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Differences between food group reports of low energy reporters and non-low energy reporters on a food frequency questionnaire

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Abstract

Background—Low-energy reporters (LERs) and non-LERs differ with respect to a number of characteristics, including self-reported intake of foods. Limited data exists investigating food intake differences with LERs identified using doubly labeled water (DLW).

Objective—In the Observing Protein and Energy Nutrition Study (September, 1999-March, 2000), differences were examined between food group reports of LERs and non-LERs on a food frequency questionnaire (FFQ) (n=440).

Design—LERs were identified using DLW. LERs' (n=220) and non-LERs' (n=220) reports of 43 food groups on the FFQ were examined in three ways: whether they reported consuming a food group (yes/no), how frequently they reported consuming it (times/day), and the reported portion size (small, medium, or large). Analyses were adjusted for total energy expenditure from DLW.

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Results—LERs compared to non-LERs were less likely to report consumption for one food group among women (soft drinks/regular) and no food groups among men. Reported mean daily frequency of consumption was lower in LERs compared to non-LERs for 23 food groups among women and 24 food groups among men (18 food groups were similar in men and women). Additionally, reported mean portion sizes were smaller for LERs compared to non-LERs for 6 food groups among women and 5 food groups among men (3 food groups were similar in men and women). Results varied minimally by sex and body mass index (BMI).

Conclusions—LERs as compared to non-LERs were more likely to differ regarding their reported frequency of consumption of food groups than their reported consumption (yes/no) of the food groups or the food groups' reported portion sizes. Results did not vary greatly by sex or BMI. It still remains to be known whether improvement in questionnaire design or additional tools or methods would lead to a decrease in differential reporting due to LER status on an FFQ.

Keywords

energy underreporting; dietary assessment; food frequency questionnaire; foods

Introduction

Collection of diet from food frequency questionnaires (FFQs) is a widespread method for obtaining self-reported diet in large population studies because, at present, collection of more objective measures is impractical or not possible. However, such self-reported assessments are subject to measurement error and reporting bias. Of special concern is systematic error, particularly underreporting of dietary intake.

As previously reviewed (1-3), many studies show that some individuals, referred to as “low energy reporters” (LERs), underreport their total energy intake (EI) on dietary assessment tools. This occurs to a greater extent on FFQs then 24-hour dietary recalls (24HRs) (4). Such LERS have been identified by comparing an individual's estimated EI, assessed via self-reported diet, to total energy expenditure (TEE) and classifying those with improbable values as LERs. TEE is calculated with the use of predictive basal metabolic rate (BMR) equations (5, 6), or the reference biomarker of doubly labeled water (DLW) (7). Unlike DLW, predictive BMR equations cannot distinguish differences in BMR between individuals of the same sex, age, and weight category, nor can they account for different levels of physical activity.

Previous research shows that LERs differ consistently from non-LERs with respect to a number of demographic, physical, and psychological characteristics (1-3, 8), as well as self-reported food intake (9-26). In the Observing Protein and Energy Nutrition (OPEN) Study (8), a large scale DLW study (n=450) of men and women, the following characteristics were most predictive of underreporting on an FFQ: fear of negative evaluation, weight-loss history and total fat intake (% kcals) (in women), and body mass index (BMI), comparison of activity level with that of others of the same sex and age, and eating frequency (in men) (4, 8). However, these factors only explained a small percentage of the variation due to underreporting status (9% in women and 10% in men).

Despite numerous studies investigating differences between LERs and non-LERs, only one previous study (20), using a 24-hour recall (24-HR), investigated differences with respect to all three aspects of self-reported food group intake: food group mentions, frequency of mentions, and portion size. It is these three aspects of food intake that are queried for on an FFQ. And, only one other previously published study, by Svendsen and Tonstad (26), investigated differences in food group intake between LERs and non-LERs defined using

DLW. This study was small, including only 23 men and 27 women. Only differences in median intakes (grams/day) of food groups between LERs and non-LERs were compared.

A better understanding of how LERs and non-LERs differ with respect to these aspects of self-reported diet will help guide researchers as to which types of questions, and for what foods, the FFQ could be improved to minimize systematic bias attributed to differential reporting by LER status. Such information could also aid researchers in their interpretation of diet and disease associations and their assessment of effects in dietary intervention studies. We need to better understand the following: Do LERs and non-LERs differ with respect to whether they report consuming particular foods? If LERs report consuming the same foods as non-LERs, do they differ with respect to how often they report consuming the foods and how they report portion sizes? Therefore, the purpose of this study was to examine different aspects of reported food group intake on an FFQ between LERs and non-LERs identified using DLW. Data were obtained from the 450 participants of the OPEN study, previously described (4). The following hypothesis was tested: LERs will be less likely to report foods, and when they do, they will tend to report foods less frequently and with smaller portion sizes than non-LERs.

Materials and Methods

Study participants and design

OPEN study participants (aged 40 to 70 years) were recruited from a random sample of 5,000 households in the Maryland metropolitan area of Washington, DC (Montgomery County), as previously described (4). Participation in the OPEN Study occurred from September 1999 to March 2000. This study was approved by the National Cancer Institute's (NCI's) Special Studies Institutional Review Board.

Of the 837 eligible participants for this study, 614 (73%) initially agreed to participate and were mailed an introductory letter and an FFQ to complete. Of these, 484 (261 men and 223 women) attended visit one where the FFQs were reviewed, and participants were administered their first dose of DLW. At visit two (~11-14 days after visit one), n=482 participants completed the DLW protocol with sufficient urine samples (4, 8). Before visit three (~three months after visit one) participants were mailed a second FFQ to complete. At visit three the second FFQ was reviewed. Thirty-one of the 482 participants had unusable TEE information determined from DLW, for reasons previously explained (4), and were excluded from these analyses. Of the 451 participants who completed the study with usable TEE data, one participant did not complete the first FFQ. Therefore, 450 participants with complete TEE and the first FFQ data were used in this analysis.

