Research and Professional Briefs

Perceived Hunger Is Lower and Weight Loss Is Greater in Overweight Premenopausal Women Consuming a Low-Carbohydrate/High-Protein vs High-Carbohydrate/Low-Fat Diet

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ABSTRACT

The impact of a low-carbohydrate/high-protein diet compared with a high-carbohydrate/low-fat diet on ratings of hunger and cognitive eating restraint were examined. Overweight premenopausal women consumed a low-carbohydrate/high-protein (n=13) or high-carbohydrate/low-fat diet (n=15) for 6 weeks. Fasting body weight (BW) was measured and the Eating Inventory was completed at baseline, weeks 1 to 4, and week 6. All women experienced a reduction in BW ($P<.01$), although relative BW loss was greater in the low-carbohydrate/high-protein vs high-carbohydrate/low-fat group at week 6 ($P<.05$). Based on Eating Inventory scores, self-rated hunger decreased ($P<.03$) in women in the low-carbohydrate/high-protein but not in the high-carbohydrate/low-fat group from baseline to week 6. In both groups, self-rated cognitive eating restraint increased ($P<.01$) from baseline to week 1 and remained constant to week 6. Both diet groups reported increased cognitive eating restraint, facilitating short-term weight loss; however, the decrease in hunger perception in the low-carbohydrate/high-protein group may have contributed to a greater percentage of BW loss.
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Many weight-loss plans and programs exist, and they have variable success rates and minimal data from well-controlled studies to support their effectiveness. The Atkins Nutritional Approach, in particular, has re-emerged as a revolutionary weight-loss program because of several studies showing the short-term benefits of this low-carbohydrate/high-protein diet on weight loss and blood lipids (1-3). This diet is promoted, in part, as a successful weight-loss program because of its ability to reduce hunger during dieting (4).

Hunger has been shown to predict failure to comply with energy-restricted diets, whereas cognitive eating restraint has been positively associated with compliance with weight-loss diets (5,6). At least one study supports the ability of a high-protein diet to reduce hunger (7). Moreover, consumption of a diet with 18% of total energy as protein was shown to improve satiety and reduce weight regain to half that of a diet with 15% of total energy as dietary protein (6). In a separate study, individuals who lost weight and maintained this weight loss over a 5-year period reported more hunger on a daily basis compared with individuals who did not lose weight or regained lost weight over the same time frame (8). Thus, hunger and cognitive eating restraint impact the ability of individuals to comply with dietary interventions designed for weight loss. The purpose of this study was, therefore, to examine the effects of a low-carbohydrate/high-protein diet compared with a high-carbohydrate/low-fat diet on self-reported scores of hunger and cognitive eating restraint in overweight premenopausal women during a 6-week dietary intervention designed for weight loss. We hypothesized that the low-carbohydrate/high-protein diet would result in greater weight loss, lower perceived hunger, and higher perceived cognitive eating restraint compared with the high-carbohydrate/low-fat diet.

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METHODS

Before initiation of this research, approval was granted by the Institutional Review Board for Research Involving Human Subjects at Virginia Polytechnic Institute and State University, Blacksburg. Twenty-eight overweight premenopausal women, ages 32 to 45 years, participated in this study. All participants read and signed informed consent forms before participation.

An investigator-designed medical/health screening form was completed by potential participants. Individuals were excluded based on the following: (a) body mass index (BMI) ≤25 or ≥40, (b) body weight (BW) loss of ≥5 kg in the previous year, (c) self-reported menstrual cycle

Table. Age, anthropometric characteristics, and dietary intake of overweight premenopausal women following a low-carbohydrate/high-protein (LC/HP) diet (n=13) or a high-carbohydrate/low-fat (HC/LF) diet (n=15) over 6 weeks[a]

