European Journal of Clinical Nutrition (2000) 54, 281–287

www.nature.com/ejcn

Low energy reporters *vs* others: a comparison of reported food intakes

SM Krebs-Smith[1]*, BI Graubard[1], LL Kahle[2], AF Subar[1], LE Cleveland[3] and R Ballard-Barbash[1]

[1]*National Cancer Institute, Bethesda, MD, USA;* [2]*Information Management Services Inc., Silver Spring, MD, USA; and* [3]*Agricultural Research Service, USDA, Riverdale, MD, USA*

Objective: To partition the food reports of low energy reporters (LERs) and non-LERs into four aspects—tendency to report a given food, frequency of reports per user, portion sizes per mention, and the qualitative (low-fat, low-sugar, low-energy) differences of the reports—in order to determine what differentiates them from one another.
Assessment method: Two non-consecutive 24h dietary recalls. Low energy reporting was defined as energy intake lower than 80% of estimated basal metabolic rate.
Setting:In-home personal interviews.
Subjects: 8334 adults from a stratified, multi-stage area probability sample designed to be representative of noninstitutionlized persons residing in households in the United States.
Results: Across all different types of foods, there are those food groups which LERs are less likely to report (28 of 44 food groups), those which they report less frequently when they do report them (15 of 44 groups), and those for which they report smaller quantities per mention (26 of 44). Qualitative differences in the food choices—that is, differences in fat, sugar, and/or energy content—were not so widespread (4 of 24 food groups).
Conclusions: The practical application of analyses such as these is to improve the methods of gathering dietary data so that this kind of bias can be reduced. Further methodological research is needed to reduce the likelihood of respondents neglecting to mention foods and underestimating portion sizes.
Descriptors: diet surveys; dietary underreporting; energy intake; dietary assessment; diet recalls
European Journal of Clinical Nutrition (2000) **54,** 281–287

Introduction

Implicit in dietary surveillance studies is the assumption that respondents do not change their diets as a function of being 'observed'—that they report their intakes accurately, and that if food intakes are changed or misrepresented i.e. if there is measurement error—that it is spread across the population evenly so that within-study comparisons can be made (Pryer *et al*, 1997) However, although we still do not know whether people tend to change their diets or simply misrepresent them (Goris & Westerterp, 1998; Mela & Aaron, 1997), it is now well recognized that there is a bias toward under reporting, and that this occurs more widely in some segments of the population than in others (Black *et al*, 1991; Bingham, 1994; Johnson *et al*, 1994; Breifel *et al*, 1995, 1997; Klesges *et al*, 1995; Riddick, 1996)

Low energy reporters (LERs) are those persons whose reported energy intakes are lower than what are considered to be minimally plausible levels during the measurement period. They have been identified in numerous population-based studies (Pryer *et al*, 1997; Black *et al*, 1991; Breifel *et al* 1995, 1997; Klesges *et al*, 1995; Riddick, 1996)and differentiated from non-low energy reporters (non-LERs) with respect to physiologic, demographic and lifestyle characteristics (Pryer *et al*, 1997; Johnson *et al*, 1994; Breifel *et al*, 1995, 1997; Klesges *et al*, 1995; Riddick, 1996) and reported nutrient intakes (Bingham, 1994; Pryer *et al*, 1997). A few studies have also included analyses of differences between LERs and non-LERs in the reported total consumption of different food groups and in the food group contributions to energy intake (Bingham *et al*, 1995; Pryer *et al*, 1997; and Johansson *et al*, 1998). The current study further probes the question of reported food intake differences between LERs and non-LERs by examining differences in their tendency to report a given food, the frequency of reports per user, the portion sizes per mention and the qualitative differences (i.e. differences in fat, sugar, and energy content) of the reports.

Methods

Data for this study were derived from the US Department of Agriculture's (USDA's) Continuing Survey of Food Intakes by Individuals (CSFII) 1994–96, in which interviewers conducted two in-person, non-consecutive 24 h recalls with each respondent. The CSFII employed, in each year, a stratified, multi-stage area probability sample which was designed to be representative of non-institutionalized persons residing in households in the US, for each of 40 analytic domains defined by sex, age and income level, while over-sampling among the low-income population, young children and the elderly (Tippett & Cypel, 1998). The stratification plan took into account geographic location, degree of urbanization, and socioeconomic characteristics. To account for differential rates of selection, non-coverage and non-response, the data were weighted as follows: a base weight equal to the reciprocal of the

*Correspondence: SM Krebs-Smith, National Institute of Health, National Cancer Institute, 6130 Executive Blvd MSC 7344, EPN 313, Bethesda, MD 20892, USA.
Received 3 December 1998; revised 27 September 1999; accepted 7 October 1999

probability of selection was assigned to each person; the base weights were adjusted for non-response within classes, defined by variables associated with non-response; the adjusted weights were further adjusted to population totals of the US from the US Bureau of the Census (Tippett & Cypel, 1998). Only persons who provided 2 days of dietary data were selected for the current study; the 2 day response rate for all 3 years was 76.1%. Further information regarding the sample design and the various response rates can be found in Tippett and Cypel (1998). Data for the 3 y were combined to maximize sample size, and sample weighting factors were used for all analyses.

