

# Undereating and underrecording of habitual food intake in obese men: selective underreporting of fat intake

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# Undereating and underrecording of habitual food intake in obese men: selective underreporting of fat intake<sup>1,2</sup>

Annelies HC Goris, Margriet S Westerterp-Plantenga, and Klaas R Westerterp

See corresponding editorial on page 3.

## ABSTRACT

**Background:** Underreporting of food intake is common in obese subjects.

**Objective:** One aim of this study was to assess to what extent underreporting by obese men is explained by underrecording (failure to record in a food diary everything that is consumed) or undereating. Another aim of the study was to find out whether there was an indication for selective underreporting.

**Design:** Subjects were 30 obese men with a mean ( $\pm$ SD) body mass index (in kg/m<sup>2</sup>) of  $34 \pm 4$ . Total food intake was measured over 1 wk. Energy expenditure (EE) was measured with the doubly labeled water method, and water loss was estimated with deuterium-labeled water. Energy balance was checked for by measuring body weight at the start and end of the food-recording week and 1 wk after the recording week.

**Results:** Mean energy intake and EE were  $10.4 \pm 2.5$  and  $16.7 \pm 2.4$  MJ/d, respectively; underreporting was  $37 \pm 16\%$ . The mean body mass loss of  $1.0 \pm 1.3$  kg over the recording week was significantly different ( $P < 0.05$ ) from the change in body mass over the nonrecording week, and indicated 26% undereating. Water intake (reported + metabolic water) and water loss were significantly different from each other and indicated 12% underrecording. The reported percentage of energy from fat was a function of the level of underreporting: percentage of energy from fat =  $46 - 0.2 \times$  percentage of underreporting ( $r^2 = 0.28$ ,  $P = 0.003$ ).

**Conclusions:** Total underreporting by the obese men was explained by underrecording and undereating. The obese men selectively underreported fat intake. *Am J Clin Nutr* 2000;71:130–4.

**KEY WORDS** Undereating, underrecording, underreporting, energy balance, doubly labeled water, obesity, men

## INTRODUCTION

In many Western societies, the prevalence of obesity has increased (1) and the relatively high energy intakes might be partly due to a high fat intake (2). However, food intake is hard to measure, especially in obese subjects (1, 3). Discrepancies between reported energy intakes and measured energy expenditures (with the doubly labeled water method) of  $\approx 20$ –50% have been described in obese subjects (4–12). The degree of underreporting is positively correlated with body mass index (6–8, 13–15). The aim

of the present study was to assess whether this underreporting (ie, a discrepancy between energy intake and expenditure) is also selective for macronutrients, meal types, and snacks. A second aim of the study was to assess to what extent underreporting in obese subjects is explained by underrecording or undereating. We defined underrecording (the failure to record in a food diary everything that is consumed) as a discrepancy between reported energy intake and measured energy expenditure without a change in body mass; we defined undereating as the consumption of less than usual because of the requirement to record food intake, with a resultant decline in body mass (16). Compliance with food recording was checked with the water balance technique, as we described previously (16). Briefly, healthy subjects are in water balance. The recording of water intake appears to represent total food recording; thus, a recorded water intake below the measured water loss indicates the underrecording of water and food intakes. In an earlier study in a group of lean, motivated women, the underreporting of habitual food intake was entirely explained by undereating (16). Subjects changed their food patterns during the recording period. In obese subjects reporting their total food intake, underrecording and undereating have not yet been distinguished.

## SUBJECTS AND METHODS

### Subjects

Thirty obese men with a mean ( $\pm$ SD) age of  $44 \pm 7$  y and body mass index (in kg/m<sup>2</sup>) of  $34.1 \pm 3.9$  (range: 29.5–44.8) participated in the study. Subjects were recruited by advertisements in a local newspaper and on local television for a weight-loss intervention study. The results presented are baseline measurements, made before the intervention started. The protocol was approved by the Medical Ethical Committee of the University of Maastricht.

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## Protocol

The study included a 2-wk observation period for the measurement of energy expenditure. Food intake, water intake, and water loss were measured over the first week. Energy balance was checked for by measuring body weight changes over each of the 2 wk separately. Thus, possible weight fluctuations resulting because subjects consumed less when they had to record their food intake could be compared with normal weight fluctuations measured over a nonrecording week.

