Dietary underreporting by obese individuals—is it specific or non-specific?

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Abstract

***Objective*—To examine the distribution of patterns of macronutrient density in relation to obesity.**

***Design*—Cross sectional.**

***Setting*—Denmark.**

***Subjects*—323 men and women aged 35-65 years, selected randomly from a larger population sample of Danish adults.**

***Main outcome measure*—Bias in dietary reporting of energy and protein intake in relation to percentage body fat, assessed by comparison of data from an interview on dietary intake with data estimated from 24 hour nitrogen output, validated by administering *p*-aminobenzoic acid, and estimated 24 hour energy expenditure.**

***Results*—Degree of obesity was positively associated with underreporting of total energy and protein, whereas compared with total energy reported, protein was overreported by the obese subjects.**

***Conclusion*—Errors in dietary reporting of protein seem to occur disproportionately with respect to total energy, suggesting a differential reporting pattern of different foods. Although, on average, all subjects showed a greater underreporting of energy than of protein, this was most common in the obese subjects. Snack-type foods may be preferentially forgotten when obese people omit food items in dietary reporting. These results seem to agree with the general assumption that obese people tend to underreport fatty foods and foods rich in carbohydrates rather than underreport their total dietary intake. These results may have implications for the interpretation of studies of diet and comorbidities related to obesity.**

Introduction

Associations between diet and health are often weak or inconsistent. This is generally attributed to difficulties in obtaining valid information on dietary intake. Several reports have shown that obese individuals underreport their dietary intake substantially, whether the intake is self recorded or assessed by interview.[1-5] Whether this is a consequence of selective underreporting of certain foods (such as snacks or items considered unhealthy) or general underreporting of all food, or both, is not known. Methods such as the doubly labelled water technique,[5,6] or calculating 24 hour urinary nitrogen output,[7,8] have been used to describe the magnitude of underreporting. Such errors in dietary reporting may not invalidate the dietary data, provided that the underreporting is not selective. Indeed, comparisons of methods of reporting dietary intake in obese subjects have shown similar patterns of nutrient density despite substantial differences in total energy intake shown by different methods.[9] Such results, however, are limited by the fact that no method of reporting dietary intake can be assumed to be unbiased. We examined the errors in patterns of nutrient density in relation to obesity by comparing data from an interview on dietary intake with data on urinary nitrogen output and estimated energy expenditure.

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Subjects and methods

The study was part of the Danish MONICA project (an international study conducted under the auspices of the World Health Organisation to monitor trends in and determinants of mortality from cardiovascular disease) carried out between 1987 and 1988.[10,11] The study population included 552 Danish citizens aged 35, 45, 55, and 65 years, selected at random from a larger population sample of 4581 subjects.[10]

The project was approved by the ethics committee for Copenhagen county and is in accordance with the Helsinki II declaration on human rights.

QUESTIONNAIRE DATA

All participants answered questions about physical activity during leisure (sitting most of the time; light activity at least four hours a week; active in sport at least three hours a week or heavy work during leisure; active in competitive sport several times a week) and physical activity during work (no work; sitting most of the time; light activity, walking around; walking and carrying most of the time; strenuous physical work).

DIET

One trained dietician interviewed all subjects by taking a diet history. Average daily intakes were calculated from responses about the previous month. Data on meal patterns, dishes, and food items were obtained with a precoded interview form. Quantities were assessed with food models, series of photographs, cups, and measures. Calculations of nutrients were carried out with the DANKOST program, which is derived from the Danish food composition tables.[12]

COLLECTION AND ANALYSIS OF URINE

All subjects were instructed orally and in writing on collecting 24 hour urine samples. To monitor completeness, each participant was given three tablets containing 80 mg *p*-aminobenzoic acid to take during the day of urine collection.[13] Protein intake was calculated from the 24 hour nitrogen output according to the formula of Isaksson[7]:

Calculated protein intake based on urine samples (g) = (Nitrogen output in 24 hour urine (g/day) + 2 g) × 6·25

The 30 μl urine samples were analysed for nitrogen by flash combustion technique (NA 1500 Nitrogen Analyser, Ciba Corning[13]).