Variable	LC/HP Diet Group		HC/LF Diet Group	
	Baseline	Week 6	Baseline	Week 6
Age (y)	38.8±6.2	—	40.1±6.3	—
Height (cm)	166.1±1.3	—	162.0±1.3	—
Weight (kg)	84.6±12.7	78.2±15.9[bc]	79.8±12.1	75.6±15.4[b]
Body mass index (calculated as kg/m²)	31.1±4.9	29.3±4.6[b]	30.3±5.5	29.0±5.3[b]
Energy intake (kcal/d)[d]	2,025±645	1,420±374[b]	2,340±1,236	1,395±264[b]
Carbohydrate intake (g/d)[d]	249±98	43±22[bc]	286±132	209±41
Protein intake (g/d)[d]	75±22	94±29[c]	89±20	63±16[b]
Fat intake (g/d)[d]	81±26	97±26[c]	94±78	34±15[b]
Carbohydrate intake (% of energy)[d]	49±6	12±2[bc]	49±6	60±7
Protein intake (% of energy)[d]	15±3	26±4[c]	15±4	18±4
Fat intake (% of energy)[d]	36±5	61±7[c]	36±6	22±4[b]

[a]All values are mean±standard deviation.
[b]Significantly different from baseline (*P*<.05).
[c]Significantly different from HC/LF over time (*P*<.05).
[d]For dietary intake data, n=12 for the LC/HP diet group and n=11 for the HC/LF diet group.

length of <21 or >35 days or disruption of menstruation during the past year, (d) currently pregnant or lactating, (e) physical activity of ≥7 hours per week, (f) current cigarette smoking, (g) metabolic or endocrine diseases or disorders, and (h) use of medications affecting metabolic or endocrine function. Physician clearance was required for participation.

Women were randomized to a low-carbohydrate/high-protein (n=13) or high-carbohydrate/low-fat (n=15) diet. Consistent with the Atkins Nutritional Approach (4), women in the low-carbohydrate/high-protein diet group, during the first 2 weeks, consumed ≤20 g carbohydrate/day; thereafter, they increased their carbohydrate intake by 5 g/week to 40 g carbohydrate/day at week 6. Dietary protein and fat intakes were unlimited with no specific level of energy restriction, as specified by the Atkins Nutritional Approach (4). Women randomized to the high-carbohydrate/low-fat diet restricted energy intake to 1,500 or 1,700 kcal/day based on each woman's estimated resting energy expenditure (9) to facilitate 1 to 2 lb of weight loss per week (10,11). Macronutrient composition of the high-carbohydrate/low-fat diet was designed to provide 60%, 15%, and 25% of total energy as dietary carbohydrate, protein, and fat, respectively, recommended by the National Cholesterol Education Program (11).

A registered dietitian conducted group educational sessions regarding diet treatments, and all women were provided with written guidelines. Weekly educational and motivational sessions were conducted with each diet group. Sessions were specific to each dietary intervention, although session topics were the same for both groups.

Data were collected before diet initiation (baseline) and after 1, 2, 3, 4, and 6 weeks of dietary intervention. After an overnight 12-hour fast, women reported to the laboratory for testing. Women were weighed to the nearest 0.1 kg (ScaleTronix, Wheaton, IL) and completed the Eating Inventory. The Eating Inventory was scored according to standard guidelines (12), and the hunger and cognitive eating restraint subscales of the Eating Inventory were

examined. Standing height was measured at baseline to the nearest 0.1 cm with a stadiometer (Heightronic, Measurement Concepts, North Bend, WA). An investigator calculated body mass index. Weekly physical activity recalls were completed at baseline and at each testing session to estimate hours of physical activity per week. Women were instructed to maintain their usual activity patterns until the end of the study.

Four-day food records (3 weekdays+1 weekend day) were completed by participants at baseline and during weeks 1, 2, 4, and 6. Participants recorded intake of all foods, beverages, and food and nutritional supplements in addition to portion sizes and preparation methods. Standard guidelines and handouts with two-dimensional pictures were provided to each woman for use with food records. Food records were analyzed, and mean daily energy, carbohydrate, protein, and fat intakes were estimated with The Food Processor Nutrition Analysis Software for Windows (version 8.1, 2003, ESHA Research, Salem, OR). Data are reported for 12 women in the low-carbohydrate/high-protein and 11 women in the high-carbohydrate/low-fat diet groups, because of incomplete data for one woman in the low-carbohydrate/high-protein and four women in the high-carbohydrate/low-fat diet groups.