## Food and water intake

Total food intake was estimated with use of a 7-d dietary record. Subjects received instructions from a dietitian on how to keep a food record and were asked to not change their habitual food intakes. The data on the food records were used to calculate intakes of total energy, protein, fat, carbohydrate, and water with a computer program based on food tables (BECEL NUTRITION PROGRAM, 1988; Nederlandse Unilever Bedrijven BV, Rotterdam, Netherlands) (17). Total water intake was calculated from reported food and water intakes and the calculated amount of metabolic water. The amount of metabolic water was calculated by multiplying energy expenditure by the percentages of energy from protein, fat, and carbohydrate (from the 7-d food record). Oxidation water is 0.41 mL/g for protein, 1.07 mL/g for fat, and 0.6 mL/g for carbohydrate (18).

## Energy expenditure and water loss

Energy expenditure was measured with the doubly labeled water method according to Westerterp et al (19). Water loss was calculated from deuterium elimination as included in the doubly labeled water method. Subjects were given, on the evening of day 0, a weighed dose of a mixture of 99.84 atom%  $^2\text{H}_2\text{O}$  in 10.05 atom%  $\text{H}_2^{18}\text{O}$ , such that baseline levels were increased to  $\geq 300$  ppm for  $^2\text{H}$  and  $\geq 2300$  ppm for  $^{18}\text{O}$ . A background urine sample was collected on the evening of day 0. Additional urine samples were collected on day 1 (from the second void) on the evening of day 1, the morning and evening of day 8, and the morning and evening of day 15.

## Body mass

Body mass was measured 3 times at 7-d intervals. Subjects were weighed (in underwear) in the morning, before any food or beverage consumption and after voiding, on a digital balance accurate to 0.1 kg (Seca, Almere, Netherlands). Body composition was determined by underwater weighing as described elsewhere (20).

## Statistics

The results are presented as means  $\pm$  SDs for 30 subjects. Simple regression analyses were performed for energy intake and energy expenditure and water intake and loss. A one-factor analysis of variance for repeated measures and a post hoc Scheffe test were used to compare the 3 measurements of body mass. Changes in body mass were compared with a paired *t* test.

Underreporting, underrecording, and undereating were calculated as follows:

$$\text{Underreporting} = \frac{(\text{energy intake} - \text{energy expenditure})}{(\text{energy expenditure})} \times 100\% \quad (1)$$

$$\text{Underrecording} = \frac{(\text{water intake} - \text{water loss})}{(\text{water loss})} \times 100\% \quad (2)$$

$$\text{Undereating} = \frac{(\text{body mass change recording week} \times 30 \text{ MJ/7 d})}{(\text{energy expenditure})} \times 100\% \quad (3)$$

where 1 kg body mass was assumed to be equivalent to 30 MJ (21).

**TABLE 1**

Reported food intake and measured energy expenditure and water loss<sup>1</sup>

	Value
Energy intake (MJ/d)	10.4 $\pm$ 2.5
Energy expenditure (MJ/d)	16.7 $\pm$ 2.4
Body mass change in nonrecording week (kg/wk)	0.0 $\pm$ 1.0
Body mass change in recording week (kg/wk)	-1.0 $\pm$ 1.3
Recorded water intake (L/d)	2.8 $\pm$ 0.9
Recorded + metabolic water intake (L/d)	3.3 $\pm$ 0.9
Water loss (L/d)	3.7 $\pm$ 0.5

<sup>1</sup> $\bar{x} \pm \text{SD}$ ; *n* = 30.

