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Cognitive dietary restraint is associated with higher urinary cortisol excretion in healthy premenopausal women

Judy A McLean, Susan I Barr, and Jerilynn C Prior

ABSTRACT

Background: Cognitive dietary restraint, assessed by the Three-Factor Eating Questionnaire restraint subscale, is associated with subclinical menstrual cycle disturbances. This association may be mediated by stress-activated cortisol release.

Objective: We assessed whether 24-h urinary cortisol excretion differs between women with high and low restraint scores.

Design: Participants (aged 21.6 ± 2.5 y; n = 62) with normal-length menstrual cycles and high (n = 33) or low (n = 29) restraint scores completed a questionnaire describing weight history, dietary practices, and exercise. Cortisol, calcium, and creatinine were measured in urine collected over 24 h on a day when all food and beverages were provided and measured. Previously, 3-d food records and anthropometric measurements were obtained.

Results: Age, height, weight, body mass index, and length of menstrual cycle were similar between groups. The reported amount of exercise was higher (3.4 ± 1.7 compared with 2.2 ± 1.8 h/wk; P < 0.05) and energy intakes (assessed from 3-d and 24-h food records) were lower in the high- than in the low-restraint group. Ratios of urinary cortisol (nmol) to creatinine (mmol) were higher in the high-restraint than in the low-restraint group (42.9 ± 12.9 compared with 36.3 ± 8.9; P < 0.05), whereas ratios of urinary calcium (mmol) to creatinine were lower (0.3 ± 0.1 compared with 0.4 ± 0.2; P < 0.05) in the high-restraint group. Urinary cortisol was not associated with exercise, nutrient intakes, or anthropometric measurements.

Conclusions: High dietary restraint scores are associated with urinary cortisol, a biological marker of stress, and high cortisol excretion may affect bone health. Our results suggest that further research is warranted to clarify these associations and to determine whether they persist over time. Am J Clin Nutr 2001;73:7–12.

KEY WORDS Dietary restraint, urinary cortisol, premenopause, women, Three-Factor Eating Questionnaire

INTRODUCTION

To achieve or maintain a desired body weight, many women consciously try to limit their food intake. This is referred to as dietary restraint or cognitive dietary restraint. The concept of restrained eating was originally introduced to define a type of eating behavior that was governed by cognitive processes rather than by physiologic mechanisms such as hunger and satiety (1). Of the several scales that have been developed to measure dietary restraint, the 21-item restraint subscale of the Three-Factor Eating Questionnaire (TFEQ) (2) is recognized as the most appropriate tool for the assessment of cognitive dietary restraint (3). Typically, women with high restraint scores are aware of the amount and type of food they consume.

We and others found that women with high restraint scores are more likely to experience ovulatory disturbances, including a shortening of luteal phase length or cycle length and an increased proportion of anovulatory cycles, than are women with low restraint scores (4–7). Women in these studies (5–7) experienced regular menstrual cycles of normal length and the high- and low-restraint groups had similar energy intakes and relative weights. These findings suggest that energy deprivation did not cause the observed subclinical ovulatory disturbances.

The mediating mechanism between dietary restraint and ovulatory disturbances in normal-weight women is not known, but it could be related to the psychological stress of constantly trying to monitor and control food intake. Women with high restraint scores may experience more stress in relation to food consumption than do women with low restraint scores. At the neuroendocrine level, high stress can trigger the release of corticotropin-releasing hormone (CRH) from the hypothalamus, which leads to the release of cortisol from the adrenal cortex (8). If high stress occurs in relation to dietary restraint, an elevation in cortisol concentrations is a likely consequence. High concentrations of cortisol are associated with increased reproductive disturbances because of the inhibitory effect of CRH on hypothalamic, and hence pituitary, hormone secretions required for normal menstrual cycle function (9, 10). Therefore, if dietary restraint leads to stress-related increases in serum cortisol and increases in urinary cortisol excretion, women with high restraint scores would
be more likely to experience reproductive changes such as those observed in the aforementioned studies (4–7).