Because preliminary analyses indicated that the number of LERs were limited among younger persons, only data on adults aged 20 y and older were used in this study. Anyone for whom data on height or weight (self-reported) were missing, who claimed 'sickness' 'fasting' or 'dieting' as a reason for eating less on either day of report, and/or who lived in a household which reportedly had 'not enough' food in the last 3 months, was eliminated from the analyses ($n=989$). This resulted in a study sample of 8334 individuals who were classified according to LER/non-LER status using the Schofield formula for basal metabolic rate (Schofield, 1985) and following the cut-off limit for plausible energy intakes (80% of basal metabolic rate, or BMR) estimated by Goldberg *et al*, (1991) for a single individual, with 2 days of dietary data, using 99.7% confidence limits. This cut-off was derived to determine, for each individual, whether their energy intake could be a valid estimate for a 2-day period, 'allowing for the known day-to-day and week-to-week variability and without having to postulate any systematic reduction in intake which may have been caused by the measurement procedure' (Goldberg *et al*, 1991). The cut-off, therefore, accounts for other reasons respondents may have given for eating less on either day of report, such as traveling, celebrating a special occasion, or being bored, stressed or not hungry.

LERs and non-LERs were examined for their differential rates on a number of sociodemographic and lifestyle characteristics previously identified as factors associated with energy intakes: sex, age, race/ethnicity, education, household income, smoking, weight status (body mass index based on self-reported height and weight), and exercise levels (categories shown in Table 1). Differences were tested using a modified chi square test for independence (SUDAAN, 1993). As any of these factors could account for real differences in energy intakes, as opposed to reporting differences, they were used as control variables in subsequent multivariate analyses.

Foods reported by survey respondents had been coded by USDA, using over 5000 different food codes included in the survey food coding database. For the purposes of this study, 44 food groups were constructed by combining foods that generally substitute for one another in meals (Table 2). The list of food groups examined is not exhaustive; individual foods that did not fit well within these groups or that were reported by only a very small percentage of the population, such as meal replacements and tofu, were not included. For 24 of the 44 food groups—those listed in Table 3—qualitative differences were examined to determine whether LERs' mentions of each food group were more likely than those of non-LERs' to be low-fat, low-sugar, or otherwise a lower energy version. Food mixtures reported in the CSFII have recently been disaggregated in order to group the ingredients with like foods and provide a more comprehensive accounting of food group intake for dietary assessment purposes (Cleveland *et al*, 1997; Krebs-Smith et at, 1997; US Department of Agriculture, 1997). However, as this study is concerned with the elemental components of implausibly low energy intake reports, examining foods as reported—and not disaggregated—was of greater interest.

The way foods were reported was in part a result of the probing and coding protocols used in the CSFII. Interviewers used a Food Instruction Booklet and standard measuring guides to probe for a complete description of every food item and the amount eaten. Probes varied with the type of food recalled, some foods triggering questions about additions (such as fat or cream), while others (such as sandwiches, soups and salads) required that details of each ingredient be obtained. Foods reported separately but eaten as part of such combinations were identified with special combination codes. These combination codes were used in this analysis to determine, for example, whether bread or vegetables were eaten with fat (a qualitative parameter) or whether milk was consumed as an addition to coffee/tea or cereal (a quantitative parameter affecting portion size).

LER's and non-LER's recalls were compared according to the percentage of persons reporting the food group at

Table 1 Characteristics of adult low energy reporters (LERs) and non-low energy reporters (non-LERs)

	Status, % (s.e.)	
Characteristic	*LERs (n=1224)*	*non-LERs (n=7110)*
Sex:**		
females	58.2 (1.6)	49.2 (0.7)
Age:**		
20–39 y	35.6 (2.0)	45.0 (1.0)
40–59 y	36.4 (1.7)	33.0 (0.8)
60+ y	28.0 (1.7)	22.1 (0.8)
Race/ethnicity:*		
non-Hispanic Black	16.0 (2.8)	10.4 (0.9)
non-Hispanic White	70.5 (2.7)	77.4 (1.8)
Hispanic	9.8 (1.6)	8.1 (1.5)
other	3.8 (0.9)	4.1 (0.5)
Education:**		
less than high school	23.2 (2.0)	13.6 (0.8)
high school	35.5 (2.0)	33.5 (1.2)
more than high school	39.6 (2.5)	52.0 (1.6)
unknown	1.8 (0.4)	0.9 (0.2)
Household income:**		
< US$10,000	11.8 (1.2)	7.0 (0.7)
US$10,000–29,999	33.0 (1.8)	27.4 (1.2)
US$30,000–49,999	24.2 (1.8)	28.0 (1.0)
US$50,000+	30.9 (2.6)	37.6 (1.7)
Smoking:		
smoking currently	23.8 (1.6)	24.2 (0.6)
Weight status:**		
BMI < 18.5	1.5 (0.5)	2.9 (0.3)
BMI 18.5–24.9	33.9 (2.1)	45.8 (0.8)
BMI 25–29.9	35.5 (1.8)	35.7 (0.7)
BMI ≥ 30	29.1 (1.6)	15.6 (0.6)
Exercise:**		
exercising vigorously < 1 × /week or 'rarely/never'	48.5 (2.0)	40.7 (1.1)
exercising vigorously 1–4 × /week	27.1 (1.5)	33.4 (0.8)
exercising vigorously > 4 × /week	24.2 (1.5)	25.6 (0.8)
exercise unknown	0.1 (0.1)	0.3 (0.1)

