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Misreporting of energy intake in the elderly using doubly labeled water to measure total energy expenditure and weight change

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Abstract

Background—One of the major problems in dietary assessment is inaccuracy in reporting diet.

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Objective—To examine the association between self-reported energy intake by food frequency questionnaire (FFQ) and energy expenditure (EE), measured by doubly labeled water (DLW) among the elderly.

Design—EE was assessed in 298 high-functioning, community-dwelling older adults over 2 weeks using DLW. Dietary intake was assessed using a Block Food Frequency Questionnaire (FFQ). The ratio between reported energy intake (EI) and total energy expenditure (TEE) was calculated. Misreporting was defined as: participants with an EI/TEE ratio of <0.77 were categorized as low energy reporters (LER) while participants with an EI/TEE ratio >1.28 were categorized as high energy reporters (HER). Participants with an EI/TEE ratio of 0.77 – 1.28 were categorized as “true” energy reporters (TER). One year percent weight change prior to EE visit was used as another validation indicator. Participants who were low energy reporters but lost $>2\%$ of their body weight were categorized as undereaters.

Results—296 participants had both FFQ and DLW measurements. 43% of participants were low energy reporters among them, almost 30% lost weight and, therefore, were categorized as undereaters. The undereaters consumed significantly less calories. No difference in the frequency of low energy reporting was detected between gender or race groups. Underreporters had significantly higher body weight than “true” or high reporters. Undereaters tended to have higher BMI than the underreporters.

Conclusions—Undereating is prevalent in the elderly and may be falsely perceived as underreporting. It should be further addressed and characterized in future studies.

Keywords

Doubly labeled water; misreporting; dietary intake; true energy reporters; undereating

Introduction

One of the major problems in dietary assessment is inaccuracy in reporting diet, which may be influenced by the assessment procedure and the interviewee characteristics (1). However, few studies have been performed in older individuals who may be vulnerable to either obesity or undernutrition and the associated health consequences of both (2). Notably, information regarding the gap between reported energy intake using dietary assessment and measured Total Energy Expenditure (TEE) using the doubly labeled water (DLW) method in the elderly is scarce (2, 3).

As in younger populations (4), underreporting of energy intake in the elderly is positively related to body mass index (BMI), waist circumference, fat mass (3, 5, 6) and lower education (3) when compared to a variety of dietary assessment methods. The concept of underreporting is valid provided that a stable energy balance is maintained. However, this may not hold true among those in negative energy balance. For example, in older persons with declining weight (7), low energy intake may be more prevalent (8).

In a recent evaluation of misreporting among the elderly (9), the percent of participants classified as accurate reporters varied from 40–63% among men and 60–63% among women. A significant difference in misreporting was shown between men and women; but in two other studies, no difference in misreporting was detected between older men and women (2, 10). None of these studies dealt with the question of how the underlying trajectories of negative energy balance may affect the misreporting of diet.

The purpose of the current study is to examine the association between self-reported energy intake by food frequency questionnaire and energy expenditure, measured over a 14-day period by DLW, and to characterize misreporters and accurate reporters of energy intake

among the elderly. Combining energy expenditure with 1 year weight change is an opportunity to look at and evaluate the extent of misreporting as opposed to accurately reporting the under- or over-consumption of energy relative to energy expenditure.

Subjects and Methods

Study Sample

The Health, Aging and Body Composition (Health ABC) study is a cohort study initiated by the Laboratory of Epidemiology, Demography and Biometry and carried out by investigators from the University of Pittsburgh (Pittsburgh, PA) and the University of Tennessee (Memphis). Three thousand and seventy five participants aged 70 to 79 years were recruited from a random sample of white Medicare beneficiaries and all age-eligible black community residents to participate in the Health ABC study in 1997–1998. Eligibility criteria included self-reporting no difficulty in walking a distance of 1/4 mile or climbing at least 10 stairs, independently performing activities of daily living, having plans to live in the area for the next 3 years, and having no evidence of life-threatening illnesses.

In 1998–1999 an energy expenditure sub-study was carried out enrolling 323 individuals. The study procedure is described in detail elsewhere (11, 12). Individuals were randomly selected within sex and race groups and were asked to participate in a sub-study on energy expenditure. Individuals who agreed were paid. Twenty-one individuals were excluded from this analysis because of failure to complete the protocol, lack of appropriate urine volume specimens, or lack of isotope or resting metabolic rate data to meet a priori criteria, leaving an analytic sample of 302 individuals (150 men and 152 women). Sixty percent ($n = 179$) participated in the energy expenditure sub-study in 1998 and 40% ($n = 123$) participated in the sub-study in 1999. Each participant signed a written informed consent which was approved by the institutional review boards at the University of Pittsburgh and the University of Tennessee.