ANTHROPOMETRIC DATA

All anthropometric measurements were taken in accordance with the WHO's standards.[14] Height was measured to the nearest 0·5 cm. Body weight was measured to the nearest 0·1 kg (SECA weighing scales), with the subjects wearing only underwear.

MEASUREMENT OF ELECTRICAL IMPEDANCE

A BIA 103 RJL system analyser (RJL, Detroit) was used to measure electrical impedance, according to the instructions given by the manufacturer. The measurements were taken with a tetrapolar electrode placement, with electrodes placed on the right hand and foot.

The algorithm used to estimate body fat from impedance had been developed in a subgroup of the same sample of Danes[15]:

Body fat (kg)=(0·819×body weight (kg))−(0·279 ×height²/resistance (cm²/ohm))−(0·064×sex×body weight (kg))+(0·077×age (years))−(0·231×height (cm))+14·941

where sex is coded as 1 for men and 0 for women.

Basal energy expenditure was calculated according to the formula of Gadoy *et al*[16]:

Basal energy expenditure (J)=(116·76×fat free mass) +(26·88×body fat)

where fat free mass is the difference between body weight and body fat.

Average 24 hour energy expenditure can be expressed as a multiple of basal energy expenditure, known as the physical activity level. The physical activity level was assumed to be 1·55 (men) and 1·56 (women) among those who were unemployed or whose work was classified as sedentary; 1·78 and 1·64 respectively among those whose work was classified as light activity; and 2·10 and 1·82 respectively among those engaged in heavy and strenuous work or engaged actively in sports.[14]

STATISTICAL METHODS

Multiple regression and partial correlation were used to describe associations between reporting error for energy and protein, and degree of obesity. The *F* test was used to examine differences in the mean and in regression coefficients between groups, as described earlier.[17] Reporting bias of energy and protein, adjusted for covariates, by percentage body fat in tenths was calculated for men and women separately, with analysis of variance.

Results

NON-PARTICIPATION

Of the 552 subjects invited (276 men and 276 women), 476 attended the health examination, and 435 agreed to participate in the study. In all, 386 subjects gave both the 24 hour urine sample and the dietary interview. The 63 subjects whose urine samples contained less than 85% of the administered *p*-aminobenzoic acid were excluded from further analysis.[9] Thus 323 subjects remained in the study. As described earlier[1] no difference in recovery of *p*-aminobenzoic acid was found between age groups. Slightly more women than men had acceptable compliance of *p*-aminobenzoic acid (P=0·06). Within each sex, however, no differences were found in age, body weight, height, body mass index, percentage body fat, or prevalence of obesity (body mass index >30 kg/m²) among *(a)* the 63 subjects who were interviewed about dietary intake but gave an incomplete urine sample; *(b)* the 49 subjects who did not return a urine sample; and *(c)* the 323 subjects who both were interviewed and gave a complete sample (all, P>0·30).

Table I shows the subjects' characteristics. In both men and women, estimates of total energy and total protein intake calculated from the dietary interview were lower than those calculated from the urine analyses (all, P<0·0001), whereas estimates of percentage energy from protein calculated from the dietary interview were significantly higher than estimates based on urinary nitrogen (all, P<0·001). In all, 85% (275/323) and 72% (233/323) of the subjects underreported total energy and protein respectively.

UNDERREPORTING

Reported energy and protein intakes were negatively associated, estimated 24 hour energy expenditure was positively associated, and intake of protein (calculated from urinary nitrogen output) was unassociated with obesity (table II). Relative to total energy, protein was overreported by obese subjects, as suggested by the stronger association for reporting of energy than for reporting of protein. Similar associations were seen when recalculating the data after energy from alcohol intake was omitted (associations between underreported protein relative to underreported energy and percentage body fat, *r*=0·25, P<0·0001). Differences between men and women were not significant (all, P<0·15), although associations tended to be stronger for women.