*$P<0.01$; **$P\leq 0.0001$.

Table 2 Percentage of persons reporting various foods at least once in 2 days, number of mentions in 2 days per user, and mean portion size per mention, for low energy reporters (LERs) and non low energy reporters (non LERs), after adjusting for covariates[a]

	Persons reporting food at least once in 2 days, % (s.e.)		*Number of mentions in 2 days per user, mean (s.e.)*		*Portion size (g) per mention, mean (s.e.)*	
Food	*LERs (n = 1224)*	*non-LERs (n = 7110)*	*LERs*	*non LERs*	*LERs*	*non LERs*
Grain products						
Yeast bread	77 (1.6)	87 (0.5)*	2.0 (0.04)	2.4 (0.02)*	47 (0.9)	53 (0.7)*
Crackers	16 (1.9)	25 (0.7)*	1.2 (0.04)	1.4 (0.02)	25 (1.7)	29 (0.7)
Muffins/biscuits	13 (1.2)	17 (0.8)	1.2 (0.06)	1.3 (0.02)	54 (6.7)	77 (2.9)
Pancakes/waffles/French toast	7 (0.8)	10 (0.5)	1.1 (0.03)	1.1 (0.02)	77 (6.0)	110 (5.0)*
Cooked cereal	9 (0.9)	11 (0.7)	1.3 (0.03)	1.3 (0.02)	210 (14.7)	248 (6.7)
Ready-to-eat cereal	25 (1.5)	36 (0.8)*	1.4 (0.04)	1.6 (0.02)*	43 (2.1)	57 (1.0)*
Rice, other cooked grains/mixtures	23 (1.5)	27 (0.9)	1.2 (0.05)	1.4 (0.03)	164 (9.2)	207 (4.6)*
Pasta/pasta mixture	25 (2.6)	33 (0.9)	1.2 (0.03)	1.2 (0.01)	252 (26.3)	309 (8.2)
Pizza	12 (1.2)	16 (0.5)	1.2 (0.04)	1.1 (0.01)	149 (8.7)	195 (6.1)*
Doughnuts/sweet rolls	12 (1.3)	23 (0.8)*	1.2 (0.05)	1.3 (0.02)	60 (2.1)	76 (1.3)*
Cookies/brownies	15 (1.8)	29 (0.9)*	1.3 (0.06)	1.5 (0.02)	33 (1.9)	43 (1.0)*
Cake/pie	10 (1.0)	30 (1.0)*	1.1 (0.03)	1.3 (0.02)*	84 (6.0)	121 (2.8)*
Chips/popcorn/pretzels	20 (1.8)	39 (1.1)*	1.3 (0.04)	1.4 (0.02)	26 (1.7)	46 (1.6)*
Fruits						
Fruit juice	25 (1.7)	38 (1.1)*	1.5 (0.05)	1.7 (0.02)	251 (7.2)	262 (5.0)
Fruit	44 (2.1)	55 (1.0)*	2.1 (0.07)	2.6 (0.04)*	121 (3.4)	130 (2.0)
Vegetables						
White potatoes	45 (1.9)	61 (0.9)*	1.3 (0.03)	1.5 (0.02)*	121 (4.1)	139 (1.9)*
Lettuce, other greens	40 (1.7)	48 (0.9)*	1.4 (0.05)	1.5 (0.01)	52 (4.0)	54 (1.5)
Other vegetables	77 (1.8)	86 (0.6)*	3.0 (0.06)	3.5 (0.06)*	77 (2.5)	91 (1.3)*
Milk, yogurt, cheese						
Milk on cereal	23 (1.6)	33 (0.8)*	1.3 (0.03)	1.4 (0.01)	163 (7.1)	206 (4.3)*
