Dietary methods research in the third National Health and Nutrition Examination Survey: underreporting of energy intake[1,2]

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ABSTRACT Assessment of diet is a critical component of the third National Health and Nutrition Examination Survey (NHANES III), which was designed to describe the health and nutritional status of the US population. We analyzed data collected with the primary dietary assessment instrument used in NHANES III, the 24-h recall, for 7769 nonpregnant adults aged ≥ 20 y to investigate underreporting of total energy intake. Underreporting was addressed by computing a ratio of energy intake (EI) to estimated basal metabolic rate (BMR_{est}). $EI:BMR_{est}$ was 1.47 for men and 1.26 for nonpregnant women; a population level of 1.55 is expected for a sedentary population. About 18% of the men and 28% of the women were classified as underreporters. Underreporting of energy intake was highest in women and persons who were older, overweight, or trying to lose weight. Underreporting varied according to smoking status, level of education, physical activity, and the day of the week the 24-h recall covered. Additionally, underreporting was associated with diets lower in fat ($P < 0.01$) and alcohol ($P < 0.01$ in women) when expressed as a percentage of total energy intake. *Am J Clin Nutr* 1997;65(suppl): 1203S–9S.

KEY WORDS Dietary assessment methods, energy, national nutrition surveys, National Health and Nutrition Examination Survey, NHANES, energy intake, estimated basal metabolic rate, underreporting

INTRODUCTION

Dietary interviews are included in the National Health and Nutrition Examination Survey (NHANES) as part of the assessment of nutritional status (1–4). Since the First International Conference on Dietary Assessment in 1992 (4, 5), dietary research at the National Center for Health Statistics (NCHS), Centers for Disease Control and Prevention, has focused on two areas: release of dietary reference data from NHANES III, conducted in 1988–1994 (6–8), and improvement of the comparability and usefulness of dietary intake methods for national nutrition monitoring and tracking of health objectives for the year 2000 (9, 10). A 1994 report summarized recommendations and research needs for dietary assessment identified by participants in an NCHS-sponsored consensus workshop held in 1993 (10).

In addition to efforts to improve the comparability of dietary data collected in national surveys, NCHS has ongoing dietary assessment research to identify dietary indicators (ie, particular foods or behaviors associated with diet) with use of food-frequency and 24-h recall data, to compare the intake of foods and foods rich in certain nutrients with selected risk factors (eg, intake of foods high in calcium with hypertension), and to compare reported frequencies of consumption (such as never and daily) from use of food-frequency instruments with 24-h recall data.

In the fall of 1994, population reference data on diet for the first nationally representative phase of NHANES III were released (7, 8). Mean and median intakes of macronutrients, vitamins, minerals, and fiber were based on 1 d of intake estimated with use of 24-h recalls. Since the release of this information, research has focused on the underreporting of energy intake and its effect on the intake of other nutrients (11), the use of multiple 24-h recalls collected in a subsample of the population, and the effect of improved dietary assessment methods on identifying trends in intake.

Because the NHANES dietary data are used to establish nutrition policy, to track progress toward achieving health and nutrition objectives, to provide reference information on nutrient intakes, to develop dietary guidance, and to study diet-health relations (1, 3, 12–18), continued methodologic research is essential to proper interpretation of national dietary data. We present the major findings on underreporting of energy intake in NHANES III (1988–1991). The issue of underreporting is important because it affects the interpretation of trends in diet and overweight in the US population since NHANES II, conducted in 1976–1980.

SURVEY DESIGN AND METHODS

The NHANES III sample was designed to be representative of the civilian noninstitutionalized population of the United States (1, 19). The survey included a household interview and a physical examination conducted in a mobile examination center. The examination included a 24-h dietary recall, body

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measurements, blood and urine tests, and recording of numerous other physical variables (1).

NHANES III was designed as a 6-y survey and was conducted in two 3-y phases. Both phases, as well as the entire 6-y assessment, included nationally representative samples of the US population aged ≥ 2 mo and living in households (19). Children aged 2 mo to 5 y and persons aged ≥ 60 y were oversampled, thereby expanding the age range in comparison with that in the previous surveys. Blacks and Mexican Americans were also oversampled.

Data used in the analyses included 24-h dietary recall, measured height and weight, and information on smoking, recreational physical activity, dietary behavior, and sociodemographic variables obtained through personal interviews. Age was defined as age in years at the time of the household interview. Information on self-reported race and ethnic group was used to classify persons as non-Hispanic white, non-Hispanic black, Mexican American, or other. Income level was defined by the poverty index ratio, that is, the total family income divided by the poverty threshold (adjusted for family size) for the year of the interview.

