Psychological measures of eating behavior and the accuracy of 3 common dietary assessment methods in healthy postmenopausal women

Gaston P Bathalon, Katherine L Tucker, Nicholas P Hays, Angela G Vinken, Andrew S Greenberg, Megan A McCrory, and Susan B Roberts

ABSTRACT

Background: Factors affecting the accuracy of reported energy intake (rEI) need to be identified.

Objective: Our objective was to investigate the association of psychological measures of eating behavior with the accuracy of rEI assessed by 7-d weighed intakes, a 24-h recall, and a food-frequency questionnaire.

Design: Subjects were 26 restrained eaters aged 60.3 ± 0.6 y (x ± SEM) and weighing 63.8 ± 1.7 kg and 34 unrestrained eaters aged 59.4 ± 0.6 y and weighing 64.0 kg. rEI was assessed by using 3 dietary assessment methods and total energy expenditure (TEE) was determined by using doubly labeled water. Calculated EI (cEI) was determined as TEE corrected for the estimated change in body energy. Subjects completed the Eating Inventory. rEI values were significantly lower than TEE values for all 3 dietary assessment methods (P < 0.05); there was no significant relation between rEI and TEE by any method. There was no significant difference in 100 × rEI:TEE between restrained and unrestrained eaters by any of the dietary assessment methods. When combined data from the 3 methods were used, 100 × rEI:cEI was not significantly different from 100% in unrestrained eaters (99 ± 6.8%) but was lower in restrained eaters (89.1 ± 5.3%; P < 0.05). There was a positive relation between hunger and 100 × rEI:TEE (P < 0.05).

Conclusions: Low hunger is associated with undereating relative to normal eating during measurement of dietary intake; high dietary restraint may be associated with a reduction in reporting of consumed foods. Dietary hunger and restraint assessed with use of the Eating Inventory may help to identify subjects likely to underreport dietary intake. Am J Clin Nutr 2000;71:739–45.

KEY WORDS Energy intake, total energy expenditure, psychological measures, weighed diet record, 24-h dietary recall, food-frequency questionnaire, dietary assessment, postmenopausal women

INTRODUCTION

Information on energy intake (EI) and dietary macronutrients is a critical component of many human nutrition studies. Several investigators have questioned the accuracy of energy intake determined by weighed diet record, particularly in obese subjects (1). However, there is relatively little direct evidence that factors other than obesity are associated with underreporting, or whether such factors might be more or less important when techniques other than the weighed diet record are used.

Dietary restraint, which refers to the self-imposed practice of consciously attempting to restrict EI to prevent weight gain or to promote weight loss (2), is one potential factor that may affect the accuracy of dietary reporting. Restrained eaters typically report consuming less energy than do unrestrained eaters (2–10), and >50% of older individuals in a group we recently surveyed were restrained eaters (NP Hays, G Bathalon, GE Dallal, R Roubenoff, R Lipman, SB Roberts, unpublished observations, 1999). However, the question of whether the apparently low energy intake of restrained eaters is due to low energy needs or dietary underreporting has not been answered. Two previous studies addressed this issue using either measurements of total energy expenditure (TEE) or the ratio of nitrogen intake to urine nitrogen output to independently assess reporting accuracy but the results are conflicting. In the study by Tuschl et al (11), which used doubly labeled water measurements of TEE as a reference technique (11–13), there was no effect of dietary restraint on the accuracy of reported EI (rEI) determined by weighed diet records. In contrast, in a study by Bingham et al (14) that used urinary nitrogen excretion as the validation technique, higher dietary restraint was observed among overweight women who underreported their usual diet; however, it was not possible to distinguish between the effects of overweight and dietary restraint on reporting accuracy. Thus, the question of whether dietary restraint is associated with underreporting of weighed dietary intake independent of body weight remains unanswered. In addition, the effect of other psychological predictors of eating behavior on the accuracy of dietary assessment methods has not been addressed.