We found only one study that explored a possible relation between cortisol concentrations or excretion and dietary restraint (11). There was no association between restraint score and serum cortisol concentrations; however, the overnight protocol used in that study may not have been appropriate if cortisol is released with food-related increases in stress. It is unlikely that group differences would be observed during a time when food consumption did not occur.

Accordingly, the primary purpose of this cross-sectional study was to determine whether an association exists between dietary restraint and 24-h urinary cortisol excretion in healthy, normal-weight, regularly menstruating premenopausal women.

SUBJECTS AND METHODS

Overview

Women categorized as having high or low dietary restraint scores completed 24-h urine collections, which were analyzed for cortisol, creatinine, and calcium. Urine collections were conducted within the first 10 d of the menstrual cycle on a day when all food and beverages were provided at the study center. This phase was selected to control for variability in energy intake across the menstrual cycle (12). Power analyses conducted before initiating the study indicated that a sample size of 32 subjects per group would detect a significant difference ($P < 0.05$) in 24-h urinary cortisol concentrations between groups, with a $\beta$ of 0.84.

Participants

Participants were recruited for the study from a group of 666 female university students who had completed an instrument on eating attitudes and behaviors. Among other items, the instrument included the TFEQ (2), which was scored according to the authors’ instructions. The TFEQ contains subscales for restraint (possible scores: 0–21), disinhibition (possible scores: 0–16), and hunger (possible scores: 0–14). The restraint subscale assesses the intent to control food intake to achieve or maintain a desired body weight. The disinhibition scale assesses overeating in response to a variety of situations associated with loss of control of food intake, and the hunger subscale assesses perceived hunger. The eating attitudes and behaviors instrument also included items on age, height, weight, dieting history, menstrual cycle length and history, special diets (eg, vegetarian), exercise, and vitamin, mineral, and medication use.

Enrollment criteria for the present study included age 20–35 y, stable body weight with a body mass index (BMI; in kg/m$^2$) of 18–25, nulliparity, self-reported normal menstrual cycle intervals (21–35 d), $\leq 7$ h exercise/wk, and either high (between 13 and 21) or low (between 0 and 5) scores on the TFEQ restraint scale. Exclusion criteria included cigarette smoking, use of oral contraceptives or drugs that can affect bone metabolism (eg, steroid and thyroid hormones), weight cycling [defined as the loss of $>2.3$ kg (5 lb) more than twice in the past 2 y], consumption of $\geq 2$ alcoholic beverages/d, hirsutism, and a previous diagnosis or treatment of an eating disorder. Participants were also excluded if they worked night shifts or had other unusual sleep patterns that may affect stress hormones. Finally, women were excluded if they were dieting.

Of the 666 women who completed an instrument on eating attitudes and behaviors, 281 expressed an interest in participating in the present study. No differences in age or BMI existed between those who did or did not express interest in participation (data not shown). Study entry criteria led to the exclusion of 198 women, most of whom ($n = 122$) were excluded because their TFEQ scores were between 6 and 12. Of the 83 women eligible for participation, 62 completed the study. The main reason eligible participants did not participate or complete the study was because they became unavailable or ineligible before beginning the study (eg, began oral contraceptive use). Most (84%) of the participants were not enrolled in university nutrition courses. The study protocol was approved by the University’s Clinical Screening Committee for Research and Other Studies Involving Human Subjects, and all subjects provided written consent.

Physical measurements

Height was measured at full inspiration to the nearest 0.1 cm with a stadiometer while subjects were shoeless. Weight was measured to the nearest 0.5 kg with an electronic scale while subjects were wearing a paper examination gown. Waist and hip circumferences were measured to the nearest 0.1 cm (13). Duplicate measurements were made; if differences were observed, a third measurement was made and the 2 most similar measurements were averaged. From these data, BMIs and waist-to-hip ratios (waist circumference/hip circumference) were calculated.