Smoking was defined as having ever smoked ≥ 100 cigarettes and currently smoking cigarettes. Recreational physical activity was defined as the sum of the frequency of activities such as walking, running, swimming, aerobics, bicycling, and other such activities in the past month, converted to an average number of times per week and reported as "none," "1–2 times/wk," or " ≥ 3 times/wk."

Body weight was measured with an electronic load cell scale, in kilograms, with values rounded to two decimal places. Persons being weighed were dressed in underwear, a disposable paper gown, paper pants, and foam-rubber slippers. No adjustment was made for clothing weight (0.1–0.2 kg) (1). Weight status was defined by comparison with sex-specific published NHANES II values for body mass index (BMI) for the reference population of persons aged 20–29 y (20). "Low weight" was defined as a BMI ≤ the 15th percentile (20.7 for men; 19.1 for women). "Middle weight" was a BMI between the 15th and 85th percentiles, and "overweight" a BMI ≥ the 85th percentile (27.8 for men; 27.3 for women).

Pregnancy status was determined by either self-report or a positive urine test in women aged ≥ 20 y (1). All pregnant women were excluded from the analyses.

Dietary assessment method

All baseline 24-h recall interviews were conducted privately in the mobile examination center with use of a personal computer–based, automated, interactive data collection and coding system (21–24). The phase 1 study design also included the collection of a second nonrandom 24-h recall in the mobile examination center for 8% of all examinees (1, 11, 14, 15). Data were collected for all days of the week, an improvement over past NHANES surveys, in which weekend days were covered inadequately. As part of the protocol for the 24-h recall, respondents were asked whether they considered their reported intake "usual," "much less than usual," or "much more than usual" for that day of the week. Additional details about the dietary data collection, quality control procedures, and data editing and processing are presented elsewhere (1, 23, 24).

Survey data were coded with the seven-digit food codes from the US Department of Agriculture (USDA) survey nutrient database. Nutrient intakes were calculated with a database provided for NHANES III (25). Total energy intake from protein, fat, carbohydrate, and alcohol was calculated by multiplying the grams of intake by the factors 4 kcal/g (≈17 kJ/g), 9 kcal/g (≈38 kJ/g), 4 kcal/g, and 7 kcal/g (≈29 kJ/g), respectively (7, 8).

Response rates

Survey response rates for phase 1, 1988–1991, were 86% for the interview and 77% for the examination (7, 8). Of those examined, 95% completed a reliable 24-h recall, resulting in an overall analytic response rate of 73% for the dietary component. There was no imputation for missing data. The data for the analyses were based on 7769 nonpregnant adults aged ≥ 20 y with one 24-h recall; of these, 623 also completed a second 24-h recall in the mobile examination center.

Estimation of energy requirements

To evaluate underreporting of dietary intake in NHANES III, we used standardized body weight measured in the mobile examination center to estimate the ratio of the reported energy intake (EI) (based on the 24-h recall) to the estimated basal metabolic rate (BMR_{est}), using age- and sex-specific formulas derived by Schofield (26). Cutoff values for evaluating energy intake with $EI:BMR_{est}$ vary according to the sample size and the number of days of intake. The 95th percentile for $EI:BMR_{est}$ is at the lower end of the CI for the range of $EI:BMR_{est}$ (expected energy intake based on estimated BMR) (27). The 95th percentile lower cutoff values for $EI:BMR_{est}$ based on 1 d of intake were used to determine underreporting in population subgroups and individuals. Cutoff values based on 1 d of intake range from 0.9 for one person to 1.54 for a group of 4000 people (26, 27). Cutoff values for specific NHANES III analyses ranged from 1.37 to 1.54, depending on the sample size of the subgroup being evaluated (27). The cutoff value of 0.9 was used to classify individuals on the basis of 1 d of intake (27). Participants with an $EI:BMR_{est} < 0.9$ were considered to be underreporters, whereas those with an $EI:BMR_{est} \geq 0.9$ were considered to be adequate reporters.

Statistical methods and hypothesis testing

This report presents population percentages, means, and SEMs. Data are weighted to account for survey design and nonresponse. All analyses were computed with SUDAAN (Research Triangle Institute, Research Triangle Park, NC), a computer program that takes into account the sampling weights and the complex sample design for calculating variance estimates (28). A two-sided *t* test was used for all statistical tests of differences in the means between groups.