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The purpose of this study was to determine whether psychological measures of eating behavior can identify underreporting of dietary intake by 3 dietary assessment methods in common use. In addition to using the Eating Inventory for assessment of dietary restraint, hunger, and disinhibition (15), we examined the Eating Attitudes Test and the Eating Disorders Inventory for this purpose (16). We also investigated the source of errors in dietary assessment methods, specifically to investigate whether underreporting could be attributed specifically to a failure to report consumed foods or to undereating during the measurement period.

## SUBJECTS AND METHODS

### Subjects

The subjects were 60 healthy postmenopausal women classified as restrained or unrestrained eaters, group-matched for body mass index (in kg/m²), reported stable body weight, and dietary restraint over the past 10 y (Table 1). Eating Inventory (15) scores for restraint of ≤4 or ≥13 were used to classify the women as unrestrained or restrained eaters, respectively. These cutoff points are the 25th and 75th percentiles of restraint scores in 2230 women of similar age range living in Boston (SB Roberts, unpublished observations, 1999). The subjects were free from known disorders that might affect EI and energy metabolism, including diabetes, cancer, coronary heart disease, eating disorders, depression, alcoholism, inflammatory and endocrine disorders, and hepatic, renal, or thyroid dysfunction. Additional exclusion criteria included smoking, reported endurance training (participation in sports or athletic training) of > 6 h/wk, following a weight-control diet during the past year, a history of hypertension, a vegetarian lifestyle, athletic training) of > 6 h/wk, following a weight-control diet during the measurement period, and 0.03 MJ/g (7 kcal/g) is the energy cost of weight loss (23).

### Macronutrient intakes

In addition to a self-administered FFQ (Fred Hutchinson Cancer Research Center/Block FFQ, version 06.10.88, 1988, Cancer Prevention Research Program, Fred Hutchinson Cancer Research Center) on 11 February 2018

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### Table 1

<table>
<thead>
<tr>
<th>Subject characteristics</th>
<th>Unrestrained eaters</th>
<th>Restrained eaters</th>
</tr>
</thead>
<tbody>
<tr>
<td>(n = 26)</td>
<td>(n = 34)</td>
<td></td>
</tr>
<tr>
<td>General characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (y)</td>
<td>60.3 ± 0.6</td>
<td>59.4 ± 0.6</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>63.7 ± 1.7</td>
<td>64.0 ± 1.5</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>164.4 ± 1.2</td>
<td>160.8 ± 1.1</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>23.6 ± 0.6</td>
<td>24.8 ± 0.5</td>
</tr>
<tr>
<td>Weight change (g/d)</td>
<td>-32.5 ± 12.6</td>
<td>-27.9 ± 9.8</td>
</tr>
<tr>
<td>Fat-free mass (kg)</td>
<td>40.9 ± 0.8</td>
<td>40.2 ± 1.0</td>
</tr>
<tr>
<td>Body fat (% of wt)</td>
<td>35.3 ± 1.2</td>
<td>36.6 ± 1.6</td>
</tr>
</tbody>
</table>

Psychometric scores

- Restraint: 3.9 ± 0.2 vs 15.7 ± 0.4
- Hunger: 5.8 ± 0.8 vs 4.6 ± 0.6
- Disinhibition: 6.4 ± 0.8 vs 7.0 ± 0.5
- Eating Attitudes Test: 7.7 ± 0.6 vs 13.7 ± 1.35
- Eating Disorders Inventory: 0.4 ± 0.2 vs 3.1 ± 0.8

1 x SEM.
2 P < 0.05, 4 P < 0.001.
3 Significantly different from zero: 5 P < 0.05, 6 P < 0.01.
4 Based on the Eating Inventory (15).
5 Reference 16.
Center, Seattle) completed at screening to assess dietary intake over the previous 6-mo period, subjects also quantified food and drink consumed using a 7-d weighed diet record and three 24-h dietary recalls as described elsewhere (24). Subjects were encouraged to consume usual amounts of typical foods and beverages and to avoid gaining or losing weight. Nutrient intakes were calculated by using standard food-composition tables (Minnesota Nutrition Data System, software developed by the Nutrition Coordinating Center, University of Minnesota, Minneapolis; Food Database version 11A; Nutrient Database version 26; 1996). Daily macronutrient intakes, as reported by 7-d weighed diet records, and the mean of the three 24-h dietary recalls were used in data analysis. Reporting accuracy was assessed with calculations of 100 × rEI:TEE, and 100 × rEI:cEI.