Total Energy Expenditure

DLW is an objective biomarker of energy intake among persons in energy balance (maintaining weight), which has small random within-person variation (7). DLW was used to determine the TEE among participants. The DLW dosing protocol and the mass spectrometry isotopic analysis were previously described (4, 27). A small sub-study determined that the coefficient of variation for the DLW energy expenditure measurement in OPEN was 5.1% and that the random within-person variation in DLW in OPEN was small (27).

Definition of low energy reporters and high energy

LERs are persons who report a total EI on a dietary assessment tool that would be implausibly low to maintain their current weight. High energy reporters (HERs) are just the opposite. To identify LERs and HERs in this study, a participant's reported total EI was

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compared to his or her TEE determined from DLW. TEE is assumed to be an objective biomarker of EI under conditions of weight maintenance.

Using DLW measurements, LERs were identified with the following methods as in previous OPEN manuscripts (4, 8). First, DLW measurements were log-transformed to make their measurement error additive and homoscedastic and to create approximately normal distributions. For unbiased dietary assessment instruments, the log of the ratio of reported EI (determined from the first FFQ) to biomarker measurements of TEE (determined from DLW) would have a mean of zero and a variance equal to the sum of within-person variation in dietary instrument and biomarker measurements under energy balance. Therefore, values above or below the 95 percent confidence interval of the log ratio of reported intakes to biomarker measurements indicate the presence of reporting bias, and they are used to define HERs and LERS, respectively (4).

Dietary assessment and construction of food groups

The FFQ used in this study was the Diet History Questionnaire (DHQ) (available at http://www.riskfactor.cancer.gov/DHQ/), developed and evaluated at NCI (28-33). This questionnaire assesses the frequency of intake for 124 individual food/food group items over the past 12 months and asks the portion size of most items. Diet*Calc Software (version 1.4.3, 2005, National Cancer Institute, Bethesda, MD) was used to analyze data from the DHQ.

The 124 line-items on the OPEN FFQ were collapsed into 43 food groups designed to replicate, as close as possible, food groups created in a previous study by Krebs-Smith et al. (20) using data from two, non-consecutive 24-hour recalls administered by the United States Department of Agriculture's (USDA) Continuing Survey of Food Intakes by Individuals (CSFII) 1994-96 (34). Food groups were created by combining foods that generally substitute for one another in meals.

Statistical Methods

Logistic regression was used to estimate the probability of reporting consumption of a food group (any positive response on the FFQ) among LERs versus non-LERs stratified by sex. The logistic regression model included TEE estimated from DLW as an adjustment for observed differences in food group reports that may be explained by differences in a participant's EI, as DLW is an objective biomarker for EI. No adjustment was made for within-person variation in DLW as it was minimal and would not affect the adjustment materially. Adjusted percentages of LERs and non-LERs who reported consuming a food group were estimated using the logistic regression parameter estimates and the group mean DLW values among participants being analyzed. When close to 100% of the LERs or non-LERs reported consuming a food group, the logistic regression model adjusted for DLW could not be fit, and crude percentages are presented and noted in Table 1's footnote.

Among the consumers of food groups, the daily frequency of consumption of foods composing the food groups was extracted from the details file created upon analysis of the DHQs using Diet*Calc. Next, the daily frequencies of foods within a food group were summed to obtain a total daily frequency of food group consumption. Among consumers of each food group, the total daily frequency of consumption was regressed on log transformed DLW estimates to compute least squares means and 99% confidence intervals (CIs) for daily frequency of consumption of a food group in LERs and non-LERs. These analyses were conducted separately in men and women.

Among the consumers of food groups, the reported portion size of consumption (small, medium, or large) of foods composing the food groups was extracted from the details file created upon analysis of the DHQ using Diet*Calc. Reports of portion size were assigned a 1 for small, a 2 for medium, and a 3 for large for each reported foods consumed. Next, the mean reported portion size per food group was determined using portion size reports of each food within a food group. Ordinal logistic regression was used to estimate the probability of reporting a smaller serving size in LERs compared to non-LERs. A 3-level ordinal serving size dependent variable (a mean small (< 1.5), medium (≥ 1.5 to < 2.5) or large (≥ 2.5) portion size) was applied. Certain food groups did not meet the proportional odds assumption ($p<0.05$) using the score test for the proportional odds assumption (35). In these cases, logistic regression was used to estimate the probability of reporting a smaller serving size among LERs versus non-LERs by sex. Either the small and medium or the medium and large categories were collapsed, as shown in Table 3. The logistic regression models included adjustment for TEE estimated from DLW. Adjusted percentages of LERs and non-LERs who reported consuming a food group as a mean small, medium or large were estimated using the logistic regression parameter estimates and the mean DLW values among participants being analyzed. Analyses were conducted separately in men and women.

Analyses are presented stratified by sex because men and women have different caloric needs, due to differences in lean body mass (reviewed in (36)). In OPEN, data from the first FFQ showed that women and men had different reported daily caloric intakes (37). The median (1st, 3rd quartile) for kcals/day was 1,516 (1,173, 1,991) in women and 1,955 (1,537, 2,550) in men (37). Stratifying the data by sex, in addition to controlling for DLW, further controlled of true differences in caloric intake. Additionally, dietary patterns and differential reporting by LER status may vary by gender. Gender stratified results are also consistent with previous publications on the OPEN study (4, 8, 37, 38). Effect modification of the relationship between food group reporting and LER status was investigated by testing the interaction of sex and LER status, and BMI and LER status. BMI was defined categorically (<25, normal; ≥ 25 and < 30 overweight; ≥ 30 obese). Previous research has observed that a greater proportion of LERs, as compared to non-LERs, tend to be have larger BMIs (8, 10, 39).

Two-sided tests were used, and a $p \leq 0.01$ was considered statistically significantly different, to control for multiple comparisons. For interaction tests, a p-value of ≤ 0.05 for the overall interaction term was considered statistically significant. All analyses were performed in SAS (version 9.1, 2002-2003, SAS Institute, Cary, NC).

Results

On the FFQ, 220 participants were identified as LERs (100 women and 120 men), 220 were identified as non-LERs (102 women and 118 men), and 10 were identified as HERs based on DLW. Due to the small number of HERs identified they were not included in the following analyses. Table 1 shows the number or LERs and non-LERs reporting consumption of the 43 food groups that were constructed from the FFQ.