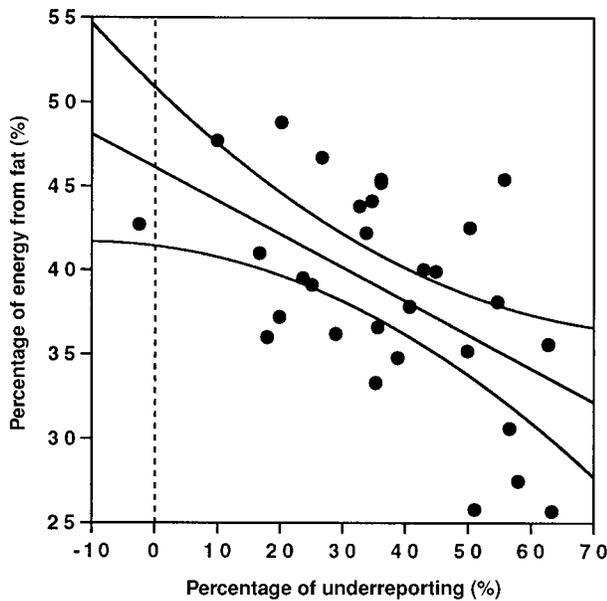
Simple regression analyses were also conducted by using the percentage of underreporting and reported percentages of energy from protein, fat, and carbohydrate to determine whether there was selective underreporting. Calculations of the percentages of energy from protein, fat, and carbohydrate included the amount of energy derived from alcohol. Significance was set at *P* < 0.05. The STATVIEW SE+ program (1988; Abacus Concepts, Inc, Berkeley, CA) was used for the statistical analysis.

## RESULTS

Reported food intake and measured energy expenditure are presented in **Table 1**. Most subjects had a reported energy intake below the measured energy expenditure. Only one subject had a reported energy intake within 10% of the measured energy expenditure. The average percentage of underreporting was 37  $\pm$  16% in this group. There was no relation between the reported energy intake and the measured energy expenditure ( $r^2 = 0.05$ , *P* = 0.2; simple regression analysis).

The 3 body mass measurements were, in sequence of time, 108.8  $\pm$  14.7, 108.1  $\pm$  14.7, and 107.7  $\pm$  14.8 kg. The first body mass measurement differed significantly from the last 2 measurements (*P* = 0.0001, one-factor analysis of variance and a post hoc Scheffe test). Changes in body mass over the nonrecording and recording weeks also differed significantly (*P* = 0.02, paired *t* test; **Table 1**). The percentage of undereating, based on the change in body mass over the recording week, was 26  $\pm$  33%.

Fifty-five percent of the variation in total water intake (recorded + metabolic) was explained by water loss (regression equation: total water intake (L/d) = 1.35  $\times$  water loss (L/d) - 1.7; *P* = 0.0001). The percentage of underrecording, based on the negative water balance, was 12  $\pm$  16%. The reported percentages of energy from protein [(-0.04  $\times$  % underreporting) + 14.3;  $r^2 = 0.11$ , *P* = 0.07] and carbohydrate ( $r^2 = 0.1$ ) were not significantly related to the percentage of underreporting (simple regression analysis). The reported percentage of energy from fat was related to the percentage of underreporting (**Figure 1**). The intercept of the regression line, which indicates the percentage of energy from fat in the case of no underreporting, was 46% of energy from fat. The 95% CIs for the adjusted 46% of energy from fat were 41% and 51%. The mean reported percentage of energy from fat was 39  $\pm$  6%. The reported percentages of energy from fat and carbohydrate were not significantly related to the percentage of undereating [ $r^2 = 0.01$  (*P* = 0.96) and  $r^2 = 0.0$  (*P* = 0.9), respectively] or to the percentage of underrecording [ $r^2 = 0.01$  (*P* = 0.6) and  $r^2 = 0.01$  (*P* = 0.6), respectively]. The reported percentage of energy from protein was pos-



**FIGURE 1.** Percentage of energy from fat (reported) as a function of the percentage of underreporting in obese men ( $n = 30$ ). Linear regression line: % energy from fat =  $46 - 0.2 \times$  % underreporting ( $r^2 = 0.28$ ,  $P = 0.003$ ).

itively related to the percentage of underreporting ( $r^2 = 0.22$ ,  $P = 0.009$ ), but not to the percentage of underrecording ( $r^2 = 0.03$ ,  $P = 0.4$ ).