**Body composition**

Body density was determined by hydrostatic weighing with repeated measurements taken until at least 3 values for body density agreed within 1% (25). Residual lung volume was then measured on land by using a modified oxygen dilution technique in which nitrogen in expired air was measured directly (model 505 Nitralyzer; Med Science, St Louis). Total body fat was calculated by using the Siri equation (26). Two restrained volunteers were unable to complete the hydrostatic weighing procedure. In this case, results from dual-energy X-ray absorptiometry (model Lunar DPX, software version 3.6z; Lunar Corporation, Madison, WI) were used because there were no significant differences between measures of body composition (fat-free mass and percentage fat) by the 2 methods in this population (data not shown).

Body weight was determined to within 100 g (model 8138; Toledo Weight-Plate, Bay State Scale Co, Cambridge, MA) in the fasting state. Height was determined to within 0.1 cm by using a wall-mounted stadiometer.

**Statistical analysis**

Reporting accuracy by the 3 intake methods was analyzed by using multivariate repeated-measures analysis of variance (ANOVA) by the general linear model procedure with restraint group as the between-subjects factor and diet method as the within-subject factor. Epsilon, by using the Greenhouse-Geiser correction, was used to adjust the degrees of freedom if Mauchly’s test of sphericity resulted in significant deviation from the assumption of sphericity. If F was significant, post hoc multiple comparisons were made by using the Bonferroni test. Significant effects of the dietary assessment methods after post hoc comparisons are reported at the P < 0.05 level (Table 2). Pearson correlation coefficients (r, bivariate and partial) were calculated to assess associations between variables. A one-sample t test was used to determine whether the accuracy (100 × the ratio of rEI to TEE or cEI) of the dietary methods differed from 1.0. Differences between and within groups were considered significant at P < 0.05. Statistical calculations were performed by using SPSS 8.0 for WINDOWS (SPSS Inc, Chicago). Values are expressed as means ± SEMs.

**RESULTS**

The characteristics of the subjects are shown in Table 1. There were no significant differences between the groups except in height, restraint score, and the drive-for-thinness score; in particular, percentage body fat was not significantly different.

**Table 2**

Reported energy intake (rEI) according to 3 different dietary assessment methods and the ratio between rEI and total energy expenditure (TEE) and calculated EI (cEI) in unrestrained and restrained women.

<table>
<thead>
<tr>
<th>TEE (MJ/d)</th>
<th>Unrestrained eaters (n = 26)</th>
<th>Restrained eaters (n = 34)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-d weighed food record</td>
<td>9.49 ± 0.23</td>
<td>8.96 ± 0.26</td>
</tr>
<tr>
<td>24-h recall</td>
<td>9.42 ± 0.23</td>
<td>8.95 ± 0.26</td>
</tr>
<tr>
<td>FFQ</td>
<td>9.61 ± 0.22</td>
<td>9.07 ± 0.26</td>
</tr>
<tr>
<td>rEI (MJ/d)</td>
<td>7-d weighed diet record</td>
<td>8.3 ± 0.3</td>
</tr>
<tr>
<td>24-h recall</td>
<td>7.6 ± 0.4</td>
<td>6.6 ± 0.3a</td>
</tr>
<tr>
<td>FFQ</td>
<td>7.4 ± 0.3</td>
<td>6.5 ± 0.4a</td>
</tr>
<tr>
<td>100 × rEI:TEE (%)</td>
<td>88.8 ± 3.7b</td>
<td>81.1 ± 3.3b</td>
</tr>
<tr>
<td>24-h recall</td>
<td>8.44 ± 0.46</td>
<td>8.11 ± 0.38</td>
</tr>
<tr>
<td>FFQ</td>
<td>8.64 ± 0.46</td>
<td>8.23 ± 0.37</td>
</tr>
<tr>
<td>100 × rEI:cEI (%)</td>
<td>106.7 ± 8.3</td>
<td>94.1 ± 5.4</td>
</tr>
<tr>
<td>7-d weighed diet record</td>
<td>97.9 ± 7.7</td>
<td>87.3 ± 5.4</td>
</tr>
<tr>
<td>Mean of 3 methods</td>
<td>92.3 ± 6.4</td>
<td>85.7 ± 7.5</td>
</tr>
</tbody>
</table>