Stepwise regression analyses were used to predict the $EI:BMR_{est}$ in separate models for men and women. Variables included in the models were age, education, race-ethnic group, poverty status, weight status, trying to lose weight, recreational physical activity, smoking, whether the participant reported the 24-h recall information as "usual" diet, day of the week (weekday or weekend), time of day (morning, afternoon, or evening), and language (English or Spanish) of the interview.

RESULTS

Sources of energy intake from food for adults in the United States have been reported (7, 11): mean energy intake is 10 892

kJ (2603 kcal) in men and 7249 kJ (1733 kcal) in nonpregnant women. Carbohydrate provided 48–50% of energy, total fat ≈34%, and protein ≈15% (7). Alcohol accounted for ≈4% of total energy in men and 2% in women and its intake is probably underreported (7, 29).

We calculated mean EI:BMR_{est} for population subgroups stratified according to age, sex, smoking status, and body weight. In both men and women, the mean EI:BMR_{est} decreased with age (**Table 1**). The overall mean ratio was 1.47 for men, 1.26 for nonpregnant women, and 1.36 for all adults (Table 1). Mean ratios did not differ significantly according to race-ethnic group. Categorization with respect to body weight showed that overweight men were below the mean EI:BMR_{est} cutoff value in all age groups, as were middle-weight men aged ≥ 60 y. For women, all middle-weight and overweight groups were below the mean EI:BMR_{est} cutoff value. Only the low-weight group met the population cutoff value for both men and women.

This pattern for weight and EI:BMR_{est} persisted when we looked at smokers and nonsmokers separately, except that smokers had higher mean EI:BMR_{est} values than did nonsmokers of similar age and the same sex (data not shown). Smokers had significantly higher mean EI:BMR_{est} values than did nonsmokers overall, persons ≥ 60 y, 20–29-y-old men, and 30–59-y-old women (**Table 2**). The mean EI:BMR_{est} was above the cutoff value only in male smokers overall and 20–29-y-old male smokers.

About 18% of men and 28% of women were classified as underreporters. For both men and women, underreporters were significantly older (**Table 3**). Among male underreporters compared with adequate reporters, a significantly higher percentage were non-Hispanic black. The percentage of the group below the poverty level and with ≤ 8 y of education was significantly higher among both male and female underreporters compared with adequate reporters.

Twenty-six percent of the men and 42% of the women reported that they were currently trying to lose weight. The overall mean EI:BMR_{est} for those trying to lose weight was 1.25 in the men and 1.16 in the women, compared with 1.55 and 1.35, respectively, in male and female respondents not trying to lose weight (data not shown). Physical activity was slightly related to mean EI:BMR_{est} in men and in women aged ≥ 60 y (data not shown). In each age group, the mean EI:BMR_{est} was higher in those who reported a higher weekly frequency of physical recreational activity.

Other risk factors and behaviors associated with underreporting are shown in **Table 4**. The prevalences of overweight and trying to lose weight were significantly higher in both male and female underreporters than in adequate reporters. About 39% of the male and 53% of the female underreporters reported that they were currently trying to lose weight at the time of their 24-h dietary recall, compared with 24% and 40%, respectively, of the male and female adequate reporters. About 47–51% of underreporters, but only 28–29% of adequate reporters, were overweight. The prevalences of cigarette smoking and any leisure-time physical activity were lower in underreporters than in adequate reporters but the differences were not significant, except for men performing recreational physical activity ≥ 3 times a week.

About 10% of men and 8% of women reported that their intake for the recall day was much less than usual, whereas 2–3% reported that it was much more. This question was useful in interpreting energy intake, at least at the group level, in that mean EI:BMR_{est} increased in men from 1.42 in the group reporting intake much less than usual to 1.47 in the group reporting usual intake to 1.90 in the group reporting intake much more than usual and from 1.07 to 1.28 to 1.63, respectively, in the comparable groups of women.

Comparisons of mean intakes of selected nutrients between underreporters and adequate reporters are shown in **Table 5**. Vitamin, mineral, fiber, and macronutrient intakes were significantly lower in underreporters and, in general, paralleled energy intakes. For both men and women, underreporters had significantly lower intakes of fat and significantly higher intakes of carbohydrate. Female underreporters had lower intakes of alcohol as a percentage of energy. Underreporters also had lower intakes of all food sources of energy as expressed in grams.