The reported percentages of energy from fat at the different meals were related to the percentages of underreporting (**Figure 2**). The same relation was found for the reported percentages of energy from fat from the afternoon and evening snacks (simple regression analysis:  $r^2 = 0.12$  and  $r^2 = 0.13$ , respectively,  $P = 0.05$ ). The results of a simple regression analysis on reported energy intakes at the different meals and the percentage of underreporting are shown in **Table 2**. The reported energy intakes at lunch, dinner, and the evening snack were related to the total percentage of underreporting. The reported energy intake in the morning (breakfast and morning snack) was not significantly related to the total percentage of underreporting.

## DISCUSSION

The results of this study showed a 37% underreporting by male obese subjects. The mean body mass loss over the recording week indicated 26% undereating and the discrepancy between total water intake and water loss indicated 12% underrecording. The recording of water does not necessarily represent the recording of food intake. However, most foodstuffs contain a certain amount of water; therefore, it was concluded that the underrecording of food intake was identical to the underrecording of water intake.

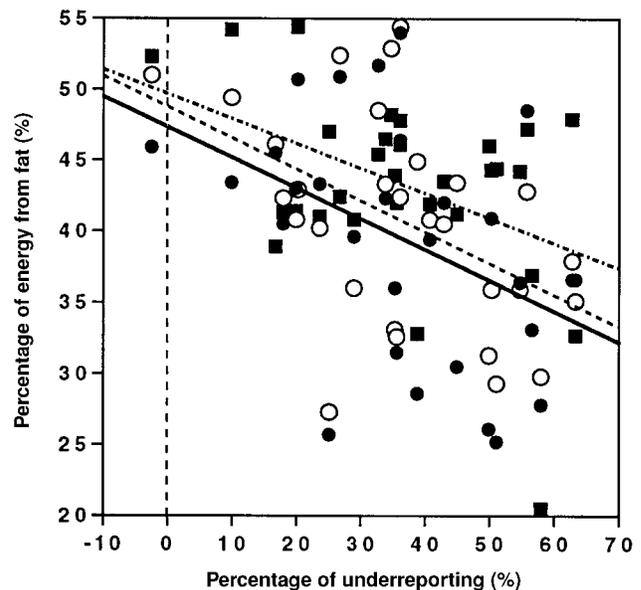
About 70% of the total underreporting was due to a diminished intake of food over the recording period. In an earlier study with lean women, total underreporting (16%) was entirely explained by undereating (16). The present study also indicated that recording itself is a useful tool for losing body mass: 70% of the total amount of underreporting was undereating. The level of

undereating found in this study (37%) was of the same magnitude as found in other studies of obese subjects (4–12).

Besides this total underreporting of 37%, there was also a selective underreporting of fat intake. The reported percentage of energy from fat was negatively correlated with the amount of underreporting, and, in the case of no underreporting, the percentage of energy from fat would be  $46 \pm 5\%$ . The reported percentage of energy from fat of  $39 \pm 6\%$  was relatively high (higher than the recommended dietary guidelines of 30–35%), although not higher than that reported previously in a sample of 34 obese subjects partly controlled for underreporting (2). In a representative sample of the Dutch population ( $n = 2625$ ), the average percentage of energy from fat, measured with a 2-d dietary record, was 40% for men (22). This value may have been underestimated because of the underreporting of food intake.

Selective underreporting of fat intake was also found in the study by Voss et al (23), in which the percentage of energy from fat decreased with lower quintiles of the ratio of energy intake to basal metabolic rate. Food intake in this study was measured with a food-frequency questionnaire, and energy expenditure was estimated from calculations of basal metabolic rate (with use of age and weight) and from the assessment of physical activity by using a questionnaire.

Lissner and Lindroos (24) compared reported intakes from 2 dietary assessment methods. Reported energy intakes differed with the 2 methods, but the various macronutrients did not. They concluded that there was no qualitative underreporting of food intake in obese men and women. Rutishauser (25) performed a similar analysis in lean and obese adults and found significantly different percentages of energy from fat and carbohydrate but no significant differences in reported energy



**FIGURE 2.** Percentage of energy from fat reported at breakfast (●), lunch (○), and dinner (■) as a function of the percentage of underreporting in obese men ( $n = 30$ ). The linear regression lines are as follows: % energy from fat reported at breakfast =  $46 - 0.2 \times$  % underreporting ( $r^2 = 0.19$ ,  $P = 0.02$ ), % energy from fat reported at lunch =  $49 - 0.2 \times$  % underreporting ( $r^2 = 0.23$ ,  $P = 0.008$ ), and % energy from fat reported at dinner =  $50 - 0.2 \times$  % underreporting ( $r^2 = 0.19$ ,  $P = 0.02$ ).