1 ± SEM. FFQ, food-frequency questionnaire. cEI = TEE + (∆wt × 0.03).
2,3,6 Significant main effect of method: P < 0.001, 2 P < 0.05, 3 P < 0.01; methods with different superscript letters are significantly different, P < 0.05 (Bonferroni post hoc multiple comparisons test).
4 Significant main effect of restraint status, P < 0.01.
5,6 Significantly different from 100%; 5 P < 0.01, 6 P < 0.05.

Values for TEE, EI, and related variables are shown in Table 2. There was no significant difference in TEE between the groups but rEI was significantly lower in restrained eaters. Dietary assessment method significantly affected 100 × rEI:TEE (P < 0.035) and 100 × rEI:cEI (P < 0.05) in both restrained and unrestrained eaters. 100 × rEI:TEE was significantly < 100% in both restrained and unrestrained eaters, and there was no significant difference in 100 × rEI:cEI between the groups. 100 × rEI:cEI was also significantly < 100% in restrained eaters but not in unrestrained eaters. ANOVA indicated no significant interaction between the groups for 100 × rEI:cEI.

Regression analysis was used to further examine associations between psychological measures of eating behavior and dietary reporting. As shown in Figure 1, there was no significant association between rEI by any method and TEE in either restrained or unrestrained eaters separately or combined. Similarly, although 100 × rEI:TEE was negatively associated with TEE by all 3 dietary assessment methods (Figure 2), there was no significant difference between restrained and unrestrained eaters in the relations. Similar relations were noted between 100 × rEI:cEI and cEI (data not shown).

Other measures of eating behavior were also examined for their ability to predict reporting accuracy (both 100 × rEI:TEE and 100 × rEI:cEI). Eating Attitudes Test scores, Eating Disorders Inventory scores, and disinhibition (from the Eating Inven-
tory) did not predict reporting accuracy in either restrained or unrestrained eaters separately or combined. There was a significant positive correlation between the hunger score of the Eating Inventory and $100 \times r_{EI:TEE}$ averaged for diet records ($P < 0.05$), but no relation between hunger and $100 \times r_{EI:cEI}$. Because the hunger score of the Eating Inventory was associated with disinhibition ($r = 0.622$, $P < 0.01$), values for hunger were adjusted for disinhibition even though disinhibition itself was not a significant predictor; the resulting relation between hunger and $100 \times r_{EI:TEE}$ is shown in Figure 3.

The 7-d weighed diet records were further used to examine the accuracy of dietary reporting of macronutrient composition in
Restrained eaters had higher hunger because of the intercorrelation of these 2 measures. Restrained eaters as a group reported consuming a diet significantly lower in fat, higher in protein, and lower in energy density than did the unrestrained eaters (Table 3). However, the macronutrient composition of the diets of accurate restrained reporters (defined as having rEI values within 25% of cEI) was not significantly different from that of accurate unrestrained reporters except that fiber intake was lower. There was no significant difference in macronutrient reporting between all low-hunger and all high-hunger eaters, and in the accurate reporters the only difference between the groups was that high-hunger eaters reported consuming less alcohol.

DISCUSSION
Identification of generally applicable factors that influence dietary reporting is an important prerequisite for the development of accurate approaches to assessing dietary intake in different population groups. Such general factors can then potentially be used to exclude either high-risk subjects from study participation, inaccurate data retrospectively from the data set, or possibly to correct data on reported intake in mixed groups of subjects.