Milk in coffee or tea	20 (1.8)	20 (1.1)	2.0 (0.09)	2.2 (0.05)	33 (4.2)	50 (3.2)
Milk as a beverage[b]	26 (1.5)	40 (0.8)*	1.6 (0.05)	1.9 (0.03)*	257 (8.1)	294 (5.1)*
Cheese	31 (1.9)	47 (0.9)*	1.3 (0.03)	1.5 (0.02)*	29 (1.1)	34 (1.0)*
Yogurt	4 (0.8)	7 (0.5)	1.3 (0.09)	1.3 (0.04)	191 (12.1)	188 (5.9)
Meat, fish, or poultry						
Meat, fish, or poultry	86 (1.4)	91 (0.5)*	2.2 (0.06)	2.7 (0.03)*	72 (1.7)	95 (1.1)*
Eggs, excluding mixtures	23 (1.3)	30 (0.7)*	1.2 (0.03)	1.2 (0.01)	73 (2.6)	88 (1.6)*
Meat, fish, poultry or egg sandwich/ mixture	41 (1.6)	56 (1.1)*	1.4 (0.03)	1.6 (0.02)*	179 (5.9)	229 (4.3)*
Beverages						
Beer	8 (1.1)	17 (0.6)*	1.3 (0.09)	1.7 (0.04)*	548 (47.9)	874 (34.5)*
Wine	4 (0.5)	8 (0.7)*	1.3 (0.10)	1.4 (0.03)	216 (25.0)	254 (8.0)
Coffee, tea	78 (1.7)	77 (0.8)	2.9 (0.06)	3.1 (0.05)	428 (12.6)	469 (8.7)
Soft drinks, regular	45 (1.8)	61 (1.1)*	1.8 (0.08)	2.4 (0.04)*	381 (11.4)	438 (7.5)*
Soft drinks, diet	26 (1.8)	23 (1.1)	2.1 (0.13)	2.3 (0.06)	401 (15.4)	409 (7.3)
Sweets						
Candy	10 (1.6)	21 (0.8)*	1.2 (0.04)	1.5 (0.03)*	27 (3.2)	42 (1.6)*
Sweet spreads/syrups	40 (2.1)	54 (0.9)*	2.0 (0.06)	2.2 (0.04)	15 (1.1)	23 (1.0)*
Artificial sweeteners	15 (1.0)	13 (0.8)*	2.4 (0.08)	2.3 (0.06)	2 (0.1)	2 (0.1)
Fats						
Fat-type spreads	40 (1.5)	58 (1.3)*	1.5 (0.04)	1.9 (0.03)*	11 (0.7)	14 (0.3)*
Cream/creamers, not whipped	17 (1.2)	21 (0.7)	2.0 (0.11)	2.0 (0.04)	18 (2.4)	20 (1.1)
Cream/creamers, liquid	10 (1.2)	12 (0.8)	2.0 (0.16)	1.8 (0.04)	27 (3.7)	31 (1.4)
Creamers, powdered	8 (0.7)	10 (0.6)	1.9 (0.10)	1.9 (0.06)	6 (1.2)	6 (0.4)
Dressings, not mayo-type	25 (1.9)	32 (0.9)	1.2 (0.04)	1.3 (0.01)	35 (1.9)	39 (0.7)
Mayo-type dressing	20 (1.5)	29 (0.8)*	1.3 (0.04)	1.3 (0.02)	11 (0.6)	13 (0.4)*
Other						
Soups	21 (1.5)	23 (0.8)	1.3 (0.04)	1.4 (0.02)	319 (13.5)	366 (7.1)
Nuts/seeds, butters	4 (0.6)	9 (0.3)*	1.2 (0.08)	1.3 (0.02)	21 (2.3)	29 (1.3)*
Frozen dairy desserts	13 (1.1)	27 (0.7) *	1.2 (0.04)	1.3 (0.01)	109 (6.5)	148 (4.1)*
Condiments	45 (1.9)	63 (0.7)*	1.5 (0.04)	2.1 (0.04)*	25 (2.1)	34 (0.9)*