Percent Reporting Consumption of Food Groups

In men and women, few to no food groups were significantly less likely to be reported by LERs as compared to non-LERs. Table 1 presents the adjusted percentages of respondents reporting consumption of food groups mentioned on the FFQ. The percentage of women reporting consumption of food groups was less among LERS compared to non-LERs for 28 of 43 (65%) food groups, although the results were only statistically significant for soft drinks/regular. For food groups where the percentage of women reporting consumption was greater among LERs compared to non-LERs (9 of 43 (21%)), results were only statistically significant for soft drinks/diet. The percentage of men reporting consumption of food groups was less among LERs versus non-LERs for 23 of 43 (53%) food groups, but none of these differences were statistically significant. For food groups where the percentage of men reporting consumption was greater among LERs versus non-LERS (14 of 43 (33%)) no statistically significant differences were observed. The relationship between percentage reporting consumption of soft drinks/regular and LER status varied by sex (p for interaction=0.004). Unlike women, the percentage of men reporting consumption of soft drinks/regular was greater in LERs compared to non-LERs, not less, but the results were not statistically significant. Interactions by sex were not observed for other food groups.

Frequency of Consumption of Food Groups among Consumers

Table 2 shows the least squares means and 99% confidence intervals of the means for the daily frequency of consumption of food groups among LERs and non-LERs users of the respective food groups. As expected, no food groups were statistically significantly reported with greater mean daily frequencies among LERs compared to non-LERs. For more than half of the food groups, the daily frequency of consumption among LERs was less than for non-LERs. In both women and men, the reported mean daily frequency of consumption was statistically significantly lower among LERs compared to non-LERs for the following 18 food groups: yeast bread, crackers, muffins/biscuits, pancakes/waffles/French toast, pasta/pasta mixtures, doughnuts/sweet rolls, cookies/brownies, cake/pie, white potatoes, other vegetables, cheese, meat/fish/poultry, eggs/excluding mixtures, meat/fish/poultry/egg sandwich/mixtures, candy, sweets/spreads/syrups, frozen dairy desserts, and condiments. The relationship between frequency of consumption and LER status did not vary statistically significantly by sex for these food groups.

Among women, the reported mean daily frequency of consumption was lower among LERs compared to non-LERs for 38 of 43 (88%) food groups, but statistically significant for only 23 food groups. In addition to those previously mentioned, these also included rice/other cooked grains/mixtures, fruit juice, beer, soft drinks/diet, and nuts/seeds. Among men, the reported mean daily frequency of consumption was lower among LERs compared to non-LERs for 37 of 43 (86%) food groups, but statistically significant for only 24 food groups. Different from women, these included chips/popcorn/pretzels, fruit, soft drinks/regular, fat-type spreads, mayo-type dressing, and soups.

The relationship between frequency of consumption and LER status varied significantly by sex for the food groups of chips/popcorn/pretzels (p for interaction=0.03) and mayo-type dressing (p for interaction=0.02). For both food groups, the reported mean daily frequency of consumption was lower (albeit not always statistically significant) among LERs compared to non-LERs regardless of sex. The difference in mean daily frequency of consumption between LERs and non-LERs for these food groups was greater in men then women. Significant interactions by sex were not observed for other food groups.

Portion Size

The adjusted percentages of respondents reporting consumption of food groups as a mean small, medium, or large portion size are shown in Table 3. For some food groups there was a statistically significant higher odds of reporting smaller portion sizes among LERs as compared to non-LERs. Among women these included 6 food groups: pasta/pasta mixtures, white potatoes, cheese, meat/fish/poultry/egg sandwich/mixtures, soups, and nuts/seeds. For men, these included 5 food groups: pasta/pasta mixtures, meat/fish/poultry/egg sandwich/mixtures, fat-type spreads, nuts/seeds, and frozen dairy desserts. The odds of reporting smaller portion sizes were never statistically significantly greater in LERs compared to non-LERs.

The relationship between reported portion size and LER status varied significantly by sex for the food groups of cooked cereal (p for interaction=0.04), milk as a beverage (p for interaction=0.05), and cheese (p for interaction=0.02). The percentages of respondents reporting consumption of a small portion size was greater among LERs compared to non-LERs for milk as a beverage and cheese in both men and women, although the results were not always statistically significant. Differently, for cooked cereal, the percentages of respondents reporting consumption of small portion sizes was greater among LERs compared to non-LERs in women, but less in men; and the differences were not statistically significant.

Analyses stratified by body mass index

The percentage of respondents reporting consumption of food groups by LER status was not modified by BMI status (<25, normal; ≥25 and < 30 overweight; ≥ 30 obese) (data not shown). The mean daily frequency of consumption of food groups by LER status was modified by BMI for the food groups of milk in coffee or tea (p for interaction=0.05), candy (p for interaction=0.003), and mayo-type dressing (p for interaction=0.009). Among participants with a normal BMI, but not among participants with an overweight or obese BMI, the adjusted mean daily frequency of consumption of milk in coffee or tea was statistically significantly lower in LERs than non-LERs (Table 4). For candy consumption, the adjusted mean daily frequency of consumption was statistically significantly lower in LERs than non-LERs for those participants with an overweight and obese BMI, but not among those with a normal BMI. And, the adjusted mean daily frequency of consumption of mayo-type dressing was lower in LERs than non-LERs regardless of BMI status, but statistically significant only among those overweight.

Discussion

Using data from the OPEN study, LERs and non-LERs keep identified with DLW, were compared with respect to three aspects of food group reporting (reported consumption, frequency of consumption, and portion size) on an FFQ in 440 women and men. In the last decade, previous studies have analyzed differential reporting of foods/food groups by LER status utilizing a number of different dietary assessment tools: 24-HRs (12, 14, 20, 21, 23), dietary records (9, 11, 15, 17-19, 22, 24, 26), and FFQs (10, 13, 15, 16, 25, 26). Only one other previous study (26) also identified LERs using DLW, but this study was small (n=50) and did not evaluate multiple aspects of food group reporting. No previous study has investigated simultaneously all three aspects of food group reporting with respect to LER status on an FFQ.