Dietary assessment

A modified Block 98 food-frequency questionnaire (FFQ) was administered by a trained dietary interviewer in year 2 (1998). The FFQ, developed and modified by Block Dietary Data Systems (Berkeley, CA) for the Health ABC study, was based on age-appropriate intake data from the third National Health and Nutrition Examination Survey. The food lists were based on 24-h dietary recall data for those aged >65 y, either non-Hispanic white or black, and residing in either the Northeast or the South. A total of 108 food items were included. Wood blocks, real food models, and flash cards were used to help participants estimate portion size. Nutrient and food group intakes were estimated by Block Dietary Data Systems. A second FFQ was administered to participants who participated in the energy expenditure sub-study in year 3 (1999).

The Healthy Eating Index (HEI) was calculated to assess compliance with specific U.S. dietary guidelines (13, 14). The HEI consists of 10 components: 5 measured conformity to the sex- and age-specific serving recommendations from the 1992 USDA Food Guide Pyramid for grains, fruit, vegetables, dairy and meat, and the other 5 assessed intake of total fat consumption as a percentage of total energy intake, saturated fat consumption as a percentage of total energy intake, total cholesterol intake, total sodium intake and variety in the diet. Each component was scored from 1 to 10 with higher scores indicating better compliance with recommended intake ranges or amounts.

Subjective appetite evaluation was measured using a question asking participants to rate their appetite or desire to eat and the responses were grouped into 2 levels: moderate, poor or fair (0) and very good or good (1). In addition, participants were asked to rate their

appetite or desire to eat compared with one year ago, with responses categorized as much better, somewhat better or better (1) and same as last year, worse or much worse (0).

Section one of the 51-item Stunkard and Messick's questionnaire was used to measure appetite and eating restraint (15). Possible scores ranged from 1 to 21 where high scores indicate higher eating restraint. The Marlow-Crowne social desirability (MCSD) score was calculated at the energy expenditure sub-study visit. The MCSD is a 33-item, self-compiled questionnaire aimed at measuring socially desirable response (16, 17). Participants were asked to rate the extent to which they agreed (True) or disagreed (False) with each item.

Doubly Labeled Water (DLW) Protocol

Total energy expenditure was measured using doubly labeled water. This procedure has previously been described in detail (11). Measurements were obtained between 2 visits separated by 2 weeks. On the first visit, participants ingested an estimated 2 g/kg total body water dose of doubly labeled water. This dose was composed of an estimated 1.9 g/kg total body water of 10% H_2^{18}O and an estimated 0.12 g/kg total body water of 99.9% $^2\text{H}_2\text{O}$. After dosing, 3 urine samples were obtained at approximately 2, 3, and 4 hours. Two consecutive urine voids were taken during a second visit to the laboratory 15 days after the first visit. Plasma from a 5 ml blood sample was obtained from everyone but only used for those who had evidence of delayed isotopic equilibration likely caused from urine retention in the bladder ($n = 28$) (11). Urine and plasma samples were stored at -20°C until analysis by isotope ratio mass spectrometry.

Dilution spaces for ^2H and ^{18}O were calculated according to the method by Coward (18). Total body water was calculated as the average of the dilution spaces of ^2H and ^{18}O after correction for isotopic exchange (1.041 for ^2H and 1.007 for ^{18}O). Carbon dioxide production was calculated using the 2-point doubly labeled water method outlined by Schoeller et al (19, 20) and total energy expenditure was derived using the equation by Weir (21) with a respiratory quotient of 0.86. All values of energy expenditure were converted to kilocalories per day and the thermic effect of meals was assumed to be 10% of total energy expenditure (22). The within-subject repeatability of total energy expenditure was based on blinded, repeated, urine isotopic analysis and was excellent (mean [SD], 1.2% [5.4%]; $n = 16$) comparing well with rates given in a review article (23).

Resting Metabolic Rate Protocol

Resting metabolic rate was measured via indirect calorimetry using a Deltatrac II respiratory gas analyzer (Datex Ohmeda Inc, Helsinki, Finland) and has been described in detail elsewhere (12). While in a fasting state and after 30 minutes of rest, a respiratory gas exchange hood was placed over the participant's head and the resting metabolic rate was measured for 40 minutes. To avoid a gas exchange created by the initial placement of the hood, only the final 30 minutes were used in subsequent calculations. Movement or sleeping during the test was noted and those values were excluded from the resting metabolic rate calculation.