*$P < 0.001$.
[a]All analysis adjusted for sex, age, race/ethnicity, education, household income, smoking, weight status, and exercise.
[b]Includes all reports of milk not on cereal or in coffee/tea.

least once in 2 days, the number of mentions per user in 2 days, the portion size per mention per user, and—for selected food groups—the percentage of persons who used a lower energy form of the food. Logistic regression, controlling on the previously mentioned covariates, was used to generate adjusted percentages of persons using a food and the adjusted percentages of mentions by LERs *vs* non-LERs which were of a particular form (eg low-fat). Linear regression, also controlling on the covariates, was used to generate adjusted mean number of times users reported a food and the adjusted mean portion size. The adjusted percentages and means were directly standardized to the distribution of the covariates for the US population, which here was represented by the weighted CSFII sample (Graubard & Korn, 1999). *t*-Tests, modified to account for the sample design of the survey, were used to test the significance of the beta coefficients from the logistic and linear regression models (SUDAAN, 1993). SUDAAN and

Table 3 Percentage of mentions of various foods which have different qualities, for adult low energy reporters (LERs) and non-low energy reporters (non LERs); after adjusting for covariates[a]

Percentage of mentions of...	*which are...*	*by status (mentions, %)*	
		LERs	*non-LERs*
Grain products			
Yeast bread	Yeast bread, fat added[b]	33 (1.7)	40 (1.0)*
	Yeast bread, no fat added	67 (1.7)	60 (1.0)*
Crackers	High-fat crackers	31 (4.4)	38 (1.6)
	Lower-fat crackers	69 (4.4)	62 (1.6)
Cooked cereal	Cooked cereal, fat added[b]	19 (6.3)	17 (2.3)
	Cooked cereal, no fat	81 (6.3)	83 (2.3)
Pasta	Pasta, fat added[b]	22 (6.0)	32 (2.0)
	Pasta, no fat added	78 (6.0)	68 (2.0)
Rice other cooked grains	Rice/grains, fat added[b]	28 (4.2)	35 (2.4)
	Rice/grains, no fat added	72 (4.2)	65 (2.4)
Cookies, brownies	Regular cookies, brownies	76 (4.5)	85 (0.9)
	Low fat cookies, brownies	24 (4.5)	15 (0.9)
Cake	Regular cake	80 (6.8)	87 (1.5)
	Low fat cake	20 (6.8)	13 (1.5)
Chips/popcorn/pretzels	Potato/corn/other chips	56 (4.7)	61 (1.4)
	Popcorn	22 (3.7)	19 (1.3)
	Low fat chips or pretzels	22 (3.8)	20 (1.4)
Vegetables			
White potatoes	White potatoes, fried	38 (2.3)	43 (0.9)
	Potatoes salads	5 (0.9)	7 (0.4)
	White potatoes, fat added[b]	39 (2.3)	42 (0.9)
	White potatoes, no fat added	18 (1.9)	8 (0.5)*
Green salad	Green salad with dressing[c]	59 (4.2)	71 (1.5)
	Green salad, no dressing	41 (4.2)	29 (1.5)
Other vegetables	Other vegetables, fat added[b]	48 (2.3)	56 (0.8)
	Other vegetables, no fat added	47 (2.2)	40 (0.8)*
	Mixtures	4 (0.6)	4 (0.2)
Milk, cheese			
Milk on cereal	Whole	19 (2.8)	21 (1.7)
	Low fat	51 (3.0)	51 (1.6)
	Skim	31 (3.8)	29 (1.4)
Milk in coffee or tea	Whole	40 (3.9)	37 (2.3)
	Low fat	47 (3.8)	45 (1.8)
	Skim	13 (2.7)	18 (1.5)
Milk as beverage[d]	Whole	24 (3.4)	26 (2.1)
	Low fat	43 (3.6)	48 (1.9)
	Skim	33 (3.9)	26 (1.4)
Cheese	Regular	85 (2.1)	89 (0.7)
	Reduced-fat cheese	15 (2.1)	11 (0.7)
Meat, meat alternates			
Eggs, excluding mixtures	Eggs, fat added	79 (2.8)	82 (1.1)
	Eggs, plain, no fat added	21 (2.8)	18 (1.1)
Beverages			
Coffee, tea	Coffee, tea, with cream/sugar	39 (2.1)	45 (1.2)
	Coffee, tea, with no cream/sugar[e]	61 (2.1)	55 (1.2)
Sweets			
Soft drinks	Regular soft drinks	61 (2.5)	74 (1.3)*
	Diet soft drinks	39 (2.5)	26 (1.3)*
Candy	Chocolate candy	65 (5.7)	67 (1.3)
	Candy, not chocolate	35 (5.7)	33 (1.3)
Fats			
Fat-type spreads and additions to food	Regular fat-type spreads/additions	81 (1.8)	83 (0.7)
	Low fat/fat-free spreads/additions	19 (1.8)	17 (0.7)
Cream/creamers, not whipped	Cream	44 (4.5)	37 (2.0)
	Creamers	56 (4.5)	63 (2.0)
Salad dressings, mayonnaise	Regular salad dressings, mayonnaise	57 (3.4)	67 (1.3)
	Low fat/fat-free salad dressings, mayo	43 (3.4)	33 (1.3)
Other			
Soup	Broth with noodles or rice	40 (4.2)	35 (1.4)
	Soup with vegetables	38 (3.8)	40 (1.6)
	Bean Soup	9 (1.9)	11 (1.1)
	Cream soup	13 (2.5)	14 (1.2)
Frozen dairy desserts	Regular ice cream	58 (4.7)	65 (1.3)
	Frozen yogurt, ice milk	42 (4.7)	35 (1.3)

[a]All analyses adjusted for sex, age, race/ethnicity, education, household income, smoking, weight status and exercise. The number of mentions (denominator) varies food to food, by LER status.
[b]Fat added includes reports of foods prepared without fat (eg plain bread or boiled potatoes), but eaten together with fat (eg with butter added at the table). 'Fat' includes butter, margarine, sour cream, gravy, cream, mayonnaise and salad dressings.
[c]With dressing includes reports of undressed salad coupled with reports of dressing. Green salad does not include lettuce eaten as part of a sandwich.
[d]Includes all reports of milk not on cereal or in coffee/tea.
[e]Includes presweetened diet tea. * $P < 0.001$.