This study identified 50% of women and men as LERs, a greater percentage than identified in other non-DLW studies analyzing differential reporting of foods by LER status. These studies identified, when a dichotomized EI:BMI ratio was used, anywhere from 14 % (26) to 40% (16) of persons as LERs. In the study by Svendsen and Tonstad (26), which used DLW, 52% of men and 59% of women were identified as LERs, a slightly greater percentage than observed in OPEN.

Not many differences were observed between LERs and non-LERs with respect to whether they reported certain food groups. Only women (not men) LERs differed from non-LERs in whether they reported consumption of food groups, but only for two food groups (soft drinks/regular and soft drinks/diet). Perhaps this is because, on the FFQ, participants were asked to estimate how often, over the course of an entire year, they ate a certain food group. This resulted in estimates for many food groups that were over 90%, making it difficult to distinguish differences in food group reports between LERs and non-LERs. The majority of food groups, 37 of 43 (86%), were reported as being consumed over the past year by 50% or more participants in any subgroup.

However, differential reporting by LER status with respect to daily frequency of consumption of food groups was consistent with similar findings in the literature (12, 15, 20, 21, 23). This differential reporting may relate to social desirability bias, such as the tendency for LERs versus non-LERs to report sweets and desserts less frequently, whereas other differences may relate to cognitive difficulties. An example of the latter would be LERs reporting snack foods, nuts/seed, fruit and crackers less frequently than non-LERs. Perhaps LERs have more difficulty estimating frequency of snack food intake because consumption may occur over the course of a day or week in a grazing-type manner. At the same time, most food groups, with the exception of cooked cereal, ready-to-eat cereal, pizza, green salad, milk (on cereal, in coffee or tea, and as a beverage), yogurt, wine, liquor, coffee/tea, cream/creamer/liquid, cream/creamer/not whipped, and dressing/not may-type were differentially reported between LERs and non-LERs with respect to frequency of consumption. This suggests that LERs' tendency to underreport frequency of consumption may not be specific to any one food group but more general across all food groups.

In this FFQ study, participants were asked to recall intake over the last year. It is possible that a shorter recall period (i.e., 3 months) would have resulted in less food groups that were reported differentially between LERs and non-LERs with respect to frequency of consumption. Only one other study has analyzed differential reporting of food frequency consumption by LER status (15) with an FFQ. However, this study did not mention the time frame that their FFQ captured.

In addition to frequency of consumption, some food groups were more likely to be reported as consumed in smaller portion sizes by LERs as compared to non-LERs. The number of food groups (<10) for which portion sizes were likely to be reported as smaller among LERs as compared to non-LERs was less than the number of food groups (>20) for which LERs compared to non-LERS reported with less daily frequency of consumption. Food groups that are served as mixed dishes, such as pasta/pasta mixture and meat/fish/poultry/egg sandwich mixtures, were reported with smaller portion sizes among LERs compared to non-LERs in both men and women. These were the only food groups for which both men and women LERs as compared to non-LERs also reported with a lower daily frequency of consumption. Mixed dishes may be one food group for which people have more cognitive difficulties estimating portion size than other food groups, and this challenge may be greater for LERs than non-LERs. For example, on the DHQ, portion size of a pear is defined as small (< 1 pear), medium (1 pear), or large (> 1 pear). Differently, portion size for lasagna/stuffed shells/stuffed manicotti/ravioli/tortellini is defined as small (< 1 cup), medium (1-2 cups), and large (> 2 cups).

Differences between how LERs and non-LERs reported food group intake did not vary greatly by sex. Men and women had a similar number of food groups, as well as similar types of food groups, reported as consumed less frequently and with smaller portion sizes in LERs as compared to non-LERs. Additionally, effect modification of the relationship between food reporting and LER status by BMI was investigated as previous results in OPEN showed that men LERs were more likely to have larger BMIs (8). However, differences in food reporting between LERs and non-LERs only varied statistically significantly by BMI status for a few foods and only with respect to frequency of consumption.

It is unclear whether all differences in frequency of consumption or portion size estimates between LERs and non-LERS represent true underreporting by LERs. It is possible that

LERs and non-LERs simply have different dietary patterns of intake. Although participants were told not to diet during OPEN, and the participant weight loss patterns do not suggest dieting, it is possible that LERs have adopted food habits of "dieters" (such as drinking diet soda), even if they were not currently dieting. In OPEN, a greater percentage of LERs than non-LERs have reported dieting in the past (8), and may have adopted some of the dieting behaviors from their past, such as women LERs drinking regular soda less frequently. However, the present study cannot determine *why* LERs and non-LERs are more or less likely to differentially report frequency of consumption and portion size estimates

Application of Findings

This study's results suggest that people may have cognitive difficulties in estimating intake over the past year using an FFQ, especially with respect to frequency of intake more so than portion sizes. The question remains whether development of better tools or methods to help subjects gauge the frequency and portion sizes of the foods they consume would actually improve differential reporting due to LER status on an FFQ. For example, often portion size booklets are provided along with diet records and 24-HRs to help participants estimate portion size. Some FFQs have portion size booklets with pictures, but it is not clear that this tool improves portion size estimates.

If, after additional research, it seems that low energy reporting cannot be minimized through improvement in questionnaire study design, then the best approach may be to develop statistical models to help adjust for these biases or to develop recovery biomarkers for nutrients and foods of interest. At the same time, the knowledge gained about the characteristics of low energy reporters from FFQs could be used to aid in the interpretation of findings from epidemiologic studies of diet and disease associations.

This study was limited by its inability to determine *why* LERs and non-LERs are more or less likely to differentially report frequency of consumption and portion size estimates, as previously stated. There was no measure of truth with respect to what participants were consuming. Therefore, it is unknown whether the observed differences between LERs and non-LERs represent differences in reporting or differences in food patterns. This study cannot evaluate the extent to which foods listed on the FFQ, are more or less inclusive of foods consumed by LERs versus non-LERs. Additionally, as this study was conducted from 1999-2000, dietary patterns may have fluctuated over the last decade, especially with respect to processed foods. Observations of differential reporting of food group consumption between LERs and non-LERs may not hold constant over time.