TABLE 1
Mean ratio of reported energy intake to estimated basal metabolic rate (EI:BMR_{est}) according to age, sex, and weight status in the third National Health and Nutrition Examination Survey, 1988–1991[1]

	Total	Low weight	Middle weight	Overweight
Men (y)				
20–29	1.64 [840]	1.83 [110]	1.67 [534]	1.41 [196]
30–59	1.45 [1832]	1.66 [108]	1.53 [1053]	1.29 [671]
≥ 60	1.32 [1284]	1.73 [104]	1.38 [732]	1.17 [448]
Total ≥ 20	1.47 [3956]	1.75 [322]	1.54 [2319]	1.28 [1315]
Women (y)				
20–29	1.36 [739]	1.72 [60]	1.40 [470]	1.08 [209]
30–59	1.25 [1804]	1.59 [56]	1.33 [892]	1.11 [856]
≥ 60	1.18 [1270]	1.54 [57]	1.25 [697]	1.05 [516]
Total ≥ 20	1.26 [3813]	1.62 [173]	1.32 [2059]	1.09 [1581]
Total (y)				
20–29	1.51 [1579]	1.79 [170]	1.54 [1004]	1.25 [405]
30–59	1.35 [3636]	1.63 [164]	1.43 [1945]	1.19 [1527]
≥ 60	1.24 [2554]	1.64 [161]	1.30 [1429]	1.10 [964]
Total ≥ 20	1.36 [7769]	1.69 [495]	1.43 [4378]	1.18 [2896]

[1] *n* in brackets. Excludes pregnant women.

TABLE 2
Mean ratio of energy intake to estimated basal metabolic rate (EI:BMR_{est}) according to age, sex, and smoking status in the third National Health and Nutrition Examination Survey, 1988–1991[1]

	Men		Women	
Age (y)	Smokers	Nonsmokers	Smokers	Nonsmokers
20–29	1.79 ± 0.08	1.54 ± 0.04[2]	1.41 ± 0.04	1.34 ± 0.05
30–59	1.50 ± 0.04	1.43 ± 0.03	1.32 ± 0.04	1.22 ± 0.02[3]
≥ 60	1.49 ± 0.08	1.29 ± 0.03[3]	1.32 ± 0.07	1.16 ± 0.02[3]
Total	1.58 ± 0.02	1.42 ± 0.02[2]	1.34 ± 0.03	1.23 ± 0.01[2]

[1] $\bar{x}$ ± SEM.
[2,3] Significantly different from smokers: [2] $P < 0.01$, [3] $P < 0.05$.

TABLE 3
Characteristics of male and female underreporters and adequate reporters of intake in the third National Health and Nutrition Examination Survey, 1988–1991

	Men		Women	
	Underreporters	Adequate reporters	Underreporters	Adequate reporters
n (%)	874 (18.1)	3082 (81.9)	1189 (27.7)	2624 (72.3)
EI:BMR_{est}[1]	0.71 ± 0.01[2]	1.64 ± 0.02[3]	0.69 ± 0.01	1.48 ± 0.01[3]
Age (y)	48.0 ± 1.0	42.7 ± 0.5[3]	48.7 ± 1.0	45.0 ± 0.5[3]
Education (%)				
0–8 y	20.4 ± 1.7	9.2 ± 0.7[3]	15.1 ± 1.5	9.6 ± 1.0[3]
9–11 y	15.7 ± 1.6	14.4 ± 1.1	16.8 ± 1.8	13.3 ± 1.1
12 y	28.7 ± 2.2	33.2 ± 1.6	34.6 ± 2.1	38.5 ± 1.1
≥ 13 y	35.2 ± 2.4	43.3 ± 2.2[4]	33.5 ± 2.0	38.6 ± 1.9
Below poverty (%)[5]	16.0 ± 1.6	9.4 ± 0.8[3]	18.2 ± 1.9	11.9 ± 0.9[3]
Race-ethnic group (%)				
Non-Hispanic white	74.8 ± 2.7	79.9 ± 2.4	77.2 ± 2.8	80.1 ± 2.3
Non-Hispanic black	15.0 ± 1.9	9.0 ± 1.1[3]	14.2 ± 1.8	10.0 ± 1.2
Mexican American	4.8 ± 0.5	4.7 ± 0.5	4.1 ± 0.5	3.8 ± 0.4

[1] Ratio of energy intake to estimated basal metabolic rate.
[2] $\bar{x}$ ± SEM.
[3,4] Significantly different from underreporters: [3] $P < 0.01$, [4] $P < 0.05$.
[5] Defined as a poverty income ratio < 1.00.