in-house software based on Graubard and Korn (1999) were used to account for the sample weighting and clustered nature of the sample design for the standard errors and P-values of the descriptive and regression analyses. Because multiple comparisons were being made, conservative tests of statistical significance were applied ($P < 0.001$)

Results

Table 1 shows the sociodemographic and lifestyle characteristics of adult LERs and non-LERs. These values are weighted and therefore represent population estimates rather than descriptions of the sample. LERs are more likely than non-LERs to be female, in the older age groups, and non-Hispanic Black; to have less than a high school education; and to reside in a household with less than $30,000 yearly income. While there was no difference in the smoking rates, LERs are also more likely to have a higher body mass index (BMI) and to exercise less frequently. Finally, they report substantially fewer food items on their 24 how recalls than do non-LERs—mean values of 11 vs 16, respectively (data not shown).

Table 2 shows the percentage of both LERs and non-LERs who reported each of the food groups, after adjusting for the covariates. There were significant differences for 29 of 44 food groups and, in all cases except for artificial sweeteners, LERs were less likely to report the food than were non-LERs; the reverse was true for artificial sweeteners. LERs were less likely than non-LERs to report all kinds of foods—grains, dairy, fruits, vegetables, meats, sweets, fats and other foods; all fruit, vegetable and meat groups examined showed significant differences. Some of these differences were very large: while only 10% of LERs reported cake/pie, 30% of non-LERs did so; likewise, only 20% of LERs reported chips popcorn/pretzels compared to 39% of non-LERs. Other food groups which showed at least a 15 percentage point spread were white potatoes; cheese; meat, fish, poultry and egg sandwiches or mixtures; regular (non-diet) soft drinks; fat-type spreads; and condiments.

Table 2 also shows those foods for which there were significant differences in the adjusted frequency of mentions of a food, looking only at users. For every food except artificial sweeteners and liquid coffee creamers, the LERs reported a frequency that was the same or smaller than the non-LERs. However, only 15 of the 44 groups showed significant differences; these differences were small, generally less than half a portion (ie a mention) in 2 days.

The last column in Table 2 shows the adjusted average portion sizes (grams) per mention for both LERs and non-LERs. Consistent with previous results, LERs had a pattern across nearly all food groups to report smaller portions of a food if they reported it at all, and 26 of 44 differences were significant. Some of these differences were quite large: LERs' reported portion sizes of beer and chips/popcorn/pretzels were about 40% lower than those of non-LERs, and their reports of many other grain products and several other food groups (pancakes/waffles; rice, other grains; ready-to-eat cereal; cookies/brownies; cake/pie; pizza; milk on cereal; frozen dairy desserts; meat mixtures; and condiments) were 20–30% lower.

When the 24 food groups were examined for qualitative differences between LERs and non-LERs, there were significant differences in only 4 (Table 3). Controlling on the covariates, LERs' mentions of bread, potatoes, and other vegetables were more likely to be without fat added, and their mentions of soft drinks were more likely to be diet.

Discussion

Any analysis of differences between LERs and non-LERs requires that certain assumptions be made regarding who is a low energy reporter, if this cannot be measured directly. In this study, the determination was made using a formula for predicting basal metabolic rate, based on a respondent's age, sex and self-reported height and weight (Schofield, 1985), and a statistical cut-off for determining implausibly low levels of energy (Goldberg *et al*, 1991). Some persons who were not identified as LERs in this study may have had reported energy levels that were below what would have been necessary to sustain their weight but which could not have been assessed more accurately without precise quantitative measures of activity and other factors which might influence energy expenditure. For example, this scheme could have missed potential LERs who had a more than minimally active lifestyle. Black (1996) has suggested that some assessment of physical activity be included in dietary surveys routinely for just this reason. However, it also could have erred in the other direction, as no accounting was made regarding whether body weight had recently been lost. Limited research suggests that persons who have recently lost weight have a decreased BMR relative to unit mass (Leibel *et al*, 1995). Nonetheless, the Schofield formula and the Goldberg *et al* cut-offs are widely used for identifying LERs when direct measurement is not possible (Bingham, 1994; Breifel *et al*, 1995, 1997; Klesges *et al*, 1995; Riddick, 1996; Black, 1998).

Related to this, the group of non-LERs could have included persons who overreported their energy intake, which would have exaggerated the differences between LERs and non-LERs. However, the overall bias in dietary studies is toward underreporting rather than overreporting (Black, 1998), a finding which is consistent with social desirability considerations and the respondent burden associated with reporting food intake. Finally, the 2 day sample may have had a greater degree of bias than the 1 day sample would have had, because there was greater non-response. Nonetheless, the weighting factors for both the samples were designed to correct for non-response bias related to a number of factors related to food intake, and the 2 days of data for each person were considered so superior to the 1 day data in estimating the percentage of persons using the various foods that their choice seemed warranted.