Other measurements

Sociodemographic measurements included age, sex, race (black or white), study site (Memphis or Pittsburgh), education (<high school, high school graduate, and >high school), and marital status (married, not currently married). Self-reported health status was categorized as fair or poor (1) and good, very good or excellent (0). Smoking behavior (never, former, or current) was assessed by interview at the year 1 Health ABC visit in 1997–1998.

Body fat and body weight were measured at the first energy expenditure sub-study visit. Body weight was measured with a calibrated balance beam scale while the participant was wearing a hospital gown (no shoes). A question regarding the intention to lose weight was included as well as a question regarding weight change from age 50. Body fat was assessed using dual-energy x-ray absorptiometry (QDR-4500, version 8.21, Hologic Inc, Bedford, Mass) and calculated as the ratio of body fat mass to total mass (percent body fat).

Seated blood pressure was measured twice and the average of the two measurements was used. Depressed mood was assessed with the Center for Epidemiologic Studies Depression (CES-D) short scale and cognitive status was assessed using the Modified Mini-Mental State Examination (3MS) score (24) at the time of the clinic visit in year 3. Physical performance was assessed using modified performance tests based on the Epidemiologic Population Studies of the Elderly (EPESE) in year 1 (25). The performance score summarizes, on a scale from 0 (poor) to 12 (good), a participant's performance on a 6 meter walk test, a standing balance test, and five repetitions of chair rises. A timed 20 meter walk was also measured. The test started with the participant's feet behind and just touching the starting line. Participants were instructed to walk at their usual pace down the hallway and across the tape line at the second cone.

Definition of misreporting (under- or overreporters)

For the purpose of the current study we used the definitions and cutoffs based on the OPEN study (26). We log-transformed all measurements in order to create approximately normal distributions. Total energy expenditure measured by DLW is an unbiased measure of true energy intake. For unbiased dietary assessment instruments, the log ratio of reported energy intake to the true energy expenditure calculated by the DLW would have a mean of zero and a variance equal to the sum of within-person variation in the dietary instrument (FFQ). The within-person variation was calculated using data from 123 participants who completed the FFQ in year 2 and year 3. For the within-person variation for the DLW, the within-person variation reported in the OPEN study was used (26). Values above or below the 95 percent confidence interval of the log ratio of reported intakes to biomarker measurements indicate the presence of reporting bias. The values are population sensitive, as they rely on the values measured in the elderly. Misreporting was defined in the following way: Participants with an energy intake (EI)/total energy expenditure (TEE) ratio of <0.77 were categorized as low energy reporters (LER) while participants with an EI/TEE ratio >1.28 were categorized as high energy reporters (HER). Participants with an EI/TEE ratio of $0.77-1.28$ were categorized as "true" energy reporters (TER). Participants with extreme outlier values were excluded from the current analyses (2 participants, one with ratio of 0.01 and one with ratio of 4.28).

Definitions of misreporters and accurate reporters

Both low energy reporting and high energy reporting may be associated with under- or overeating. Undereating and overeating can occur if participants are not actually weight-stable but, instead, are in a phase of weight loss or weight gain, respectively. One year percent weight change prior to the energy expenditure sub-study visit (year 2 or year 3) was used as another validation indicator for the accuracy of reported EI. Percent weight change was calculated and defined as weight loss if the percent weight change was $<-2.0\%$, weight stable if percent weight change was between $-2-2.0\%$, and weight gain if percent weight change $> 2\%$.

Participants who were low energy reporters and lost weight were categorized as undereaters (UE); while participants who were low energy reporters but did not lose weight were categorized as underreporters (UR). Participants who were considered "true" energy

reporters but were weight stable were categorized as correct reporters (CR); while those who lost or gained >2% of their weight were categorized as incorrect reporters (IR). For high energy reporters, participants who gained weight were considered overeaters (OE); while those who did not gain weight were considered overreporters (OR). The definitions are described in table 1.

Statistical analyses

First, comparisons were made across the 3 categories of under- or overreporting: low energy reporters, “true” energy reporters, and high energy reporters. Next, comparisons were made across all 6 categories of reporting: undereaters, underreporters, correct reporters, incorrect reporters, overeaters, and overreporters. Finally, comparisons were made between the whole group of accurate reporters (undereaters, correct reporters, and overeaters) reporters and misreporters (underreporters, incorrect reporters, and overreporters) as well as undereaters compared to everyone else. Participant characteristics were assessed using analysis of variance (ANOVA) for continuous variables and χ^2 statistics for categorical variables. Generalized linear models were used to compare anthropometric, health and functional indices, dietary intake and diet quality between the different reporting levels with the necessary adjustments (based on the findings from the comparisons between demographic characteristics, dietary intake comparisons were adjusted for energy intake). Post-hoc analyses using Bonferroni adjustments were used to test the difference between the mean outcomes in multiple levels. Multivariate logistic regression models were used to determine the independent contribution of nutritional, health and functional variables to undereating and misreporting controlling for possible confounders. Goodness of fit measures were used to select the best fitting model. The statistical analyses were performed using SPSS version 14 (SPSS Inc., Chicago, IL).