We found that rEI was significantly lower in restrained eaters than in unrestrained eaters, although there was no significant difference in TEE between the groups. Moreover, although 100 × rEI < cEI did not differ significantly between groups, values were not different from 100% in the unrestrained eaters but were significantly <100% in the restrained eaters. Although not conclusive, these data suggest a modest degree of underreporting of consumed items in restrained eaters but not in unrestrained eaters. Note also that reporting accuracy in restrained eaters tended to be better when a 7-d weighed diet record was used than when a 24-h recall or FFQ was used, thus failing to substantiate the hypothesis that dietary assessment methods requiring a greater degree of effort by subjects might be subject to a greater degree of underreporting in restrained eaters. In addition, there was no significant relation between rEI and TEE with any of the dietary assessment methods, a finding comparable with that reported previously for a smaller group of older subjects (24) and contrasting with improved relations in young subjects (24). Factors such as impaired memory associated with aging and perhaps other causes, may explain why the precision of dietary reporting may be more significantly impaired in older individuals than in younger ones.

The suggestion that all subjects tended to undereat relative to normal during measurement of EI and that, in addition, restrained eaters modestly underreported consumed food, may help to provide a unifying explanation for the apparently different results of previous investigations. On the basis of studies in women who were both overweight and restrained eaters, Bingham et al (14) suggested that restrained eating is associated with underreporting of EI but they could not differentiate restrained eating from the known effects of obesity on reporting accuracy.

**TABLE 3**
Reported dietary macronutrient composition in subject groupings according to those providing accurate (±25% of calculated energy intake) records using 7-d weighed diet records

<table>
<thead>
<tr>
<th>Subject group</th>
<th>Protein (g)</th>
<th>Fat (g)</th>
<th>Carbohydrate (g)</th>
<th>Fiber (g)</th>
<th>Alcohol (g)</th>
<th>Energy density (MJ/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unrestrained eaters</td>
<td>% of energy</td>
<td>% of energy</td>
<td>% of energy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All (n = 26)</td>
<td>15.2 ± 0.6</td>
<td>30.7 ± 1.1</td>
<td>53.7 ± 1.5</td>
<td>20.4 ± 1.3</td>
<td>7.9 ± 1.9</td>
<td>3.8 ± 0.1</td>
</tr>
<tr>
<td>Accurate (n = 12)</td>
<td>15.0 ± 0.6</td>
<td>29.2 ± 1.8</td>
<td>55.4 ± 2.4</td>
<td>24.4 ± 1.8</td>
<td>9.1 ± 3.4</td>
<td>3.6 ± 0.2</td>
</tr>
<tr>
<td>Restrained eaters</td>
<td>% of energy</td>
<td>% of energy</td>
<td>% of energy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All (n = 34)</td>
<td>16.8 ± 0.6 (\text{a})</td>
<td>26.6 ± 0.9 (\text{a})</td>
<td>55.8 ± 1.4</td>
<td>19.3 ± 0.9</td>
<td>7.9 ± 1.8</td>
<td>3.4 ± 0.1 (\text{a})</td>
</tr>
<tr>
<td>Accurate (n = 17)</td>
<td>16.1 ± 0.7</td>
<td>28.8 ± 1.2</td>
<td>53.6 ± 1.8</td>
<td>18.7 ± 1.0 (\text{a})</td>
<td>9.1 ± 2.1</td>
<td>3.5 ± 0.1</td>
</tr>
<tr>
<td>Low hunger</td>
<td>% of energy</td>
<td>% of energy</td>
<td>% of energy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All (n = 30)</td>
<td>16.7 ± 0.6</td>
<td>28.6 ± 1.0</td>
<td>53.1 ± 1.5</td>
<td>18.6 ± 0.9</td>
<td>9.7 ± 1.9</td>
<td>3.6 ± 0.1</td>
</tr>
<tr>
<td>Accurate (n = 15)</td>
<td>15.9 ± 0.7</td>
<td>28.8 ± 1.2</td>
<td>52.1 ± 2.2</td>
<td>20.6 ± 1.4</td>
<td>14.0 ± 2.9</td>
<td>3.4 ± 0.2</td>
</tr>
<tr>
<td>High hunger</td>
<td>% of energy</td>
<td>% of energy</td>
<td>% of energy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All (n = 30)</td>
<td>15.6 ± 0.6</td>
<td>28.1 ± 1.1</td>
<td>56.6 ± 1.3</td>
<td>21.0 ± 1.2</td>
<td>6.0 ± 1.7</td>
<td>3.5 ± 0.1</td>
</tr>
<tr>
<td>Accurate (n = 14)</td>
<td>15.2 ± 0.7</td>
<td>29.1 ± 1.6</td>
<td>56.7 ± 1.6</td>
<td>21.5 ± 1.6</td>
<td>3.9 ± 1.2 (\text{b})</td>
<td>3.6 ± 0.2</td>
</tr>
</tbody>
</table>

\(\text{a}\) ± SEM.