This study found that, across all different types of foods, there are those food groups which LERs are less likely to report, those which they report less frequently when they do report them, and those for which they report smaller quantities per mention. Qualitative differences in the food choices—that is, differences in fat, sugar and/or energy content—were not so widespread. Those aspects which showed the greatest number of food group differences were the tendency to report a food and the portion sizes per mention. A few food groups—yeast bread; white potatoes; other vegetables; meat, fish or poultry; soft drinks, regular; condiments; and beer—showed differences in every aspect examined.

Some of these results suggest that LERs tend to be 'restrained' eaters (Stunkard & Messick, 1985). That is, even though persons who reported being on a weight loss diet were excluded, LERs exhibit a pattern of making lower

energy food choices, This is suggested by the LERs' greater tendency to report artificial sweeteners; their tendency to report bread, potatoes and other vegetables without added fat; and their more frequent reports of diet *vs* regular soft drinks.

However, the suggestion of a restrained pattern of eating does not negate the identification of these persons as LERs because their reported intakes were implausibly low for a 2 day period even allowing for day-to-day variability. Therefore, it is highly probable that these persons were underreporting their intake on these days. While these persons may be careful about the energy content of their food choices, they seem to be omitting foods from their reports and to be substantially underreporting their portion sizes of many foods.

These two aspects of reporting—tendency to report and portion size—were combined into one intake variable by examining portion sizes with the non-consumers included, in order to ascertain whether a particular combination of food groups is most discriminating/predictive of LER status. With this variable, a stepwise discriminant analysis was conducted, again controlling on the covariates. When this was done, only 10 of the 44 food groups did not significantly ($P < 0.001$) discriminate between LERs and non-LERs—crackers; pancakes/waffles/French toast; lettuce, other greens; milk on cereal; yogurt; coffee, tea; diet soft drinks; both liquid and powdered creamers; and artificial sweeteners (data not shown). This suggests that the LERs' reduced likelihood of mentioning foods and their tendency to report smaller portion sizes are widespread across many food groups, especially those that are major sources of energy (Subar *et al*, 1998).

Few studies have examined food intake differences between LERs and non-LERs and those that have generally focused on total intakes—in terms of gram weights—from the various groups rather than the different aspects of reporting (tendency to report, frequency of mention, portion size and qualitative differences), as were examined in this study. Nonetheless, it is of interest to note the foods for which differences were observed in previous studies, to see how the results of this study compare. Johansson *et al*, (1998) compared dietary data obtained from underreporters of food energy to those obtained from other subjects, using a food frequency questionnaire, and found that the former reported less cake, potato chips, fats, chocolate and sweets, sugar-containing soft drinks, potatoes, meat, fish and non-alcohol-containing beverages. Binghain *et al* (1995) identified underreporters using a urinary nitrogen to dietary nitrogen ratio and found that they reported lower intakes of fats, cake, breakfast cereals, milk and sugars than other subjects. Pryer *et al* (1997) found more widespread differences across food groups—18 of 26 groups among women and 19 of 26 among men—which seems more concurrent with the present study.

This study examined the various aspects of food reporting in surveys in order to understand which of them is most influential in accounting for differences in intakes reported by LERs and non-LERs. The practical application of analyses such as these is to improve the methods of collecting dietary data so that this kind of bias can be reduced. Because food consumption survey data serve such essential purposes as studying diet and disease relationships, setting federal nutrition policy, and developing and evaluating national dietary guidance, continued methodologic improvements are necessary to facilitate their appropriate interpretation. Improvements were made in the 1994–96 CSFII over previous surveys in that series, such as the exclusive use of 24 h recalls rather than a recall combined with diet records, and the use of a multiple-pass approach for interviewing, which provides different types of cues designed to enhance food recall (Tippett & Cypel, 1998). Indeed, in the 1994–96 CSFII, a smaller proportion of the sampled adults were classified as LERs than in the 1989–91 CSFII: 15%, as shown in this study, *vs* 25% (comparable analyses of 1989–91 data; data not shown). Nonetheless, further research is needed to improve dietary data collection methods so that the likelihood of neglecting to mention foods or underestimating portion sizes is reduced, Research that focuses on development of interview protocols that better cue respondents' memory for forgotten foods and measurement aids that improve respondents' ability to accurately visualize, estimate and report amounts of foods consumed should prove particularly beneficial.

Acknowledgements—The authors gratefully acknowledge the thorough reviews by Rachel Johnson and Mary Serdula.

References

Bingham SA (1994). The use of 24-h urine samples and energy expenditure to validate dietary assessments. *Am. J. Clin. Nutr.* **59**(Suppl), 227S–231S.

Bingham SA, Cassidy A, Cole TJ, Welch A, Runswick SA, Black AE, Thurnham D, Bates C, Khaw KT, Key TJA & Day NE (1995): Validation of weighed records and other methods of dietary assessment using the 24 h urine nitrogen technique and other biological markers. *Br. J. Nutr.* **73**, 531–550.