Conclusions

In conclusion, this study observed differential reporting by LER status on an FFQ primarily due to differences in reporting of frequency of consumption, not due to food group mentions alone or reported portion size estimates. These differences in reporting did not vary greatly by sex or BMI. Additional studies could examine further changes in the design of FFQs to assess whether they improve the amount of low energy reporting that occurs with respect to food group reported frequency of consumption and portion sizes.

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Table 1

The number and adjusted [a] percentage of low energy reporters (LERs) and non-low energy reporters (non-LERs), by sex, who reported consuming the listed food groups on the food frequency questionnaire: the Observing Protein and Energy Nutrition (OPEN) Study

	Women		Men	
	LER (n =100)	non-LER (n=102)	LER (n=120)	non-LER (n118)
	n (%)	n (%)	n (%)	n (%)
1. Yeast bread	100 (100%)	102 (100%)	120 (100%)	118 (100%)
2. Crackers	93 (93.0%)	100 (98.0%)	111 (92.4%)	112 (95.3%)
3. Muffins/biscuits	95 (95.0%)	102 (100%)	116 (96.8%)	112 (94.8%)
4. Pancakes/waffles/French toast	85 (84.5%)	96 (94.4%)	113 (94.2%)	113 (95.7%)
5. Cooked cereal	80 (80.0%)	72 (70.6%)	79 (66.4%)	79 (66.5%)
6. Ready-to-eat cereal	97 (97.1%)	94 (91.9%)	107 (89.0%)	105 (90.1%)
7. Rice/other cooked grains/mixtures	97 (97.0%)	101 (99.0%)	115 (95.8%)	118 (100%)
8. Pasta/pasta mixtures	99 (99.0%)	102 (100%)	119 (99.2%)	118 (100%)
9. Pizza	96 (95.8%)	99 (97.4%)	117 (97.5%)	112 (95.3%)
10. Doughnuts/sweet rolls	84 (83.7%)	92 (90.4%)	110 (91.6%)	111 (94.1%)
11. Cookies/brownies	98 (98.0%)	101 (99.0%)	115 (95.8%)	115 (97.5%)
12. Cake/pie	100 (100%)	101 (99.0%)	120 (100%)	117 (99.2%)
13. Chips/popcorn/pretzels	99 (99.0%)	101 (99.0%)	119 (99.2%)	118 (100%)
14. Fruit juice	98 (98.0%)	101 (99.0%)	116 (96.7%)	115 (97.5%)
15. Fruit	100 (100%)	102 (100%)	120 (100%)	118 (100%)
16. White Potatoes	100 (100%)	102 (100%)	119 (99.2%)	118 (100%)
17. Green Salad	98 (98.0%)	101 (99.0%)	117 (97.5%)	117 (99.2%)
18. Other vegetables	100 (100%)	102 (100%)	120 (100%)	118 (100%)
19. Milk on cereal	88 (88.2%)	85 (83.1%)	100 (83.0%)	101 (87.0%)
20. Milk in coffee or tea	53 (52.5%)	52 (51.4%)	61 (50.7%)	55 (46.7%)
21. Milk as beverage	64 (63.3%)	72 (71.2%)	82 (67.8%)	78 (66.8%)
22. Cheese	97 (97.0%)	100 (98.0%)	115 (95.8%)	112 (94.9%)
23. Yogurt	79 (78.8%)	85 (83.5%)	76 (64.3%)	82 (68.9%)
24. Meat/fish/poultry	100 (100%)	102 (100%)	120 (100%)	116 (98.3%)

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	Women		Men	
	LER (n =100)	non-LER (n=102)	LER (n=120)	non-LER (n118)
	n (%)	n (%)	n (%)	n (%)
25. Eggs/excluding mixtures	90 (89.5%)	93 (91.8%)	108 (89.9%)	102 (86.7%)
26. Meat/fish/poultry/egg sandwich/mixtures	100 (100%)	101 (99.0%)	120 (100%)	118 (100%)
27. Beer	45 (43.0%)	43 (44.0%)	84 (69.4%)	92 (78.9%)
28. Wine	66 (64.5%)	75 (75.2%)	81 (68.7%)	89 (74.9%)
29. Liquor	41 (40.2%)	53 (52.7%)	72 (59.4%)	74 (63.4%)
30. Coffee/tea	94 (94.6%)	100 (97.9%)	115 (95.8%)	113 (96.0%)
31. Soft drinks/regular [b]	66 (64.3%)	84 (83.8%) *	107 (89.0%)	98 (84.0%)
32. Soft drinks/diet	65 (65.4%)	43 (41.7%) *	63 (51.8%)	47 (40.5%)
33. Candy	98 (98.0%)	102 (100%)	118 (98.3%)	116 (98.3%)
34. Sweets/spreads/syrups	97 (97.0%)	100 (98.0%)	119 (99.2%)	116 (98.3%)
35. Fat-type spreads	97 (97.0%)	101 (99.0%)	115 (95.8%)	116 (98.4%)
36. Cream/creamer/liquid	27 (24.4%)	25 (26.0%)	30 (24.4%)	32 (27.6%)
37. Cream/creamer/not whipped	50 (52.0%)	44 (41.1%)	50 (40.1%)	53 (46.3%)
38. Dressing/not mayo-type	96 (95.8%)	98 (96.3%)	116 (96.7%)	112 (95.7%)
39. Mayo-type dressing	93 (92.6%)	97 (95.6%)	107 (89.0%)	105 (89.2%)
40. Soups	99 (99.0%)	98 (96.1%)	119 (99.2%)	117 (99.2%)
41. Nuts/seeds	95 (94.8%)	101 (99.1%)	118 (98.3%)	117 (99.2%)
42. Frozen dairy dessert	96 (96.0%)	101 (99.0%)	117 (97.5%)	115 (97.5%)
43. Condiments	98 (98.0%)	102 (100%)	120 (100%)	117 (99.2%)

*Percentages statistically significantly different $p \le 0.01$.