Dietary records

To provide an assessment of the usual energy, macronutrient, and calcium intakes of the 2 groups of women, each subject completed a 3-d food record (on 2 weekdays and 1 weekend day). Records were kept during the midfollicular phase (days 4–10 of the cycle) of a menstrual cycle preceding the cycle in which urine samples were collected. Participants were individually instructed about how to complete the food records and were provided with measuring cups and spoons to assist in quantifying portion sizes. Any ambiguous entries were clarified with the participant before data entry. To quantify dietary intakes on the day that urine collections were made, participants consumed only food and beverages supplied at the study center. Participants chose the types and amounts of foods they wanted to eat during the day from a variety of foods that were available to them, and were free to consume as much as they wanted. All portions were weighed or measured before being served; any items remaining after the meals were consumed were subtracted. Both 3-d and 24-h food records were analyzed by using FOOD PROCESSOR II (version 7.0, 1997; ESHA Research, Salem, OR).

Urinary collection and analyses

Urine samples were collected during a designated 24-h period within the first 10 d of the subjects’ menstrual cycles. On this day, the women were instructed to maintain their usual activities but to avoid intense exercise. After waking, the subjects noted the time of their first void but discarded this sample; thereafter, all urine excreted was collected up until and including the first-voided urine 24 h later on the next day. The volume (mL) of the 24-h sample was measured and aliquots were analyzed for cortisol, creatinine, and calcium. Urinary calcium was included in the analysis to provide information on the relation between calcium intakes and excretion on the day of collection. Urinary cortisol was quantitatively determined by using Chiron Diagnostics.
Table 1: Physical and lifestyle characteristics of the participants grouped according to low and high dietary restraint scores

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Low-restraint group ((n = 29))</th>
<th>High-restraint group ((n = 33))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>22.2 ± 3.1</td>
<td>21.2 ± 1.7</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>163.7 ± 8.1</td>
<td>162.7 ± 6.9</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>55.3 ± 8.3</td>
<td>56.4 ± 5.8</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>20.5 ± 2.0</td>
<td>21.3 ± 1.6</td>
</tr>
<tr>
<td>Waist (cm)</td>
<td>66.1 ± 4.7</td>
<td>67.1 ± 4.0</td>
</tr>
<tr>
<td>Hip (cm)</td>
<td>89.2 ± 6.3</td>
<td>89.4 ± 5.5</td>
</tr>
<tr>
<td>Waist-to-hip ratio</td>
<td>0.74 ± 0.03</td>
<td>0.75 ± 0.05</td>
</tr>
<tr>
<td>Weight fluctuation</td>
<td>0.9 ± 0.9</td>
<td>1.4 ± 0.8</td>
</tr>
<tr>
<td>Menstrual cycle length (d)</td>
<td>28.3 ± 3.4</td>
<td>28.8 ± 3.0</td>
</tr>
<tr>
<td>Coffee or tea (cups/d)</td>
<td>1.0 ± 1.0</td>
<td>1.1 ± 1.0</td>
</tr>
<tr>
<td>Alcohol consumption (drinks/wk)</td>
<td>1.2 ± 1.6</td>
<td>0.8 ± 1.4</td>
</tr>
<tr>
<td>Exercise (h/wk)</td>
<td>2.2 ± 1.8</td>
<td>3.4 ± 1.7</td>
</tr>
<tr>
<td>Vegetarian (%)</td>
<td>10.3</td>
<td>12.1</td>
</tr>
<tr>
<td>Vitamin-mineral supplement use (%)</td>
<td>48.3</td>
<td>36.4</td>
</tr>
</tbody>
</table>

1 Scores of 0–5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (2).
2 Scores of 13–21 on the TFEQ restraint scale.
3 \(\pm\) SD.
4 Number of times subjects lost > 2.3 kg (5 lb) during the past 2 y.
5 Significantly different from the low-restraint group (t test): \(P < 0.05\).
6 Self-reported menstrual cycle length.

The mean energy, macronutrient, and calcium intakes from 3-d and 24-h food records are shown in Table 2. Energy intakes were lower in women with high restraint scores, when assessed by both 3-d and 24-h food records. Carbohydrate as a percentage of energy did not differ significantly between the 2 groups by either method. On the basis of the 24-h food records, protein intakes were significantly higher and fat intakes were significantly lower in the high-restraint group; similar nonsignificant trends were observed on the basis of the 3-d food records. Calcium intake did not differ significantly between groups by either method.