Results

Dietary and energy expenditure data were available for 298 participants. Two participants were at the extreme range of the ratio between reported energy intake and energy expenditure by DLW and were excluded from the analyses (one with ratio of 0.01 and one with ratio of 4.28), therefore 296 participants were included in the final analyses. The percentage of participants in each level of reporting is presented in figure 1 for the whole group, figure 1a for men and 1b for women. Among the whole group, 43% were low energy reporters, 45% “true” energy reporters and 12% high energy reporters. Over 14% were undereaters. Among men, 46.3% were low energy reporters, 41.5% “true” energy reporters and 12.2% high energy reporters. Over 16% of men were undereaters. Among women, 40.3% were low energy reporters, 47.7% were “true” energy reporters and 12.1% were high energy reporters. Over 13% of women were undereaters. No significant differences were detected between men and women ($P=0.56$).

Descriptive characteristics are presented in table 2. Significant differences were shown in age, education, energy expenditure and energy intake. The low energy reporters had significantly lower energy intake and higher total energy expenditure (TEE) than “true” or high energy reporters ($P<0.001$). A higher proportion of the low energy reporters completed high school compared to “true” and high energy reporters (81.8%, 66%, and 69%, respectively, $P=0.02$). Low energy reporters were also significantly younger ($P=0.005$). When comparing the 6 groups, age, EI and TEE were significantly different. TEE was significantly lower in the group of true energy reporters-incorrect reporters compared to undereaters and underreporters.

Table 3 presents differences in anthropometric measurements adjusted for age and education. Low energy reporters had significantly higher body weight compared to “true”

and high energy reporters. Among “true” energy reporters, a significantly higher proportion of correct reporters were trying to lose weight than incorrect reporters. Weight and percent body fat were significantly higher among undereaters than in all other groups except for overreporters.

Table 4 presents differences in health and functional indices. No significant differences were detected in any of the variables except for cognitive function which was significantly higher in low energy reporters than in “true” or high energy reporters (90.7 ± 8.5 , 88.0 ± 9.8 , and 85.3 ± 9.1 respectively, $P=0.03$). Among high energy reporters, cognitive function was significantly higher in overreporters than in overeaters. Overeaters had significantly lower cognitive function compared to all other categories. Dietary intake of selected nutrients was compared between the categories adjusted for age, education and energy intake in table 5. When comparing low, “true” and high energy reporters, low energy reporters consumed more calories from protein ($P=0.04$), more servings of meat ($P=0.052$), and fewer servings of sweets and sodas ($P=0.03$) compared with “true” and high energy reporters. “True” energy reporters also had significantly higher HEI scores than low or high energy reporters (68.7 ± 12.6 vs. 66.5 ± 12.8 and 61.1 ± 13.7 , respectively, $P=0.02$). Undereaters consumed a significantly higher percent of calories from protein, most likely because of their higher meat intake, than underreporters. No differences were shown in any of the self rated appetite evaluations except a greater proportion of overreporters reported having a good or very good appetite compared with overeaters. Overreporters also reported significantly higher HEI scores than overeaters.

In table 6, comparisons were made between the whole group of accurate reporters (undereaters, correct reporters, and overeaters) and misreporters (underreporters, incorrect reporters, and overreporters) as well as between undereaters and the rest of our sample for selected characteristics. No significant differences were shown between accurate and misreporters except for a trend for accurate reporters to report fewer medications. In the comparison between undereaters and the rest of the sample, no significant differences were detected in any of the characteristics except for energy intake which was significantly lower among the undereaters ($p<0.001$).

We constructed 2 logistic regression models to predict misreporting compared with accurate reporters and undereating compared with all the other participants. Both models included the following variables: health status, appetite and restraint eating scores, HEI score, weight, age, better appetite compared with one year ago, depression and cognitive scores. None of the variables were significant in the model predicting misreporting. For undereating with the same variables entered in the logistic regression model, only weight was a significant predictor of undereating (OR=1.04, 95% CI: 1.01–1.06).

Discussion

The problem of misreporting, and particularly underreporting, by participants has been noted and discussed by several investigators (27, 28). We showed that 43% of our participants were low energy reporters. Among low energy reporters, almost 30% were losing weight, probably because they were eating less than their energy expenditure level, and therefore, were categorized as undereaters. The undereaters consumed significantly less calories. We did not show any differences between undereaters and the other categories of accurate and misreporters in health status, appetite and functional measurements.