[a]Percentages adjusted for individual doubly labeled water using logistic regression except for the following foods when close to 100% of the LERs or non-LERs reported consuming a food: in both men and women (yeast bread, rice/other cooked grains/mixtures, pasta/pasta mixtures, cookies/brownies, cake/pie, chips/popcorn/pretzels, fruit juice, fruit, white potatoes, green salad, other vegetables, cheese, meat/fish/poultry, meat/fish/poultry/egg sandwich/mixtures, candy, sweets/spreads/syrups, soups, condiments), women alone (crackers, muffins/biscuits, fat-type spreads, frozen dairy dessert), in men alone (nuts/seeds)

[b]Significant interaction between LER status and sex ($p \le 0.05$).

Table 2

Least squares means and 99% confidence intervals for reported daily frequency of consumption of foods groups on the food frequency questionnaire, for low energy reporters (LERs) (n=220) and non-low energy reporters (Non-LERs) (n=220) by sex: The Observing Protein and Energy Nutrition (OPEN) Study

Food groups	Mean (99% confidence intervals) of daily frequency of food groups			
	Women		Men	
	LERs (n=100)	Non-LERs (n=102)	LERs (n=120)	Non-LERs (n=118)
Yeast bread	0.45 (0.36, 0.57)	0.69 (0.55, 0.86) *	0.50 (0.41, 0.62)	0.95 (0.77, 1.17) *
Crackers	0.06 (0.04, 0.09)	0.10 (0.07, 0.14) *	0.05 (0.04, 0.07)	0.09 (0.07, 0.13) *
Muffins/biscuits	0.04 (0.03, 0.05)	0.07 (0.05, 0.09) *	0.04 (0.04, 0.06)	0.06 (0.05, 0.08) *
Pancakes/waffles/French toast	0.02 (0.02, 0.03)	0.04 (0.03, 0.05) *	0.03 (0.02, 0.03)	0.04 (0.03, 0.05) *
Cooked cereal	0.05 (0.04, 0.08)	0.08 (0.06, 0.13)	0.06 (0.04, 0.08)	0.05 (0.04, 0.08)
Ready-to-eat cereal	0.15 (0.10, 0.23)	0.18 (0.12, 0.28)	0.21 (0.14, 0.31)	0.20 (0.13, 0.29)
Rice/other cooked grains/mixtures	0.08 (0.06, 0.11)	0.15 (0.11, 0.21) *	0.11 (0.08, 0.14)	0.14 (0.11, 0.18)
Pasta/pasta mixtures	0.10 (0.08, 0.13)	0.18 (0.14, 0.23) *	0.12 (0.10, 0.14)	0.18 (0.14, 0.21) *
Pizza	0.03 (0.02, 0.04)	0.04 (0.03, 0.06)	0.04 (0.03, 0.05)	0.05 (0.04, 0.06)
Doughnuts/sweet rolls	0.03 (0.02, 0.04)	0.04 (0.03, 0.06) *	0.04 (0.03, 0.05)	0.06 (0.04, 0.08) *
Cookies/brownies	0.05 (0.04, 0.07)	0.11 (0.07, 0.15) *	0.06 (0.04, 0.08)	0.14 (0.10, 0.19) *
Cake/pie	0.04 (0.04, 0.06)	0.08 (0.06, 0.10) *	0.06 (0.05, 0.07)	0.08 (0.06, 0.10) *
Chips/popcorn/pretzels [a]	0.14 (0.11, 0.19)	0.20 (0.15, 0.27)	0.11 (0.08, 0.14)	0.24 (0.18, 0.31) *
Fruit juice	0.28 (0.20, 0.39)	0.50 (0.35, 0.70) *	0.35 (0.26, 0.46)	0.42 (0.32, 0.56)
Fruit	0.90 (0.71, 1.14)	1.23 (0.97, 1.54)	0.77 (0.63, 0.95)	1.04 (0.85, 1.28) *
White Potatoes	0.12 (0.10, 0.15)	0.23 (0.18, 0.28) *	0.19 (0.16, 0.23)	0.29 (0.24, 0.35) *
Green Salad	0.21 (0.15, 0.29)	0.23 (0.17, 0.31)	0.20 (0.16, 0.26)	0.25 (0.19, 0.32)
Other vegetables	1.33 (1.09, 1.62)	1.97 (1.62, 2.40) *	1.01 (0.87, 1.19)	1.74 (1.48, 2.03) *
Milk on cereal	0.15 (0.10, 0.23)	0.17 (0.11, 0.27)	0.21 (0.14, 0.31)	0.18 (0.12, 0.27)
Milk in coffee or tea	0.27 (0.14, 0.54)	0.41 (0.20, 0.81)	0.25 (0.13, 0.47)	0.22 (0.11, 0.43)
Milk as beverage	0.14 (0.08, 0.23)	0.21 (0.13, 0.34)	0.21 (0.14, 0.32)	0.20 (0.13, 0.31)