The initial stepwise regression found that the most significant variables for main effects were weight status, age, trying to lose weight, usual intake, and day of the week, but these explained only 10–12% of the variance in EI:BMR_{est} (**Table 6**). Several other variables were also significant (Table 6) but their addition to the model did not change the R^2 appreciably. The numbers of meals, snacks, and foods reported on the 24-h recall were added to the model as components of underreporting for a second analysis. The results indicated that the total number of foods was the most important variable in predicting the EI:BMR_{est}, followed by (in order of importance) age, weight status, smoking, and trying to lose weight in men, and weight status, age, trying to lose weight, and smoking in women. These factors accounted for ≈30% of the variance in

TABLE 4
Risk factors and behaviors of adult underreporters and adequate reporters in the third National Health and Nutrition Examination Survey, 1988–1991[1]

	Men		Women	
	Underreporters	Adequate reporters	Underreporters	Adequate reporters
		%		
Overweight[2]	47.2 ± 1.6	28.3 ± 1.4[3]	51.0 ± 2.5	29.4 ± 1.2[3]
Trying to lose weight	38.8 ± 2.0	23.6 ± 1.3[3]	52.6 ± 2.2	39.6 ± 1.7[3]
Smoking	32.5 ± 3.1	35.7 ± 1.5	25.2 ± 2.4	28.6 ± 1.3
Leisure-time physical activity				
None	21.5 ± 2.2	13.8 ± 1.5[3]	29.9 ± 3.0	25.3 ± 1.7
1–2 times/wk	34.4 ± 1.9	35.3 ± 1.2	33.7 ± 1.7	34.8 ± 1.1
≥ 3 times/wk	44.1 ± 2.0	50.9 ± 2.2[4]	36.4 ± 2.9	39.9 ± 1.9

[1] $\bar{x}$ ± SEM.
[2] Defined as BMI (in kg/m^2) ≥ 27.8 for men and ≥ 27.3 for women
[3,4] Significantly different from underreporters: [3] $P < 0.01$, [4] $P < 0.05$.

TABLE 5
Nutrient intake of adult underreporters and adequate reporters in the third National Health and Nutrition Examination Survey, 1988–1991[1]

	Men		Women	
	Underreporters	Adequate reporters	Underreporters	Adequate reporters
Energy				
(kJ)	5408 ± 86.0	12 100 ± 158.5[2]	4096 ± 36.7	8455 ± 84.1[2]
(kcal)	1293 ± 20.6	2892 ± 37.9[2]	979 ± 8.8	2021 ± 20.1[2]
Protein (% of energy)	16.9 ± 0.4	15.1 ± 0.1[2]	17.3 ± 0.3	15.0 ± 0.1[2]
Fat (% of energy)	30.9 ± 0.6	35.0 ± 0.3[2]	30.4 ± 0.5	35.0 ± 0.3[2]
Carbohydrate (% of energy)	50.3 ± 0.7	47.0 ± 0.4[2]	52.9 ± 0.4	49.2 ± 0.4[2]
Alcohol (% of energy)	3.4 ± 0.5	4.3 ± 0.3	1.1 ± 0.2	2.5 ± 0.3[2]
Iron (mg)	10.3 ± 0.3	19.5 ± 0.2[2]	8.1 ± 0.2	14.0 ± 0.2[2]
Calcium (mg)	513 ± 17.4	1043 ± 17.9[2]	437 ± 11.4	803 ± 14.3[2]
Fiber (g)	11 ± 0.4	20 ± 0.3[2]	9 ± 0.3	15 ± 0.2[2]
Cholesterol (mg)	186 ± 7.0	385 ± 9.4[2]	131 ± 4.5	264 ± 5.0[2]
Vitamin C (mg)	79 ± 4.2	124 ± 4.4[2]	71 ± 3.9	104 ± 3.3[2]
Vitamin A (mg RE)	739 ± 53.2	1280 ± 46.4[2]	691 ± 34.5	1003 ± 29.0[2]
Number of meals	2.4 ± 0.06	2.7 ± 0.04[2]	2.5 ± 0.04	2.8 ± 0.03[2]
Number of snacks	1.5 ± 0.10	2.5 ± 0.09[2]	1.8 ± 0.08	2.3 ± 0.04[2]
Number of foods[3]	8.1 ± 0.2	11.5 ± 0.1[2]	8.5 ± 0.15	11.3 ± 0.1[2]

[1] $\bar{x}$ ± SEM. RE, retinol equivalents. Intakes are based on one 24-h recall.
[2] Significantly different from underreporters, $P < 0.01$.
[3] Food items as consumed, eg, sandwich, beverage, or main dish.