In most validation studies underreporting is calculated by estimating the gap between energy intake and energy expenditure (2–5, 26–29, 30). Several studies used DLW as an unbiased reference biomarker of TEE to estimate energy misreporting from diet records (22, 26, 27,

28, 31–35). However, information regarding weight change prior to the dietary assessment was not taken into account in all but one of these studies (36). This study is the first conducted among the elderly evaluating “misreporting” using both DLW and measured weight change. Weight change prior to the energy expenditure sub-study visit was used to identify true reporters and misreporters. Our hypothesis was that participants losing weight are “true under-eaters” rather than misreporters.

In the OPEN study which evaluated dietary misreporting in a sample of 484 adults age 40–69 years from Montgomery County, Maryland (26), 35% of men and 23% of women were low energy reporters. In comparison, 46% of men and 40% of women in our study were low energy reporters. In another study among postmenopausal women with an average age of 60 (37), 42% were low energy reporters. Combined, these data suggest that, with increasing age, the rate of low energy reporting increases as well, possibly due to the increased rate of undereating.

In contrast to other studies that have found women more likely to be low energy reporters, women in our study did not differ from men in the frequency of low energy reporting. It has been assumed by other investigators that low reported energy intake among women seen in younger populations reflects social desirability bias (38). In our study, we did not show any difference in the social desirability score, possibly because older women in our study were less concerned about their weight than younger women (39, 40). In addition, body image dissatisfaction was shown to increase the risk for underreporting among younger African-American women, while older African American women were less susceptible to body image dissatisfaction and thus less prone to under-reporting (41). Our results are consistent with these findings.

We did not find significant differences in reporting status by ethnicity, in contract to other studies (2, 9, 29, 42). Factors that are associated with ethnicity, such as lower socioeconomic status, may better explain previous findings that have showed differences in reporting status by ethnicity, rather than ethnicity itself.

Like findings from other studies among young and old populations (4, 43), underreporters had significantly higher body weight than “true” or high reporters. Surprisingly, undereaters tended to have even higher BMI than the underreporters. Obesity is the factor most consistently associated with low energy reporting across all age groups (4, 29, 44, 45). Underreporting among obese participants may be explained by omission of certain items, mainly snacks, or by actually undereating while recording. This explanation may hold true exclusively for the underreporters. For the undereaters, we used weight over time as a marker for truly decreased energy intake.

TEE was higher among the underreporters in our study. Previously in Health ABC, an increased TEE was shown in men compared with women and among blacks as compared with whites due to a higher Resting Metabolic Rate (RMR) (12). Gender differences with higher TEE among men compared with women was also shown in another study conducted among Latin American elderly (35). Our results did not indicate significant differences in race or gender between the reporting groups, however, a slightly higher percent of white participants were included in the underreporting category. TEE decreases with age due to the decrease in fat free mass and thus RMR (12) and weight is associated with an increase in RMR (46). Therefore younger age and higher weight may explain the significant difference shown in TEE between low, “true” and high energy reporters.

Unlike findings from other studies (43, 47, 48), cognitive functioning and higher education were associated with both underreporting and undereating. The relationships between education level and compromised cognitive function and misreporting is complex.

Epidemiological studies indicate that underreporting of energy intake was more frequent in subjects with either a low (4, 49) or a high (49, 50) educational level. In a study in Belgium (43), no association between underreporting and educational level was shown, probably due to the low educational level among the participants.

We showed significant differences in macro-nutrient intake between the groups. The “true” energy reporters consumed more daily servings of fats, oils, sweets and sodas. These findings suggest that sweets and high fat foods may be less accurately reported by low or high energy reporters. This is also supported by the significantly higher HEI scores among the “true” energy reporters. In a study that was conducted among obese men (36), 37% underreported energy intake, with a selective underreporting of fat intake. Selective underreporting of fat intake was also found in a study by Poppitt et al (51) in which the percentage of energy from fat decreased with lower quintiles of the ratio of energy intake to basal metabolic rate. Among both obese and non-obese women, the major cause of underreporting was failure to report between meal snack foods (51, 52). Our study was limited by its cross sectional design. The DLW was administered only once, and therefore, it might not adequately reflect long-term energy intake as queried by the FFQ. However the weight change 1–2 years prior to the current evaluation may better reflect long-term energy intake. For this study, we chose a change in weight in either direction of greater than 2% as the cutoff to define weight change in order to increase our sensitivity for weight change. Using a cutoff of 3 or 5%, as was used in other studies (43, 41, 53), would result in either 9 or 5%, respectively, of the participants categorized as undereaters, as opposed to over 14% using 2% as the cut-off. Moreover, using 3 or 5% as the cutoff for weight change did not change the results.