TABLE I—*Characteristics of 323 Danish subjects who completed interview on dietary intake and gave complete 24 hour urine sample. Values are means (SD) unless stated otherwise*

	Men (n=152)	Women (n=171)
Age (years)	49·5 (10·9)	50·2 (11·3)
Weight (kg)	78·6 (11·6)	65·7 (11·4)
Height (m)	1·76 (0·07)	1·63 (0·06)
Body fat (kg)	18·6 (7·1)	21·6 (8·4)
% Body fat	23·1 (6·0)	32·1 (7·2)
Fat free mass (kg)	59·9 (6·4)	44·0 (4·4)
No (%) of smokers	68/152 (45)	40 (69/171)
No (%) of subjects physically active during work*	33/152 (22)	9 (16/170)
No (%) of subjects taking part in sport†	33/151 (22)	14 (24/170)
Protein intake based on urine sample (g)	96·5 (24·1)	77·9 (20·2)
% Energy from protein based on urine sample	12·3 (3·4)	14·2 (3·7)
Protein intake based on diet (g)	83·4 (20·8)	63·9 (16·4)
% Energy from protein based on diet	14·2 (2·2)	15·3 (2·8)
24 Hour energy expenditure (MJ)	13·5 (2·3)	9·4 (1·2)
Energy intake based on diet (MJ)	10·2 (2·6)	7·3 (1·8)

*Heavy or strenuous work.
†Engaged actively in sports at least three hours a week.

TABLE II—*Partial correlations between percentage body fat and calculated and reported total energy and protein intakes*

	r	P
Absolute:		
Protein intake based on diet (g)	−0·12	0·03
Protein intake based on urine sample (g)	0·08	0·16
Δ Protein intake based on diet and urine sample (g)	0·17	0·002
Energy intake based on diet (J)	−0·13	0·02
24 Hour energy expenditure (J)	0·42	0·0001
Δ Energy based on 24 hour expenditure and diet	0·38	0·0001
Relative:		
% Protein intake (diet)/protein intake (urine)	−0·20	0·0001
% Energy intake (diet)/energy (24 hour expenditure)	−0·37	0·0001
Underreported protein relative* to underreported energy†	0·20	0·0001

Adjustment was made for sex, age, and smoking.
*% Protein intake (diet)/protein urine.
†% Energy intake (diet)/energy (24 hour expenditure).

Figure 1 shows percentage body fat in relation to total energy and protein intake (estimated from the diet), energy expenditure, and urinary nitrogen output. In both men and women the difference between reported and estimated intake of total energy and protein increased with increasing percentage body fat (all, P<0·03). With increasing obesity the proportion of underreported energy compared to underreported protein increased. Underreporting of energy in subjects in the highest tenth in terms of percentage body fat was 13% greater among men and 15% greater among women than for protein (fig 2).

Discussion

This study shows that the degree of obesity influences dietary reporting both quantitatively and qualitatively. In agreement with other studies,[1-4] a direct relation was seen between obesity and dietary underreporting of energy and protein. With obesity, however, underreporting was proportionally greater, and increasingly greater for energy than for protein, suggesting a differential dietary reporting pattern with