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Food groups	Mean (99% confidence intervals) of daily frequency of food groups			
	Women		Men	
	LERs (n=100)	Non-LERs (n=102)	LERs (n=120)	Non-LERs (n=118)
Cheese	0.11 (0.08, 0.16)	0.22 (0.15, 0.31) *	0.13 (0.10, 0.17)	0.21 (0.16, 0.28) *
Yogurt	0.07 (0.05, 0.11)	0.06 (0.04, 0.09)	0.05 (0.03, 0.08)	0.05 (0.04, 0.08)
Meat/fish/poultry	0.52 (0.44, 0.61)	0.88 (0.74, 1.04) *	0.66 (0.58, 0.75)	1.16 (1.02, 1.32) *
Eggs/excluding mixtures	0.05 (0.04, 0.07)	0.10 (0.07, 0.13) *	0.06 (0.05, 0.08)	0.10 (0.07, 0.13) *
Meat/fish/poultry/egg sandwich/mixtures	0.13 (0.10, 0.16)	0.23 (0.18, 0.28) *	0.15 (0.13, 0.18)	0.27 (0.23, 0.33) *
Beer	0.04 (0.03, 0.06)	0.07 (0.05, 0.12) *	0.07 (0.05, 0.10)	0.11 (0.08, 0.16)
Wine	0.06 (0.04, 0.08)	0.07 (0.05, 0.10)	0.07 (0.05, 0.10)	0.09 (0.07, 0.12)
Liquor	0.04 (0.03, 0.07)	0.07 (0.05, 0.10)	0.05 (0.04, 0.08)	0.07 (0.05, 0.10)
Coffee/tea	1.75 (1.26, 2.42)	1.37 (1.00, 1.88)	1.54 (1.17, 2.02)	1.97 (1.50, 2.59)
Soft drinks/regular	0.14 (0.08, 0.22)	0.26 (0.17, 0.39)	0.16 (0.11, 0.23)	0.44 (0.30, 0.65) *
Soft drinks/diet	0.43 (0.27, 0.69)	0.38 (0.21, 0.67) *	0.37 (0.23, 0.60)	0.39 (0.22, 0.68)
Candy	0.13 (0.09, 0.18)	0.23 (0.16, 0.32) *	0.09 (0.07, 0.12)	0.18 (0.13, 0.24) *
Sweets/spreads/syrups	0.23 (0.16, 0.35)	0.53 (0.36, 0.78) *	0.25 (0.17, 0.36)	0.54 (0.37, 0.78) *
Fat-type spreads	0.40 (0.30, 0.54)	0.70 (0.52, 0.94)	0.39 (0.29, 0.51)	0.64 (0.49, 0.85) *
Cream/creamer/liquid	0.36 (0.13, 1.00)	0.38 (0.13, 1.11)	0.29 (0.12, 0.72)	0.44 (0.18, 1.05)
Cream/creamer/not whipped	0.26 (0.13, 0.53)	0.19 (0.09, 0.40)	0.17 (0.08, 0.34)	0.24 (0.12, 0.48)
Dressing/not mayo-type	0.18 (0.13, 0.25)	0.18 (0.13, 0.25)	0.16 (0.12, 0.21)	0.23 (0.17, 0.30)
Mayo-type dressing [a]	0.09 (0.06, 0.13)	0.13 (0.09, 0.18)	0.08 (0.06, 0.11)	0.22 (0.16, 0.30) *
Soups	0.05 (0.04, 0.07)	0.08 (0.06, 0.11)	0.05 (0.04, 0.06)	0.08 (0.06, 0.10) *
Nuts/seeds	0.05 (0.04, 0.08)	0.14 (0.10, 0.19) *	0.08 (0.06, 0.10)	0.11 (0.08, 0.15)
Frozen dairy dessert	0.06 (0.04, 0.08)	0.12 (0.09, 0.16) *	0.07 (0.06, 0.10)	0.12 (0.09, 0.16) *
Condiments	0.14 (0.1, 0.18)	0.20 (0.16, 0.27) *	0.15 (0.12, 0.19)	0.33 (0.26, 0.42) *

[*] p<0.01 LER compared to Non-LER. Among consumers of each food group, the total daily frequency of consumption was regressed on log transformed total energy intake (estimated using doubly labeled water) to compute least squares means and 99% confidence intervals for daily frequency of consumption of a food group in LERs and non-LERs.

[a] Significant interaction between LER status and sex ($p \leq 0.05$).

Table 3

Adjusted percentages of LERs (n=220) and non-LERs (n=220) who report consuming a food group as a small, medium or large portion size; presented by sex on the food frequency questionnaire. The Observing Protein and Energy Nutrition (OPEN) Study.

	Women						Men					
	LERs (n=100)			Non-LERs (n=102)			LERs (n=120)			Non-LERs (n=118)		
Food groups [a]	Small (%)	Medium (%)	Large (%)	Small (%)	Medium (%)	Large (%)	Small (%)	Medium (%)	Large (%)	Small (%)	Medium (%)	Large (%)
Yeast Bread	14.3	84.7	1.0	13.1	85.8	1.1	4.6	92.4	3.0	1.6	90.0	8.4
Crackers	19.7	77.0	3.3	10.5	82.8	6.7	14.6	75.2	10.2	13.2	75.5	11.3
Muffins/Biscuits	9.3	88.5	2.2	3.1	90.1	6.8	7.8	83.5	8.7	6.7	83.2	10.1
Pancakes/waffles/French toast [b]	93.6		6.4	82.7		17.3	81.4		18.6	67.3		32.7
Cooked cereal [b, c]	30.4	69.6		19.7	80.3		10.4	89.6		18.9	81.1	
Ready-to-eat cereal	28.9	70.5	0.6	17.6	81.2	1.2	16.4	81.6	2.0	9.6	86.8	3.6
Rice, other cooked grains/mixtures	13.7	81.2	5.1	6.4	82.6	11.0	8.2	85.7	6.1	3.8	83.5	12.7
Pasta/pasta mixture	16.1	80.6	3.3	4.0	82.5	13.5 *	7.1	83.3	9.6	1.9	68.8	29.3 *
Pizza	6.4	84.8	8.8	3.0	79.3	17.7	1.4	65.3	33.3	1.0	57.3	41.7
Doughnuts/sweetrolls	18.0	80.9	1.1	6.8	90.0	3.2	8.4	89.0	2.6	4.0	90.6	5.4
Cookies/brownies	19.7	70.2	10.1	12.1	71.3	16.6	12.9	66.5	20.6	7.6	60.6	31.8
Cake/pie	26.1	69.2	4.7	17.0	75.1	7.9	13.0	76.0	11.0	7.0	73.3	19.7
Chips/popcorn/pretzels	28.6	69.4	2.0	14.0	81.2	4.8	21.9	73.6	4.5	12.8	78.9	8.3
Fruits juice	30.8	63.7	5.5	21.9	69.6	8.5	23.4	66.2	10.4	18.9	67.9	13.2
Fruit	4.2	91.6	4.2	4.7	91.6	3.7	3.2	92.6	4.2	3.1	92.5	4.4
White Potatoes	20.5	77.1	2.4	4.9	84.1	11.0 *	4.8	82.5	12.7	2.4	74.9	22.7
Green Salad	2.3	65.9	31.8	1.7	59.8	38.5	3.2	73.9	22.9	2.5	70.0	27.5
Other vegetables	3.6	89.8	6.6	1.4	82.5	16.1	7.1	87.8	5.1	2.9	85.1	12.0
Milk on cereal [b]	20.2	79.8		24.7	75.3		26.0	74.0		20.3	79.7	
Milk in coffee or tea	22.5	70.0	7.5	15.5	73.0	11.5	22.7	68.1	9.2	11.3	69.8	18.9
Milk as beverage [c]	39.4	58.1	2.5	20.5	73.5	6.0	25.4	65.3	9.3	24.2	65.9	9.9
Cheese [c]	16.5	70.3	13.2	6.1	62.5	31.4 *	8.1	60.0	31.9	7.5	58.7	33.8
Yogurt	13.1	86.9	0	12.4	87.6	0	11.2	87.0	1.8	6.6	90.2	3.2
Meat/fish/poultry	9.1	90.0	0.9	2.0	93.9	4.1	1.8	84.6	13.6	1.1	78.5	20.4
Eggs/excluding mixtures	51.4	47.6	1.0	31.7	66.1	2.2	20.5	71.9	7.6	17.7	73.3	9.0
Meat/fish/poultry/egg sandwich/mixtures	11.3	87.5	1.2	2.3	91.4	6.3 *	6.9	87.4	5.7	1.7	78.3	20.0 *