In conclusion, FFQ is an accepted and widely used dietary assessment tool. However, its reliability is limited by a tendency toward underreporting. Low reported energy intake may be due to deliberate or accidental omissions, failure of recall or actual low energy intake. However, in the old, the proportions of the above causes may differ from the young. Weight changes, which are common in older adults, must be taken into account when evaluating reporting bias. Further work should be done in characterizing underreporting in the elderly.

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Figure 1.

Percent of low energy reporters (LER), “true” energy reporters (TER) and high energy reporters (HER) by accurate reporting categories (underreporters, correct reporters, and overreporters) and misreporters (underreporters, incorrect reporters, and overreporters)

Figure 1a: Percent of low energy reporters (LER), “true” energy reporters (TER) and high energy reporters (HER) by accurate reporting categories (underreporters, correct reporters, and overreporters) and misreporters (underreporters, incorrect reporters, and overreporters) **among men**

Figure 1b: Percent of low energy reporters (LER), “true” energy reporters (TER) and high energy reporters (HER) by accurate reporting categories (underreporters, correct reporters, and overreporters) and misreporters (underreporters, incorrect reporters, and overreporters) **among women**

Table 1

Definition of under and over reporters, under eaters, accurate and misreporters

EI/TEE Ratio	Levels of reporting bias	Percent weight change	EI/TEE ratio and weight change match
<0.77	LER (low energy reporters)	< -2.0	Yes-UE (correct reporters-undereaters)
		-2.0	No-UR (underreporters)
0.77–1.28	TER (“true” energy reporters)	-2.0–2.0	Yes-CR (correct reporters)
		<-2.0 or >2.0	No-IR (incorrect reporters)
>1.28	HER (high energy reporters)	>2.0	Yes-OE (correct reporters-overeaters)
		<2.0	No-OR (overreporters)

Table 2

Descriptive variables by levels of reporting bias and accuracy

Variable	Levels of reporting bias					
	LER ¹		TER ²		HER ³	
	UE ⁴ N=44	UR ⁵ N=84	CR ⁶ N=53	IR ⁷ N=79	OE ⁸ N=8	OR ¹ N=28
Age, mean (SD), y ^{##}	73.9 (2.9)	73.8 (2.9)	74.7 (2.7)	75.0 (2.8)	76.3 (2.8)	74.3 (3.2)
Black, %	13 (33.3)	37 (44)	25 (50)	42 (56.8)	4 (40)	14 (53.8)
Women, %	21 (54)	46 (55)	23 (46)	349 (46)	5 (50)	13 (50)
Education, % completed high school [#]	35 (79.5)	69 (82.1)	35 (66)	52 (52)	5 (62.5)	20 (71.4)
Current or former smoker, %	23 (58.9)	54 (64.3)	30 (60)	41 (55.4)	5 (50)	50 (57.7)
Marital status, % married	24 (61.5)	44 (52.4)	25 (50)	37 (50)	4 (40)	16 (61.5)
Reported EI, mean (SD) Kcal/d ^{***}	1280.3 (335.5)	1312.2 (415.9)	1968.6 (426.3)	1975.8 (581.4)	3348.8 (1023.8)	3172.7 (813.9)
TEE, mean (SD) Kcal/d ^{***}	2321.5 (457.0)	2296.2 (458.4)	2133.0 (363.7)	2027.5 (470.2)	2031.5 (479.6)	2024.8 (458.9)

[#] P value between LER, TER and HER <0.05

^{*} P between the 6 groups

^{*} P-value <0.05

^{**} P-value <0.01

Post-Hoc results; Age: 2#4 TEE 1#4, 1#6 2#4 2#6

¹ LER: low energy reporters

² TER: "true" energy reporters

³ HER: high energy reporters

⁴ UE: undereaters

⁵ UR: underreporters

⁶ CR: correct reporters

⁷ IR: incorrect reporters

⁸ OE: overeaters

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Anthropometric measurements by levels of reporting bias and accuracy adjusted for age and education