Table 2: Daily energy and macronutrient intakes from 3-d and 24-h food records of participants grouped according to low and high dietary restraint scores

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Low-restraint group ((n = 29))</th>
<th>High-restraint group ((n = 33))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (kJ/d)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-d record</td>
<td>9342 ± 2282</td>
<td>8021 ± 1484</td>
</tr>
<tr>
<td>24-h record</td>
<td>10128 ± 1986</td>
<td>8757 ± 2378</td>
</tr>
<tr>
<td>Carbohydrate (% of energy)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-d record</td>
<td>55.5 ± 5.8</td>
<td>57.8 ± 11.4</td>
</tr>
<tr>
<td>24-h record</td>
<td>62.5 ± 5.0</td>
<td>64.9 ± 6.8</td>
</tr>
<tr>
<td>Protein (% of energy)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-d record</td>
<td>15.0 ± 3.4</td>
<td>16.3 ± 4.5</td>
</tr>
<tr>
<td>24-h record</td>
<td>11.9 ± 1.9</td>
<td>13.9 ± 1.8</td>
</tr>
<tr>
<td>Fat (% of energy)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-d record</td>
<td>29.2 ± 4.3</td>
<td>25.9 ± 8.7</td>
</tr>
<tr>
<td>24-h record</td>
<td>25.5 ± 4.0</td>
<td>21.2 ± 6.4</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-d record</td>
<td>840.3 ± 440.7</td>
<td>780.1 ± 293.2</td>
</tr>
<tr>
<td>24-h record</td>
<td>637.8 ± 328.4</td>
<td>578.3 ± 323.0</td>
</tr>
</tbody>
</table>

1 \(\pm\) SD.
2 Scores of 0–5 on the Three-Factor Eating Questionnaire (TFEQ) restraint scale (2).
3 Scores of 13–21 on the TFEQ restraint scale.
4 Significantly different from the low-restraint group (t test): \(P < 0.05\).
5 \(P < 0.01\).

RESULTS

Physical and lifestyle characteristics

Of the 62 women who completed the study, 29 were categorized as having low restraint and 33 were categorized as having high restraint. Descriptive physical and lifestyle characteristics of the 2 groups are presented in Table 1. There were no significant differences in age, physical characteristics, or menstrual cycle length between groups; however, BMI tended to be higher in the high-restraint group, although not significantly so. Although subjects who had lost 2.3 kg (5 lb) > 2 times in the past 2 y were excluded, there was a significant difference in weight fluctuation between the 2 groups. The 2 groups of subjects had similar intakes of coffee or tea and alcoholic beverages and there were no significant differences between groups in the proportions who reported following vegetarian diets or using vitamin-mineral supplements. Reported weekly exercise, however, was significantly higher in the high-restraint group.

Eating behavior and dietary intakes

By definition, scores on the dietary restraint scale differed between restraint groups: the women in the high-restraint group had a score of 15.0 ± 2.2 and the women in the low-restraint group had a score of 2.7 ± 1.8 (\(P < 0.001\)). Women with high restraint scores also had higher scores on the TFEQ disinhibition scale (7.6 ± 4.1 compared with 3.5 ± 2.5; \(P < 0.001\), but scores on the hunger subscale were similar (6.4 ± 3.7 compared with 5.2 ± 2.2).