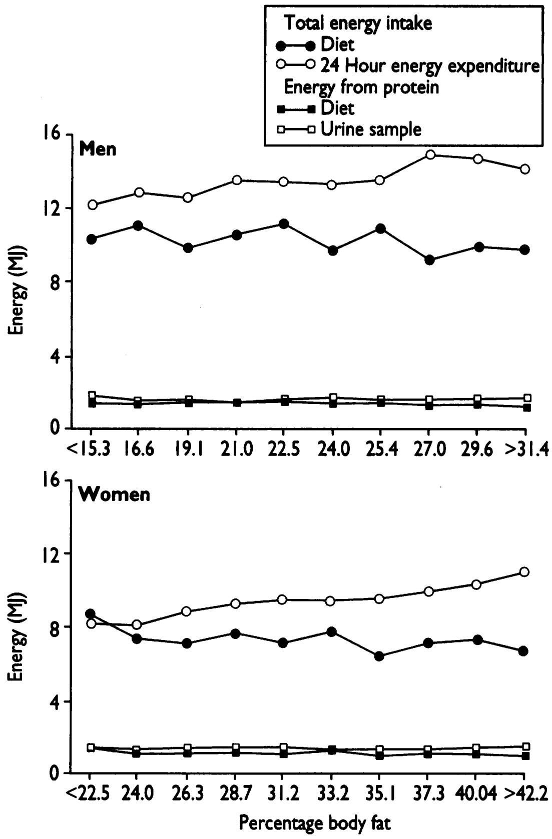

FIG 1—*Total energy and protein intake estimated from reported dietary data, calculated urinary nitrogen output, and estimated 24 hour energy expenditure, by percentage body fat, adjusted for age and smoking*

respect to different foods. Thus the results seem to support the general assumption that obese people tend to underreport fatty foods or foods rich in carbohydrates, or both, rather than underreport all constituents.

Only a few biological markers of dietary intake are available, and none of these validates intakes of total fat or carbohydrates. Although this study shows that obese people tend to overreport relative energy from protein intake, it does not show to what degree, or in what proportion, reporting bias occurred for these other macronutrients. Furthermore, that obesity might influence reporting of alcohol intake cannot be excluded. The fact, however, that similar associations remained between reporting bias and obesity, without energy from alcohol included in the analyses, implies differences of energy densities from other macronutrients.

Reporting bias tended to be stronger for women than for men, although not significantly so. This finding is consistent with the observations of Drewnowsky *et al*[18] that obese men prefer protein and fat mixtures while women prefer carbohydrate and fat mixtures. Thus the overreporting of protein is probably easier to detect in women.

The question of specific errors in dietary reporting has been addressed in other population studies,[9 19-21] but results are inconsistent. One study suggested selective underreporting of snacks,[19] while another showed no selective underreporting[20] but did not consider obesity. Comparing results of different methods of assessing dietary intake among obese subjects, one study showed similar densities of macronutrients[9] and another showed different densities,[21] despite large differences in energy intake, indicating that method specific biases probably differ among populations.

POSSIBLE LIMITATIONS OF STUDY

This study has potential limitations. Selective overreporting of physical activity by obese people could invalidate our findings. However, recalculating associations between percentage body fat and underreported protein relative to underreported energy—assuming that all obese subjects (top third) were physically inactive (physical activity level 1·56)—gave virtually identical values (r=0·15 v r=0·20) but an upward shift of the intercept, suggesting that reporting pattern of physical activity was similar in lean and obese subjects. Unbiased calculation of 24 hour energy expenditure is crucial for estimating percentage energy from protein from urinary nitrogen output. Rather than estimating 24 hour energy expenditure from height and weight, we used sex specific and age specific equations based on body fat, fat free mass, and physical activity during work and leisure.[14 16] In studies using doubly labelled water or indirect calorimetry, body fat and fat free mass have been found to explain more than 90% of the variation in energy expenditure.[22 23] At the individual level, calculation of oxygen consumption by using doubly labelled water would be expected to give a more accurate estimate of energy expenditure, by accounting for genetic variation in 24 hour energy expenditure, residual variation in voluntary physical activity level, and bias in reporting of physical activity by obese people[24] not captured by the relatively crude activity measure. The results reported here should therefore be confirmed by using doubly labelled water to determine actual free living 24 hour energy expenditure.