EI:BMR_{est}. Other significant variables were day of the week, physical activity, and education in men, and "usual" intake, day of the week, race-ethnic group, and number of snacks in women (data not shown).

We also studied a subsample of 623 adults (311 men and 312 women) who completed two 24-h dietary recalls conducted ≈1 mo month apart in the mobile examination center to determine whether persons may habitually underreport. In both the men and the women, mean energy intake was ≈200 kJ (50 kcal) lower in the second recall than in the first. The mean EI:BMR_{est} values for the sample were 1.31 and 1.30, respectively, for the first and second recall. Within the total group, 27% of participants were classified as having underreported on the first recall and 30% underreported on the second recall. Although only 13% of men and 18% of women were observed to be underreporters on both 24-h recalls, 55% of male and 58% of female underreporters on the first recall also underreported on the second recall.

TABLE 6
Results of multiple-regression analyses to predict the ratio of energy intake to estimated basal metabolic rate (EI:BMR_{est}) in men and women in the third National Health and Nutrition Examination Survey, 1988–1991

Variable	Partial R^2	Total R^2
Men		
Weight status	0.05	0.05
Age	0.02	0.07
Trying to lose weight	0.02	0.09
Day of the week	0.01	0.10
"Usual" intake	< 0.01	0.10
Physical activity	< 0.01	0.11
Smoking	< 0.01	0.11
Race-ethnic group	< 0.01	0.11
Education	< 0.01	0.11
Women		
Weight status	0.07	0.07
"Usual" intake	0.03	0.10
Trying to lose weight	< 0.01	0.10
Age	< 0.01	0.11
Day of the week	< 0.01	0.12
Education	< 0.01	0.12
Smoking	< 0.01	0.12

DISCUSSION

Previous studies documented that food consumption (energy) is underreported by as much as 25% and that such underreporting occurs most often in women, overweight persons, and weight-conscious respondents (29–38). The differential effect of underreporting on specific food components and in population subgroups is not well understood. NHANES III provides a comprehensive database for investigating the magnitude of underreporting of energy intake, identifying population groups at risk of underreporting, and correlating health and behavioral characteristics with underreporting in a national survey.

The 24-h recall method was selected as the primary dietary assessment method in NHANES III to provide detailed quantitative information on diet for nutrition-monitoring and research purposes (1, 4, 16, 17). Emphasis was placed on improving the method through automated, standardized data collection and quality control procedures (1, 4, 24). The values for EI:BMR_{est} in NHANES III (1988–1991) are higher than those reported by Black et al (34) for NHANES I and II, suggesting that NHANES III has more complete reporting of food intake. Efforts to improve the 24-h recall method, representative inclusion of weekend days, and strict quality control procedures may have reduced underreporting in NHANES III compared with NHANES I and II and other national food-consumption surveys (11, 34). However, EI:BMR_{est} remained lower than expected in some groups, particularly women and overweight adults. A population level of 1.55 is expected for a

sedentary population. Apparent changes in energy intake are likely to be, at least in part, an artifact of the methods used. This is difficult to assess in detail, however, because physical activity expenditures were not measured in NHANES. Changes in reported energy intake are consistent with increases in mean body weight and the prevalence of overweight. The prevalence of overweight in adults aged 20–74 y increased from 25% to 33% between NHANES II, conducted in 1976–1980, and NHANES III, conducted in 1988–1991 (39).

Some respondents classified as underreporters in NHANES III may have reported accurate intakes for the day, just as some individuals may have overreported intake. The collection of two independent 24-h recalls in a subsample of the survey population showed consistent findings in mean energy intakes and the level of underreporting. Mean energy intakes in the first and second 24-h recalls were not significantly different. Moreover, the overall level of underreporting for the total group was similar in the first (27%) and second (30%) recalls, thus supporting the main survey's finding of a 23% rate of underreporting of energy intake in the adult population.