	Women						Men					
	LERs (n=100)			Non-LERs (n=102)			LERs (n=120)			Non-LERs (n=118)		
Food groups [a]	**Small (%)**	**Medium (%)**	**Large (%)**	**Small (%)**	**Medium (%)**	**Large (%)**	**Small (%)**	**Medium (%)**	**Large (%)**	**Small (%)**	**Medium (%)**	**Large (%)**
Beer	54.1	45.3	0.6	32.1	66.3	1.6	17.8	75.2	7.0	16.2	76.0	7.8
Wine	50.0	47.6	2.4	28.2	65.9	5.9	33.8	62.3	3.9	26.5	68.1	5.4
Liquor	61.5	37.3	1.2	41.4	55.9	2.7	32.1	63.4	4.5	29.6	65.3	5.1
Soft drinks, regular	37.2	61.5	1.3	38.2	60.5	1.3	27.6	69.9	2.5	14.4	80.1	5.5
Soft drinks, diet	34.3	62.1	3.6	25.4	69.2	5.4	18.4	77.1	4.5	16.6	78.3	5.1
Candy	27.7	67.1	5.2	22.7	70.7	6.6	19.5	72.5	8.0	13.2	74.6	12.2
Sweets, spread/syrups [b]	13.9	86.1		13.4	86.6		7.1	92.9		5.0	95.0	
Fat-type spreads	24.5	73.6	1.9	22.9	75.0	2.1	30.3	68.7	1.0	15.7	82.0	2.3 *
Cream/creamer, not whipped	31.7	63.5	4.8	30.4	64.5	5.1	27.4	66.1	6.5	21.3	69.8	8.9
Cream/creamer, liquid [b]	28.1	71.9		8.4	91.6		42.1	57.9		34.6	65.4	
Dressing, not mayo-type	39.7	56.9	3.4	33.6	62.1	4.3	30.9	63.0	6.1	26.8	65.8	7.4
Mayo-type dressing	2.9	95.4	1.7	1.4	95.1	3.5	6.9	92.8	0.3	0.6	95.9	3.5
Soups	11.6	86.0	2.4	3.3	88.1	8.6 *	2.2	86.4	11.4	1.2	79.1	19.7
Nuts/seeds	23.2	68.5	8.3	11.2	71.0	17.8 *	19.6	67.8	12.6	9.5	65.4	25.1 *
Frozen dairy dessert	5.8	85.2	9.0	4.3	83.7	12.0	5.9	79.2	14.9	2.5	67.1	30.4 *
Condiments	16.3	82.1	1.6	8.0	88.6	3.4	11.4	84.1	4.5	5.7	85.3	9.0

*p <0.01, LER compared to Non-LER by ordinal logistic regression adjusted for total energy intake (estimated by doubly labeled water).

[a]Data is not presented for the food group of coffee/tea. The food frequency questionnaire did not ask about consumption of different portions sizes for these beverages.

[b]Food groups that did not meet the proportional odds assumption ($p<0.05$). In these cases, logistic regression was used to estimate the probability of reporting a larger serving size among LERs compared to non-LERs by sex, and adjusted for total energy intake (estimated by doubly labeled water). Either the small and medium or the medium and large categories were collapsed, as shown.

[c]Significant interaction between LER status and sex.

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Table 4

Least squares means and 99% confidence intervals for reported daily frequency of consumption of selected foods groups on the food frequency questionnaire, for low energy reporters (LERs) (n=220) and non-low energy reporters (Non-LERs) (n=220) by body mass index (BMI): The Observing Protein and Energy Nutrition (OPEN) Study

Food groups	Mean (99% confidence intervals) of daily frequency of food groups n=number of participants						
	Normal BMI (<25 kg/m^2)		Overweight BMI (≥ 25 and < 30 kg/m^2)		Obese BMI (≥ 30 kg/m^2)		P for interaction
	LERs	Non-LERs	LERs	Non-LERs	LERs	Non-LERs	
Milk in coffee or tea	0.19 (0.08, 0.46) n=28	0.47 (0.24,0.93) * n=47	0.28 (0.15, 0.55) n=53	0.18 (0.08, 0.38) n=41	0.30 (0.12, 0.80) n=33	0.28 (0.08, 1.02) n=19	0.05
Candy	0.14 (0.09, 0.22) n=54	0.13 (0.09, 0.19) n=80	0.09 (0.07, 0.13) n=92	0.22 (0.16, 0.31) * n=87	0.11 (0.07, 0.17) n=70	0.27 (0.16, 0.45) * n=51	0.003
Mayo-type dressing	0.09 (0.05, 0.14) n=48	0.12 (0.08, 0.18) n=74	0.07 (0.05, 0.10) n=85	0.21 (0.15, 0.31) * n=80	0.13 (0.08, 0.19) n=67	0.18 (0.11, 0.29) n=48	0.009

* p<0.01 LER compared to Non-LER. Among consumers of each food group, the total daily frequency of consumption was regressed on log transformed total energy intake (estimated using doubly labeled water) to compute least squares means and 99% confidence intervals for daily frequency of consumption of a food group in LERs and non-LERs.