A *t*-test was conducted to compare mean BMI at baseline to ensure no significant difference in BMI after randomization of women to diet groups. Repeated-measures analysis of covariance (ANCOVA, baseline measures as covariates) were conducted to detect significant group×time interactions in BW, BMI, hunger, cognitive eating restraint, and dietary intake across time. Statistical significance was set at *P*<.05. The Statistical Analysis System (version 8.2 for Windows, 2001, SAS Institute, Inc, Cary, NC) was used to perform all analyses.

RESULTS AND DISCUSSION

Age, height, BW, BMI, and energy intake did not statistically differ between diet groups at baseline (Table).
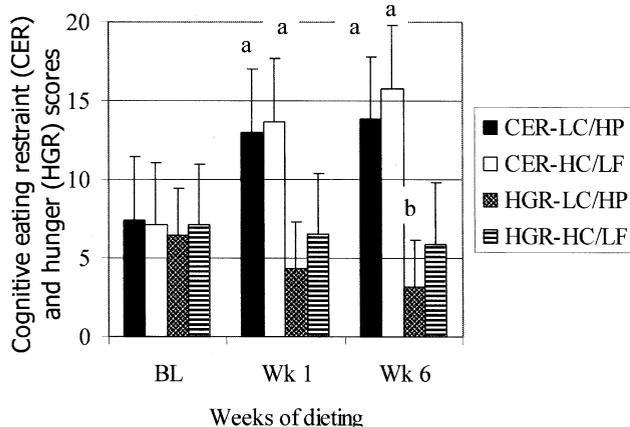
Figure. Cognitive eating restraint and hunger scores of overweight premenopausal women following a low-carbohydrate/high-protein diet (LC/HP, n=13) or a high-carbohydrate/low-fat diet (HC/LF, n=15) over 6 weeks. All values are mean±standard deviation. [a]Score significantly different from baseline (*P*<.01). [b]Score significantly different from high-carbohydrate/low-fat from baseline to week 6 (*P*<.05).

Mean BW significantly decreased in both diet groups over time (*P*<.01). Specifically, after 1, 2, 3, and 4 weeks of dietary compliance, average weekly BW loss was 2.2, 0.7, 0.5, and 0.3 kg, respectively, in the low-carbohydrate/high-protein group and 0.8, 0.4, 1.0, and 0.4 kg, respectively, in the high-carbohydrate/low-fat group. During weeks 5 and 6 combined, women in the low-carbohydrate/high-protein group lost an average of 1.2 kg, and women in the high-carbohydrate/low-fat group lost an average of 0.8 kg (Table). Women in the low-carbohydrate/high-protein diet group lost more BW (5.7%) compared with women in the high-carbohydrate/low-fat diet group (3.3%) after 6 weeks of dietary intervention (*P*<.05). Women in both diet groups experienced significant changes in BMI (*P*<.0001) over time, although the mean reduction in BMI was not different between diet groups. These changes in BW and BMI suggest that both dietary interventions were effective at inducing short-term changes, with the low-carbohydrate/high-protein diet promoting greater reductions in percentage of BW loss compared with the high-carbohydrate/low-fat diet. These results are consistent with other studies that report similar short-term BW and BMI losses in individuals complying with low-carbohydrate/high-protein diets (1-3). Of importance is that a proportion of the BW reduction in the low-carbohydrate/high-protein diet group may have been attributable to body water losses associated with glycogen depletion (13), particularly in the first week of dietary intervention. Although the patterns of weight loss between groups suggest this possibility, methodologic limitations of the study and individual variation (14,15) do not allow certainty in this assumption.