Black AE (1996): Physical activity levels from a meta-analysis of doubly labeled water studies for validating energy intake as measured by dietary assessment. *Nutr. Rev.* **54**, 170–174.

Black AE (1998): Poor validity of dietary assessment: what have we learnt? (Abstract). *Eur. J. Clin Nutr.* **52**, 517.

Black AE, Goldberg GR, Jebb SA, Livingstone MBE, Cole TJ & Prentice AM (1991): Critical evaluation of energy intake data using fundamental principles of energy physiology: 2. Evaluating the results of published surveys. *Eur. J. Clin. Nutr.* **45**, 583–599.

Breifel RR, McDowell MA, Alaimo K, Caughman CR, Bischof AL, Carroll MD & CL Johnson (1995): Total energy intake of the US population: the third National Health and Nutrition Examination Survey, 1988–91. *Am. J. Clin. Nutr.* **62**(Suppl), 1072S–1080S.

Breifel RR, Sempos CT, McDowell MA, Chien S(C-Y) & Alaimo K (1997): Dietary methods research in the third National Health and Nutrition Examination Survey: underreporting of energy intake. *Am. J. Clin. Nutr.* **65**(Suppl), 1203S–1209S.

Cleveland LE, Cook DA, Krebs-Smith SM & Friday J (1997): A method for assessing food intakes in terms of food guidance based servings. *Am. J. Clin. Nutr.* **65**(Suppl), 1254S–1263S.

Goldberg GR, Black AE, Jebb SA, Cole TJ, Murgatroyd PR, Coward WA & Prentice AM (1991): Critical evaluation of energy intake data using fundamental principles of energy physiology: 1. Derivation of cut-off limits to identify under-recording. *Eur. J. Clin. Nutr.* **45**, 569–581.

Goris AHC & Westerterp KR (1998): Under reporting of habitual food intake, under recording or under eating? (Abstract) *Eur. J. Clin. Nutr.* **52**, S18.

Graubard BI & Korn EL (1999): Predictive margins with survey data. *Biometrics* **55**, 652–659.

Johansson L, Solvoll K, Bjorneboe G E A & Drevon CA (1998): Under and overreporting of energy intake related to weight status and lifestyle in a nationwide sample. *Am. J. Clin. Nutr.* **68**, 266–274

Johnson RK, Goran M I & Poehlman ET (1994): Correlates of over and underreporting of energy intake in healthy older men and women. *Am. J. Clin. Nutr.* **59**, 1286–1290.

Kiesges RC, Eck LH & Ray JW (1995): Who underreports dietary intake in a dietary recall? Evidence from the Second National Health and Nutrition Examination Survey. *J. Consult. Clin. Psych.* **63**(3), 438–444.

Krebs-Smith SM, Cleveland LE, Ballard-Barbash R, Cook DA & Kahle LL (1997): Characterizing food intake patterns of American adults. *Am. J. Clin. Nutr.* **65**(Suppl), 1264S–1268S.

Leibel RL, Rosenbaum M & Hirsch J (1995): Changes in energy expenditure resulting from altered body weight. *New Engl. J. Med.* **332**, 621–628.

Mela DJ & Aaron JI (1997): Honest but invalid: what subjects say about recording their food intake, *J. Am. Dietet. Assoc.* **97**, 791–793.

Pryer JA, Vrijheid M, Nichols R, Kiggins M & Elliott P (1997): Who are the 'low energy reporters' in the Dietary and Nutritional Survey of British adults? *Int. J. Epid.* **26**, 146–154.

Riddick H (1996): Assessment of energy intakes in the US population, 1989–91. *Family Econ. Nutr. Rev.* **9**(3), 21–32.

Schofield WN (1985): Predicting basal metabolic rate, new standards and review of previous work. *Human Nutr. Clin. Nutr.* **39C**(Suppl 1), 5–41.

Stunkard AJ & Messick S (1985): The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. *J. Psychom. Res.* **29**, 71–83.

Subar AF, Krebs-Smith SM, Cook A & Khale LL (1998): Dietary sources of nutrients among US Adults, 1989–91. *J. Am. Dietet. Assoc.* **98**, 537–547.

SUDAAN (1993): Survey Data Analysis Software, release 6.34. Research Triangle Institute.

Tippett KS & Cypel YS (eds) (1998): *Design and Operation: The Continuing Survey of Food intakes by Individuals and the Diet and Health Knowledge Survey. 1994–96.* US Department of Agriculture, Agricultural Research Service, Nationwide Food Surveys Report No. 96-1. 264pp.

US Department of Agriculture (1997): Pyramid servings data: results from USDA's 1995 and 1996 Continuing Survey of Food Intakes by Individuals. In: *1994–96 Continuing Survey of Food Intakes by Individuals and 1994–96 Diet and Health Knowledge Survey.* (CD-ROM). Agriculture Research Service, US Department of Agriculture.