The mean energy, macronutrient, and calcium intakes from 3-d and 24-h food records are shown in Table 2. Energy intakes were lower in women with high restraint scores, when assessed by both 3-d and 24-h food records. Carbohydrate as a percentage of energy did not differ significantly between the 2 groups by either method. On the basis of the 24-h food records, protein intakes were significantly higher and fat intakes were significantly lower in the high-restraint group; similar nonsignificant trends were observed on the basis of the 3-d food records. Calcium intake did not differ significantly between groups by either method.
restraint assessed by the TFEQ. We measured cortisol in a 24-h studies comparing women with different levels of dietary
the bloodstream (17) and leading to increased urinary excretion. amic-pituitary-adrenal axis, resulting in a release of cortisol into
their daily food-related experiences. Stress activates the hypothal-
activating the stress response. We speculated that women with
scores had higher 24-h urinary free cortisol concentrations and
DISCUSSION

Urinalysis

Results from the analysis of the 24-h urine collections are pre-
Tкрови из таблицы 3. The number of urine samples analyzed differed from
the number of participants because there were 2 laboratory
errors and 1 incomplete collection. Furthermore, 1 woman was
excluded from the analysis because she had both a very high urine
output (3700 mL) and a high cortisol excretion. A high urine vol-
ume was shown recently to be associated with an increase in uri-
inary cortisol excretion. Women in both restraint groups consumed
8–9% more energy on the study day than they reported on their
3-d food records, suggesting that women in both groups responded
similarly to the study conditions. These differences in energy
intake may have been due to underreporting on the 3-d food
records, higher consumption on the study day because of the vari-
ety of food available and lack of cost, or to a combination of both
factors. Finally, there was no evidence from either the 3-d or 24-h
food records to suggest that women with high restraint scores had
higher cortisol excretion because of binge eating or fasting, either
of which could have activated the stress response (26).

Implicit in our hypothesis that women with high restraint
scores have higher cortisol excretion than do women with low
restraint scores is the supposition that cognitive dietary restraint is
a psychological stressor. In earlier animal research, Selye (27)
documented that psychosocial stressors elicited the same physio-
logic responses as did physical stressors, a finding that was sub-
sequently supported in the literature (28). Others have suggested
that it is the individual’s response to the stressor as opposed to the
stressor itself that determines the extent of the biological
response (29). Although the conditions on the study day differed
from those of normal daily experiences, all efforts were made to
ensure that the experience was comparable for all participants.
For unrestrained eaters it is unlikely that the decisions made
regarding food selections and quantity on the study day would be
stressful. External stresses were assumed to be similar between
groups because all subjects were university students, although it
is possible that the groups differed in this regard.

Ovulatory function was not assessed in the present study;
however, we and others previously observed relations between
dietary restraint and ovulatory disturbances (4–7). The higher
urinary cortisol and cortisol-creatinine ratios in the high-restraint

TABLE 3
Analysis of 24-h urine samples of participants grouped according to low and high dietary restraint scores.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Low-restraint group</th>
<th>High-restraint group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n = 28)</td>
<td>(n = 30)</td>
</tr>
<tr>
<td>Urine volume (mL)</td>
<td>1391 ± 665</td>
<td>1370 ± 418</td>
</tr>
<tr>
<td>Creatinine (mmol)</td>
<td>10.0 ± 1.9</td>
<td>9.8 ± 1.7</td>
</tr>
<tr>
<td>Cortisol (nmol)</td>
<td>354.7 ± 83.7</td>
<td>418.8 ± 134.6</td>
</tr>
<tr>
<td>Cortisol:creatinine</td>
<td>36.3 ± 8.9</td>
<td>42.9 ± 12.9</td>
</tr>
<tr>
<td>Calcium (mmol)</td>
<td>3.8 ± 2.1</td>
<td>2.7 ± 1.3</td>
</tr>
<tr>
<td>Calcium:creatinine</td>
<td>0.4 ± 0.2</td>
<td>0.3 ± 0.1</td>
</tr>
</tbody>
</table>

1 ± SD.
2 Scores of 0–5 on the TFEQ restraint scale.
3 Scores of 13–21 on the TFEQ restraint scale.
4 Reference interval: 7.0–16.0 mmol/24 h.
5 Reference interval: 80.0–600.0 mmol/24 h.
6 Significantly different from the low-restraint group, P < 0.05 (t test).
7 Reference interval: 2.5–7.5 mmol/24 h.