Table 3

Variable	Levels of reporting bias						
	LER ²		TER ³			HER ⁴	
	UE ⁵ N=44	UR ⁶ N=84	CR ⁷ N=53	IR ⁸ N=79	OE ⁹ N=8	OR ¹ N=28	
Currently trying to lose weight, %	19 (43.2)	29 (34.5)	20 (37.7)	20 (21.5)	1 (12.5)	8 (28.6)	
Body weight, mean (SD) ^{***}	84.0 (17.5)	77.7 (16.0)	75.0 (14.5)	73.3 (14.2)	67.2 (10.1)	74.4 (14.4)	
BMI, mean (SD) ^{#####}	28.5 (4.9)	27.9 (5.1)	27.1 (4.8)	26.4 (4.1)	24.1 (3.2)	26.9 (5.1)	
Percent body fat, mean (SD) [*]	37.2 (6.7)	33.9 (8.1)	34.0 (7.4)	34.5 (8.3)	28.0 (8.2)	35.3 (9.4)	
from age 50, mean (SD) ^{***}	9.2 (13.1)	6.9 (11.5)	10.3 (19.6)	6.5 (11.9)	-5.9 (7.1)	6.7 (16.8)	

[#] P value between LER, TER and HER <0.05

^{*} P between the 6 groups - <0.05

^{**} P-value <0.01

^{***} P-value <0.001

Post-Hoc results; Weight 1#3, 1#4, 1#5

¹ OR: overreporters

² LER: low energy reporters

³ TER: "true" energy reporters

⁴ HER: high energy reporters

⁵ UE: under eaters

⁶ UR: underreporters

⁷ CR: correct reporters

⁸ IR: incorrect reporters

⁹ OE: over eaters

Table 4

Comparison of health and functional indices by levels of reporting bias and accuracy (adjusted for age and education for continuous variables)

Variable	Levels of reporting bias					
	LER ¹		TER ²		HER ³	
	UE ⁴ N=44	UR ⁵ N=84	CR ⁶ N=53	IR ⁷ N=79	OE ⁸ N=8	OR ⁹ N=28
Fair/poor health (self rated), %	7 (15.9)	11 (13.1)	14 (26.4)	16 (20.3)	1 (12.5)	5 (17.9)
No. of medications, mean (SD)	5.7 (3.9)	4.9 (4.1)	5.9 (4.2)	4.8 (3.2)	4.1 (3.5)	4.4 (3.7)
EPSE score, mean (SD)	10.4 (1.3)	10.3 (1.2)	10.2 (1.4)	10.1 (1.4)	10.1 (1.8)	10.3 (1.7)
Timed 20 meter walk (seconds), mean (SD)	1.2 (0.2)	1.1 (0.2)	1.1 (0.2)	1.1 (0.2)	1.1 (0.2)	1.1 (0.2)
Cognitive function-3MS, mean (SD) **	89.7 (10.1)	91.2 (7.5)	89.0 (9.5)	87.3 (9.9)	77.5 (13.0)	87.5 (6.2)
Depression-CES-D-10 score, mean (SD)	4.5 (4.5)	3.5 (3.4)	4.7 (4.4)	4.5 (3.7)	5.6 (4.2)	4.2 (3.8)
Systolic BP, mean (SD)	135.8 (19.9)	138.7 (22.5)	138.3 (19.5)	133.8 (20.9)	140.8 (22.5)	142.3 (22.6)
Diastolic BP, mean (SD)	72.5 (13.1)	74.2 (10.6)	70.9 (11.9)	71.1 (11.8)	71.8 (16.3)	75.0 (11.5)

[#] P value between LER, TER and HER <0.05

^{*} P between the 6 groups <0.05

^{**} P<0.01

¹ LER: low energy reporters

² TER: "true" energy reporters

³ HER: high energy reporters

⁴ UE: underreporters

⁵ UR: underreporters

⁶ CR: correct reporters

⁷ IR: incorrect reporters

⁸ OE: overreporters

⁹ OR: overreporters

Table 5

Dietary intake of selected nutrients, food groups and eating quality by the level of reporting bias and accuracy (adjusted for age, education and energy intake for continuous variables)