CONCLUSION

The results of this study suggest that imprecise dietary reporting can be both a quantitative and a qualitative phenomenon. The quantitative dimension, which has been shown in obese populations,[1-5] may be a direct function of the quantity of food consumed, making it natural that those obese people who eat the most underreport to a greater extent.[25] On the other hand, the qualitative dimension is independent of the quantity of energy consumed. The fact that this bias does not seem to be present when contrasting methods of dietary reporting[9] suggests that selective underreporting may occur even with methods that are relatively efficient at capturing total energy intake.[26]

Our results have implications for the interpretation of dietary surveys and will be relevant in studies of

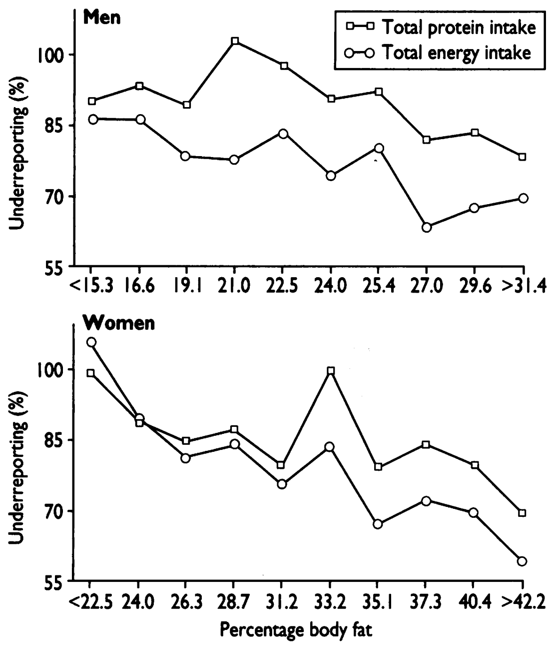

FIG 2—*Percentage underreporting of total energy and protein estimated from reported dietary intake and calculated urinary nitrogen output/24 hour energy expenditure as a function of percentage body fat, age, and smoking*

Key messages

- Obese individuals generally underreport food intake, but it is unknown whether the underreporting is related to certain macronutrients
- Actual intake of energy from protein can be calculated from 24 hour urinary nitrogen output and energy expenditure
- This study shows that obese subjects underreport both total energy and protein intake, with 15% more underreporting of energy than protein
- The results have implications for interpreting studies of effects of dietary intake on comorbidities related to obesity
- Future research is needed to identify valid biomarkers for total fat and complex and simple carbohydrates

effects of dietary intake on comorbidities related to obesity. The results are consistent with the idea that even macronutrient densities may be biased with respect to obesity. If, in fact, the proportion of fat is differentially underreported by obese individuals, this would imply that previous studies showing positive associations between percentage energy from fat intake and health outcomes related to obesity may have overestimated the true effects. Future research is needed to identify valid dietary biomarkers for total fat and complex and simple carbohydrates. Such techniques are necessary to understand fully the nature of the bias in the Danish population sample shown here.

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Prediction of acute mountain sickness

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Acute mountain sickness is a common problem when ascending above 3000 m.[1-3] Attempts to predict its development have so far been unsuccessful, and the side effects of current prophylaxis limit its widespread use. We tried to develop a simple clinical method of prediction.

Subjects, methods, and results

Two groups of New Zealanders (23 in 1992 and 17 in 1993) went to Nepal, ascending to a maximum of 5640 m. Before they left they completed a questionnaire on illnesses related to mountain sickness and had their breath holding times and responses to hyperventilation and pharyngeal stimulation measured. Breath holding was measured in seconds with subjects seated after a maximal inspiration. The gag reflex was assessed by touching the posterior pharynx with a wooden spatula and scoring the response as 0 if there was no response, 1 if the response was mild, 2 if it was moderate, and 3 if it was severe. The subjects also hyperventilated maximally for one minute and assessed their own response on this four point scale.

Twice daily during the trek we completed a variant of the general high altitude questionnaire[4] and measured breath holding times. Measurements were taken at the same time and while subjects were seated at each attempt. Subjects scoring 15 and under were classed as being well, those scoring 16-30 as having mild acute mountain sickness, and those scoring over 30 as having severe sickness, 15 being a traditional cut off point.[2]

The figure shows the relation between worst score on the questionnaire during the ascent and scores for the gag reflex and hyperventilation before the ascent.