\(\text{b}\) Significantly different from unrestrained eaters (total groups compared with total groups and accurate compared with accurate); \(^2 P < 0.05, ^2 P < 0.01.\)
In contrast, Tuschi et al (11) found no significant difference in reporting accuracy between restrained and unrestrained eaters, but they studied a relatively small number of subjects. Further research is needed to confirm or deny our suggestion of a modest effect of dietary restraint on underreporting, and to examine dietary reporting accuracy in different population groups and within the full spectrum of dietary restraint scores.

The question of why restrained eaters may have an increased tendency to underreport consumed food is not known. Although underreporting can be due to a variety of reasons, including conscious or subconscious misreporting of portion sizes, failure to report whole food items, or a combination of these factors, the results of this study suggest that failure to report consumed foods, perhaps due to self denial (27, 28), may be a primary reason why restrained eaters underreport EI. The average underreporting in unrestrained eaters was small, suggesting that EI was inadvertently reduced by the simplification of dietary patterns to make recording easier (28).

The results of this study also suggest that individuals with low scores on the hunger scale of the Eating Inventory are particularly likely to undereat during measurement of dietary intake. We observed a significant positive relation between hunger and 100 × reEI:TEE, which reflects the difference between reported intake and usual intake (29, 30). In contrast, there was no significant relation between hunger and 100 × reEI:ceEI, a comparison that reflects the difference between reported and actual intakes during the measurement period (29, 30). These findings were determined by using mean values for all dietary assessment methods combined, but similar trends were noted in the different dietary assessment methods examined separately.

The reason for an association between hunger and undereating is not known. However, one possible explanation is that individuals with a relative absence of hunger may undereat during measurement of dietary intake because they lack an active drive to eat that compels hungrier individuals to continue their usual intake despite the inconvenience of weighing and recording all consumed items. In relation to this suggestion, it may be relevant that elderly individuals are thought to have a reduced ability to regulate EI (31). In this group of postmenopausal women who were approaching old age, some individuals may have experienced a relatively greater loss of energy regulation abilities than others, and could thus have been at greater risk of undereating.

In a simple comparison of the 2 groups, the restrained eaters appeared to consume a diet providing a higher percentage of energy from protein, a much lower percentage of energy from fat, and a lower energy density, a finding consistent with previous reports (3, 5, 8, 27). However, the validity of such overall group differences is uncertain because EI was underreported by some individuals in both groups. We therefore classified dietary records as accurate or inaccurate on the basis of their relation to cEI, making the assumption that individuals who reported EI to within 25% of TEE reported their usual macronutrient intakes more accurately than did individuals who did not. In the subjects providing accurate dietary records, there was no significant difference between the groups. Statistical power was relatively high for fat (0.80 power), but was low for the comparisons of protein (0.47 power) and energy density (0.58 power). These observations imply that the prevailing idea that restrained eaters choose diets with low energy densities and high protein contents may not be valid. However, the possibility cannot be excluded that the inaccurate reporters of energy were accurately reporting the relative contribution of different macronutrients to energy, and further studies in this area are needed.

In summary, the results of this study suggest that hunger and restraint assessed by the Eating Inventory may predict the accuracy of reported dietary intake in postmenopausal women. Additionally, the results suggest that low hunger is associated with significant underreporting during assessment relative to usual eating, whereas high restraint may be associated with a degree of underreporting of consumed items. Further studies are needed to examine the extent to which these results obtained in postmenopausal women are relevant to other populations.

We gratefully acknowledge the cooperation of the study volunteers and we thank the staff of the Metabolic Research Unit and the Dietary Assessment Program at the Jean Mayer Human Nutrition Research Center on Aging for their assistance in data collection and analysis.

REFERENCES