Variable	Levels of reporting bias					
	LER ¹		TER ²		HER ³	
	UE ⁴ N=44	UR ⁵ N=84	CR ⁶ N=53	IR ⁷ N=79	OE ⁸ N=8	OR ⁹ N=28
% energy from protein ^{**}	15.9 (3.4)	14.4 (3.2)	14.0 (3.0)	13.5 (2.8)	12.8 (2.2)	14.1 (3.2)
% energy from carbohydrates	51.7 (9.1)	53.1 (8.6)	52.3 (8.0)	54.0 (8.3)	51.8 (5.5)	51.5 (9.4)
% energy from fat	32.5 (7.2)	32.6 (8.0)	35.0 (7.1)	33.6 (7.5)	39.9 (4.7)	38.2 (8.4)
Daily servings of vegetables, mean (SD)	2.2 (1.5)	2.3 (1.5)	3.1 (1.4)	3.0 (2.1)	3.6 (1.1)	2.1 (1.3)
Daily servings of fruit, mean (SD)	1.7 (1.2)	1.791 (0)	1.9 (1.0)	1.9 (1.1)	8.4 (4.4)	9.4 (3.7)
Daily servings of grains, mean (SD)	4.6 (1.8)	4.8 (2.2)	6.8 (2.8)	7.0 (2.6)	3.1 (1.8)	3.4 (1.7)
Daily servings of meat/protein, mean (SD) ^{**}	1.5 (0.7)	1.1 (0.8)	1.8 (0.96)	2.0 (1.7)	3.1 (1.8)	3.4 (1.7)
Daily servings of milk, yogurt and cheese, mean (SD)	0.86 (0.88)	0.98 (0.94)	1.6 (1.4)	1.3 (1.2)	2 (1.2)	1.4 (1.0)
Daily servings of fats, oils, sweets and sodas, mean (SD) ^{***#}	2.4 (1.3)	2.3 (1.5)	3.4 (1.5)	3.5 (1.7)	2.0 (1.2)	1.4 (1.0)
Healthy Eating Index score, mean (SD) [#]	68.3 (14.1)	66.4 (13.4)	68.3 (11.4)	68.7 (13.4)	58.3 (10.4)	64.1 (17.0)
Appetite and restraint score, mean (SD)	9.1 (5.5)	9.6 (4.9)	8.3 (5.0)	7.9 (5.5)	6.0	7.1
Marlowe-Crowne Social Desirability score, mean (SD)	23.6 (4.6)	24.5 (4.5)	24.4 (3.7)	23.9 (3.9)	24.5 (3.9)	24.1 (4.6)
Good appetite (self rated), %	35 (79.5)	73 (86.9)	42 (79.2)	62 (78.5)	4 (50)	25 (89.3)
Better appetite (self rated), %	5 (11.4)	12 (14.5)	9 (17.3)	7 (8.9)	1 (12.5)	6 (21.4)

[#] P value between LER, TER and HER <0.05

Post-Hoc results; Protein % 1#4, Daily servings of meat/protein 1#5, 1#6, 2#3, 2#4, 2#5, 2#6

^{*} P between the 6 groups

^{*} P-value<0.05

^{**} P-value <0.01

^{***} P<0.001

¹ LER: low energy reporters

- ² TER: “true” energy reporters
- ³ HER: high energy reporters
- ⁴ UE: under eaters
- ⁵ UR: underreporters
- ⁶ CR: correct reporters
- ⁷ IR: incorrect reporters
- ⁸ OE: overeaters
- ⁹ OR: overreporters

Table 6
Comparison between accurate reporters and misreporters and between underreporters and everyone else for selected characteristics

	Misreporters N=191	Accurate reporters N=105	P-value	Underreporters N=44	Others N=252	P-value
Age, mean (SD), y	74.9 (2.9)	74.7 (3.0)	0.77	74.2 (3.0)	74.9 (3.0)	0.16
Black, %	47 (44.8)	95 (49.7)	0.42	16 (36.4)	126 (50.0)	1.0
Women, %	51 (48.6)	98 (51.3)	0.65	20 (45.5)	129 (51.2)	0.6
Weight, mean (SD), Kg	75.4 (15.2)	78.1 (16.3)	0.15	83.9 (17.5)	75.0 (15.0)	0.34
Energy intake, mean (SD), Kcal	1860.6 (868.7)	1792.2 (752.8)	0.50	1278.3 (343.0)	1933.8 (850.4)	<0.001
Healthy Eating Index score, mean (SD)	66.4 (13.5)	67.6 (12.1)	0.44	68.1 (12.9)	66.6 (13.0)	0.48
Appetite and restraint score >8, %	47 (45)	87 (46)	0.84	20 (45.5)	114 (45.6)	1.0
Good appetite (self rated)	24 (22.9)	31 (16.2)	0.16	35 (79.5)	206 (81.7)	0.73
Better appetite (self rated)	15 (14.4)	25 (13.2)	0.76	5 (11.4)	35 (13.9)	0.65
Poor/fair health (self-rated)	22 (21)	32 (16.8)	0.37	7 (15.9)	47 (18.7)	0.6
Number of medications, mean (SD)	4.8 (3.7)	5.7 (4.0)	0.057	5.7 (3.9)	5.0 (3.8)	0.24
Cognitive function-3MS, mean (SD)	89.1 (8.6)	88.4 (10.5)	0.58	89.7 (10.2)	88.7 (9.2)	0.5
Depression CES-D-10 score, mean (SD)	4.0 (3.6)	4.7 (4.4)	0.15	4.6 (4.5)	4.2 (3.8)	0.6