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.
Results: 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 methods were used, 100 × rEI:cEI was not significantly different from 100% in unrestrained eaters (99 ± 6.8%; P > 0.05) 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 the 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.
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.

The study was conducted at the Metabolic Research Unit at the Jean Mayer US Department of Agriculture Human Nutrition Research Center on Aging at Tufts University with ethical approval granted by the New England Medical Center/Tufts University Human Investigations Review Committee. Written, informed consent was given by each subject before participating in the study.

### Study protocol

The main component of the study was conducted over an 18-d period. Dietary intake during the previous 6 mo was assessed by using a food-frequency questionnaire (FFQ) at screening. After an overnight fast, a doubly labeled water measurement of TEE was started and body composition and anthropometric measures were taken. In addition, subjects completed a 24-h recall of foods consumed. They were then discharged from the research center and instructed to lead their usual lives at home. Subjects returned to the center on the morning of study day 9 to deliver and provide urine samples for the doubly labeled water study, to have their body weights taken, and to provide a second 24-h recall of foods consumed. They also returned on the morning of study day 11 to have final repeat anthropometric measurements, to provide a urine sample, to give a third 24-h recall of foods consumed, and to receive instruction on keeping a 7-d weighed diet record. Subjects were then discharged and during study days 11–17 recorded all food and beverages consumed and collected urine samples. On study day 18 they brought the urine samples and 7-d diet records to the center.

### Measurements of total energy expenditure

A mixed dose of $^2$H$_2$O containing 0.15 g$^3$H$_2$O/kg body wt and 0.075 g$^18$O/kg body wt was given orally between 0745 and 0830 on study day 1 after an overnight fast and collection of a baseline urine specimen. The dose was followed by two 25-mL rinses with tap water. Subjects then fasted for 4 h while urine specimens were collected 3, 4, and 5 h after isotope administration. Samples from the second or later void of the day were collected on subsequent study days, and those obtained at home were stored in airtight storage tubes in the subject’s home freezer before transportation to the research center.

Abundances of $^2$H and $^18$O in dilutions of the isotope doses and in 7 urine specimens (baseline, 5 h, and study days 2, 3, 8, 14, and 15) were analyzed by isotope-ratio mass spectrometry as described previously (17). Values for TEE were calculated from the doubly labeled water data by using a modification of the equations of Roberts et al (17) incorporating the recommended assumption of a fixed ratio of dilution spaces ($^2$H$_2$O:$^3$H$_2$O) of 1.0342 in all subjects (18) with a standard fractionation correction for older individuals (19), using the DLW software (20). TEE values were calculated from the rate of carbon dioxide production by using de Weir’s equation (21), with estimates for respiratory quotient assumed to equal the food quotient determined from reported macronutrient intakes of each diet intake assessment method (22), ie, 3 TEE values were calculated for each subject. Calculated EI (3 cEI values for each subject) was determined by using a correction for change in body energy during the measurement period, as TEE + (Δwt 0.03), where TEE is measured as MJ/d, Δwt is measured as g/d between study days 1 and 11, and as 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

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### Subject characteristics

<table>
<thead>
<tr>
<th></th>
<th>Unrestrained eaters</th>
<th>Restrained eaters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (y)</td>
<td>60.3 ± 6.0</td>
<td>59.4 ± 6.0</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 ± 1.1³</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 ± 12.6⁴</td>
<td>−27.9 ± 9.8⁸</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>
<tr>
<td><strong>Psychometric scores</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restraint¹</td>
<td>3.9 ± 0.2</td>
<td>15.7 ± 0.4¹⁴</td>
</tr>
<tr>
<td>Hunger²</td>
<td>5.8 ± 0.8</td>
<td>4.6 ± 0.6</td>
</tr>
<tr>
<td>Disinhibition³</td>
<td>6.4 ± 0.8</td>
<td>7.0 ± 0.5</td>
</tr>
<tr>
<td>Eating Attitudes Test⁷</td>
<td>7.7 ± 0.6</td>
<td>13.7 ± 1.35</td>
</tr>
<tr>
<td>Eating Disorders Inventory⁸</td>
<td>0.4 ± 0.2</td>
<td>3.1 ± 0.8³⁹</td>
</tr>
</tbody>
</table>

¹Significantly different from unrestrained eaters: ²$P < 0.05$, ³$P < 0.001$. ⁴Significantly different from zero: ⁵$P < 0.05$, ⁶$P < 0.01$. ⁷Based on the Eating Inventory (15). ⁸Reference 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 the assumption of sphericity was significant, post hoc comparisons are reported at the P < 0.05 level (Table 2). Regression analysis was used to further examine associations between psychological measures of eating behavior and dietary intake. 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).

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:TEE 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.
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 tend 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.

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</th>
<th>Fat</th>
<th>Carbohydrate</th>
<th>Fiber</th>
<th>Alcohol</th>
<th>Energy density</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% of energy</td>
<td>% of energy</td>
<td>% of energy</td>
<td>g</td>
<td>g</td>
<td>MJ/kg</td>
</tr>
<tr>
<td>Unrestrained eaters</td>
<td></td>
<td></td>
<td></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></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>All (n = 34)</td>
<td>16.8 ± 0.6</td>
<td>26.6 ± 0.9</td>
<td>55.8 ± 1.4</td>
<td>19.3 ± 0.9</td>
<td>7.9 ± 1.8</td>
<td>3.4 ± 0.1</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</td>
<td>9.1 ± 2.1</td>
<td>3.5 ± 0.1</td>
</tr>
<tr>
<td>Low hunger</td>
<td></td>
<td></td>
<td></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></td>
<td></td>
<td></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</td>
<td>3.6 ± 0.2</td>
</tr>
</tbody>
</table>

1 ± SEM.
2 Significantly different from unrestrained eaters (total groups compared with total groups and accurate compared with accurate); 3 P < 0.05, 4 P < 0.01.
significance of hunger in regulating dietary intake. Undereating, 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 post-menopausal 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