are similar to those of our volunteers [31].

In conclusion, under-reporting of EI is a serious and prevalent error in dietary self-reports provided by this sample of healthy, older volunteers. In addition, the volunteers studied have the same profile of under-reporting of younger men and women, with increases in the percentage of fat being followed by increases in the prevalence of under-reporting of food intake. These findings strongly suggest that clinical dietitians and clinical researchers should be cautious in considering self-reported EI by older people with high body fat, especially women. This phenomenon should be further addressed and characterised in future studies.

Key points
• Older people frequently under-report their EI when it is assessed by self-report questionnaires.
• Under-reporting rates are influenced by body fatness and by the method employed for the assessment of food intake.
• Higher body fatness is associated with a higher prevalence of under-reporting in both young and old people.
• The 24-h recall questionnaire is associated with a lower prevalence of under-reporting if compared with the Food Frequency Questionnaire.
• Under-reporting must always be taken into consideration when a nutritional intervention is planned, especially for older women.

Acknowledgements
The authors thank R. M. Fisberg and D. M. Marchioni for providing access to the software used to evaluate the nutritional composition of diets.

Conflicts of interest
None declared.

Funding
The research was supported by FAPESP—Fundação de Amparo à Pesquisa do Estado de São Paulo, grant numbers 07/50150-8 and 07/07640-4 and IAEA grant number 12690.

Authors’ contributions
K.P., F.B.S. and E.F. designed research; K.P., M.V.V. and C.M.M.R. conducted research; K.P. and E.F. analysed data; K.P., J.C.M., N.K.I. and J.S.M. wrote the manuscript; K.P. had primary responsibility for final content. All authors read and approved the final manuscript.

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Received 12 November 2013; accepted in revised form 18 June 2014