Food intake was carefully monitored on the day urine was col-
lected to ensure that any difference in cortisol excretion was not the result of very low energy intakes or severely altered macronu-
trient intakes. On the study day, the high-restraint group consumed less energy and fat than did the low-restraint group; however, nei-
ther energy nor fat intakes correlated with urinary cortisol or cor-
tisol-creatinine ratios. Women in both restraint groups consumed

DISCUSSION

Our main finding was that women with high dietary restraint
scores had higher 24-h urinary free cortisol concentrations and
cortisol-creatinine ratios than did women with low restraint
scores. Our central hypothesis was contingent on dietary restraint
activating the stress response. We speculated that women with
high restraint scores would experience more stress in relation to
their daily food-related experiences. Stress activates the hypothal-
amic-pituitary-adrenal axis, resulting in a release of cortisol into
the bloodstream and leading to increased urinary excretion.

These results support our hypothesis and are unique among
studies comparing women with different levels of dietary restraint assessed by the TFEQ. We measured cortisol in a 24-h
group suggest a possible mechanism for these relations. Menstrual and ovulatory functions are reported to be disturbed when hypothalamic signals cause increased secretion of cortisol from the adrenal cortex (8, 10, 30–33). Specifically, high CRH concentrations interrupt the release of gonadotropin-releasing hormone, resulting in decreased concentrations of the circulating pituitary gonadotropins luteinizing hormone and follicle-stimulating hormone. Decreased pulsatility or lower concentrations of luteinizing hormone and follicle-stimulating hormone can lead to ovulatory disturbances (32, 33).

The higher cortisol excretion observed in women with high restraint scores may thus have long-term implications for bone health through their effect on ovulatory function. Lower reproductive hormone concentrations are generally associated with lower bone mass, regardless of the cause (34–39). Furthermore, cortisol negatively affects bone through its influence on bone formation, bone resorption, calcium absorption through the intestine, and calcium excretion through the renal tubule (39). Therefore, because lifetime bone health and strength are at least partially dependent on peak bone mass occurring during the first 3 decades of life (40), exposure to high cortisol concentrations during these years may decrease the potential for achieving maximum bone mass. Over the life span, women with high restraint scores may be at increased risk of fractures. In older adults, higher baseline overnight urinary cortisol excretion was an independent predictor of fracture (41).

Although 24-h urinary calcium excretion was not a primary outcome variable, it was lower in the high-restraint group than in the low-restraint group, which may also have implications for bone health. Calcium intakes assessed by both the 3-d and 24-h food records were similar between groups, suggesting that differences in excretion were not related to differences in intakes. Several review articles of research regarding cortisol and bone health noted an inverse relation between circulating concentrations of cortisol and intestinal calcium absorption (30, 39, 42). Calcium malabsorption is a consistent finding in cortisol-treated patients and is observed within the first 2 wk of treatment (43). A reduction in calcium absorption would likely lead to a reduction in urinary losses to protect the body’s calcium balance (44). Therefore, it is possible that the lower urinary calcium observed in women with high restraint scores reflects a cortisol-induced decrease in intestinal calcium absorption. In support of this postulate is the observation that calcium intake on the study day correlated positively with calcium excretion in the total study group and in the low-restraint group, but not in the high-restraint group. Although the women with high restraint scores may possibly have retained more dietary calcium than did the women with low restraint scores, it is more plausible that the women with high restraint scores excreted less calcium because of reduced absorption. Studies measuring calcium intake and fecal excretion would clarify this question.

Many women today are aware of their food intake and consciously monitor the quantity and quality of their diet. These attempts at dietary restraint are generally believed to be innocuous, but this may not be the case for all women. The association we observed between dietary restraint and cortisol requires further investigation because other research has shown associations between cortisol and increased bone loss, decreased fertility, or both. Because our cross-sectional study showed an association rather than causation, our findings must be interpreted with caution: other unidentified personality factors may be common to women with high restraint scores and may contribute to, or indeed be better predictors of, the observed association with cortisol excretion. Such possibilities require investigation. Additionally, recent research has refined the concept of dietary restraint into rigid and flexible restraint (45); future studies should consider this differentiation. Longitudinal research appears warranted to clarify our results and to assess whether the observed metabolic and hormonal changes persist over time.

REFERENCES