**TABLE 2**

Simple regression analysis of reported energy intakes at different meals (*y*) and the percentage of underreporting (*x*) in 30 obese men

<i>y</i>	<i>r</i>	<i>P</i>
Reported energy intake from breakfast	0.19	0.3
Reported energy intake from morning snack	0.17	0.4
Reported energy intake from lunch	0.59	0.0006
Reported energy intake from afternoon snack	0.01	0.95
Reported energy intake from dinner	0.56	0.001
Reported energy intake from evening snack	0.47	0.009

intakes between the methods used. External validation was needed in those studies because dietary assessment methods are mostly subject to the same errors.

Specific information on the energy expenditure of subjects was available in our study and this made it possible to compare the reported percentages of energy from the macronutrients with an external validation, the percentage of underreporting. In a study by Heitmann and Lissner (15), reported intakes were compared with nitrogen loss and estimated energy expenditure in 323 men and women (lean and obese). The underreporting of protein was disproportional to the underreporting of energy, suggesting a selective underreporting of fat and carbohydrate-rich foods. The degree of obesity also influenced the dietary reporting both quantitatively and qualitatively (15). Livingstone et al (26) suggested in their study that the underreporting of total food intake was explained by a selective underreporting of snacks. However, subjects who underreported total food intake did not report a significantly lower snack intake. Further analysis to determine any selective underreporting was not done.

In a study by Poppitt et al (27), nonobese women stayed for 24 h in a metabolic facility and had ad libitum food intake, which was covertly measured. The next day, subjects had to write down what they ate and drank during the previous 24 h. Food items eaten during a meal were reported accurately, but the between-meal snack foods were underreported. The snacks provided were mostly carbohydrate rich and there was a selective underreporting of carbohydrate, but not of fat and protein. In our study, there was no selective omission of snacks in the reporting of food intake. In general, the foods consumed in the morning (breakfast and morning snack) were reported accurately. Subjects reported the foods consumed at lunch, at dinner, and in the evening less accurately (higher values of underreporting were associated with lower reported energy intakes at those meals). The reported percentages of energy from fat at the different meals were higher in subjects with a lower percentage of underreporting.

Why would subjects selectively underreport their fat intakes? In general, 30% underreporting of underreporting does not show a complete lack of compliance. Obese subjects might often consume energy-dense foods (foods with a high percentage of fat according to the Atwater factors) in larger than culturally determined portion sizes (2). Therefore, when they report a normal portion of an energy-dense food with a high fat content, they might in fact consume a portion that is normal to them, but should be recorded as "large" by the dietitian. A selective underreporting of fat intake at the meals would be the consequence. Thus, a simple energy intake adjustment would not solve the problem of underreporting for estimation of energy intake. Selective underreporting might have more severe implications than would nonselective underreporting in a dietary survey of obese subjects (28, 29).

The national health campaigns aimed at lowering fat intakes are thought to be successful because results from national food consumption measurements have shown a decline in reported fat intakes over several years (30–32). However, has there been a true decline in reported fat intakes or has there been a selective underreporting of fat intake, as was found in the present study? Results from the third National Health and Nutrition Examination Survey (NHANES III, phase 1, 1988–1991) show a decline in the reported percentage of energy from fat, an increase in reported energy intakes, and an increase in the prevalence of overweight compared with NHANES II (1976–1980) (32–34). The ratio of reported energy intake to estimated basal metabolic rate was 1.36 for the total population (age  $\geq 20$  y) in NHANES III. For a sedentary population, one would expect a ratio between 1.50 and 1.55, which indicates that energy intake was underreported (34). This underreporting of energy was also probably associated with a selective underreporting of macronutrients, at least in obese participants.

In conclusion, we observed 37% underreporting of energy intake in obese men, consisting of 26% underreporting and 12% underreporting. Selective underreporting of fat intake as observed in the obese men in the present study might throw a different light on the outcome of dietary surveys. 

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