The overall level of underreporting in NHANES III was similar to rates in other studies (29, 36–38, 40). Using a cutoff value of 0.9 and 1 d of dietary measurement, Heywood et al (40) found that 12% of men and 24% of women underreported energy intakes in the 1983 Australian National Dietary Survey of Adults. In a study of persons aged 56–81 y (mean age: 66 y), underreporting was found to be higher in women and associated with adiposity in older women but not in older men (38).

The NHANES III data are in agreement with reports that alcohol tends to be underreported in national surveys, although the use of private interviews and weekend data collection probably improved the estimates of alcohol intake in NHANES III (29). In addition, nutrient intakes paralleled energy intake and any differences in mean nutrient intakes between the underreporters and adequate reporters appeared to be energy-driven, with the exception of the percentages of energy from fat in both sexes and from alcohol in women, which were significantly lower in the underreporters. This result may reflect the reporting of "health-conscious" persons, as suggested by Bingham's (35) finding that fats and sugars, but not vitamin C, are underreported. Additional analyses of food and nutrient intake in NHANES III population subgroups such as dieters, smokers, and health- and weight-conscious persons may further explain such results and provide practical suggestions for improving data-collection methods and interpretation of food-intake information.

With respect to possible underreporting of total energy intake in NHANES III, we found that mean EI:BMR_{est} values were lower in women and persons who were older, overweight, or trying to lose weight and higher in low- and middle-weight (but not overweight) smokers. Higher education and recreational physical activity levels were associated with higher mean EI:BMR_{est}, but this varied according to population subgroup. An EI:BMR_{est} below the cutoff value was associated with a diet lower in fat and (in women) alcohol.

Weight status was the largest independent predictor of underreporting, even though it accounted for only 5–7% of the variability in underreporting. About 50% of overweight men and 61% of overweight women reported that they were currently trying to lose weight, a factor that was also an independent predictor of underreporting. These results suggest that overweight people have a tendency to underreport, regardless of whether they are trying to lose weight at the time of the recall interview.

Energy intakes varied according to day of the week, with underreporting being greater for nonweekend days (Monday to Thursday). The day of the week for which the greatest underreporting occurred was Monday in men and Thursday in women. Mean energy intakes were higher in men on Saturday and Sunday and in women on Friday and Saturday.

Although underreporting was decreased in NHANES III compared with NHANES I and II and other national food-consumption surveys, it remains a problem in certain subgroups, primarily women and persons who are overweight. Underreporting of total intake should be considered along with data on body weight, smoking, and behavioral and other dietary issues in interpreting information from dietary surveys. We also recommend that all dietary surveys collect height and weight information (preferably measured because self-reported weight status is subject to reporting bias) (41) to allow interpretation of dietary data (11, 32, 35).

Initial NHANES III analyses showed that the mean numbers of meals, snacks, and foods were lower in underreporters than in adequate reporters, indicating that omitted foods, meals, or snacks—rather than differences in portion sizes—may account for lower energy intakes. We calculated the amount of energy intake needed to convert underreporters to adequate reporters and found that, on average, additional energy intakes of 1582 kJ (378 kcal) for men and 1393 kJ (333 kcal) for women were required to raise a person's EI:BMR_{est} above the cutoff value of 0.9. More survey analyses are needed to determine whether certain foods and beverages are more likely to be underreported by specific subgroups in the population.

Some of the associations with energy underreporting may be the result of imperfect prediction equations for estimating BMR and energy needs. Additional research is needed to evaluate the validity and applicability of existing formulas in various population subgroups, such as smokers, older persons, and persons with various levels of physical activity. For example, use of the same prediction equations for physically active and inactive persons of the same age group and sex may alter results because physically active persons would have a greater lean body mass and a greater true energy expenditure than would inactive persons of the same age group, sex, and body weight. Similarly, use of the same equations in smokers and nonsmokers may lead to the false conclusion that there is less energy underreporting in smokers, because smokers may have a higher basal metabolism than do nonsmokers. Improved equations for estimating BMR and energy requirements, or the development of adjustments that could be applied to equations, would enhance the study of factors associated with underreporting.

Additional research is also needed to determine the extent of underreporting of foods consumed, food-preparation methods and ingredients, and food quantities and the effect of underreporting on estimates of food and nutrient intakes; to improve interview methods with use of additional memory or recall cues, probes, and measurement aids; and to recommend analytic approaches for using national dietary data in nutrition policy development.

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