Perceptions of hunger and cognitive eating restraint are shown in the Figure. The low-carbohydrate/high-protein diet group had a significant decrease (*P*<.03) in self-reported hunger score from baseline to week 6 (6.3±4.1 vs 3.2±2.4, respectively), whereas the high-carbohydrate/low-fat diet group did not (7.1±4.0 vs 5.9±3.8, respectively). The mean cognitive eating restraint score

significantly increased (*P*<.01) in both diet groups (N=28) from baseline (7.3±4.4) to week 1 (13.4±3.9) and remained stable to week 6, with no statistically significant differences between groups over time. No other significant differences were observed at any other time points for hunger or cognitive eating restraint scores.

Interestingly, estimated average daily energy intake did not significantly differ between diet groups at any time point. By design, however, macronutrient composition of the two diets did differ at weeks 1, 2, 4, and 6 (data for baseline and week 6 shown in Table). Independent of energy intake, hunger and restrained eating are increasingly recognized as factors that impact BW regulation, body composition, success with short-term weight loss, and maintenance of long-term weight loss (8,16-20). Baseline hunger and cognitive eating restraint scores of women in the current study were similar to those of other women who were not engaged in weight-loss programs, not dieting to lose weight, or who reported BW stability over the previous 12 months (16,17,21). Once engaged in a weight-loss program and dietary intervention, the mean cognitive eating restraint scores of all women in the current study were comparable with average restraint scores reported by individuals who maintained weight loss over long-term (5 and 7 years) periods (8,21). Assessment of and attention to cognitive control over food intake for BW manipulation is a vital aspect of successful weight-loss efforts and requires a more prominent role in weight management programs (8,18,20-22).

Macronutrient composition of energy-restricted diets may play an important role in the perception of hunger during the diet induction period.

Mean self-reported hunger scores of women in the diet groups in the present study were approximately half at baseline compared with initial scores of individuals in a previous study of weight loss (8). Moreover, the mean hunger score of women in the low-carbohydrate/high-protein diet group after 1 week of dietary treatment was only one fourth that observed in the previous study. Mattes (8) reported mean hunger scores of 12.0 to 12.5 in men and women (age=42.6±10.4 years, BMI=31.6±5.0) who maintained, regained, or did not experience BW loss. Differences between the current and previous studies may be explained by dietary treatments, because the previous investigation used a liquid meal replacement for 34% to 39% of total energy in lieu of solid foods (8). Our findings regarding perception of hunger support those of a separate study with individuals consuming a high-protein vs high-carbohydrate diet (7). Macronutrient composition of energy-restricted diets may play an important role in the perception of hunger during the diet induction period. When consuming a weight-reduction diet that restricts only one macronutrient (ie, carbohydrate) but not total energy intake, cognitive perception of hunger may differ from that of a weight reduction diet that low-

ers all macronutrients and total energy compared with an individual's usual intake. It is important to note that women in the low-carbohydrate/high-protein diet group were not instructed to restrict energy intake. Yet, they did. It is possible that the macronutrient composition, monotony, or limited food choices of the diet resulted in this consequential energy restriction. Nonetheless, a reduction in self-perceived hunger may have facilitated the energy restriction and greater percentage of BW loss in the low-carbohydrate/high-protein group. Dietary protein has been shown to trigger hormonal cascades that control appetite (23); thus, diets with unlimited protein may result in less perceived hunger because of actual physiologic mechanisms that induce satiety and satiation (23,24). Because hunger predicts failure to maintain weight loss (18,20), macronutrient composition of weight maintenance diets that will optimally regulate appetite and hunger perception must be planned.

Physical activity was not included as an intervention component for this study because of concerns regarding the low level of glucose provided by the low-carbohydrate/high-protein diet. Moreover, baseline physical activity was intentionally limited to <7 h/week and kept constant for each subject throughout the study to reduce the potential impact on hunger, cognitive eating restraint, and energy balance. Physical activity for all women was <5 h/week and did not significantly differ between diet groups or significantly change over time. Although an increase in physical activity could partially explain the greater relative weight loss seen in the low-carbohydrate/high-protein group, the study protocol and physical activity recall data suggest that this contribution to weight loss was negligible. The effects of physical activity on hunger and cognitive eating restraint in these women are unknown and present limitations to this study. Physical activity has been shown to increase hunger (25), yet humans have the capacity for dietary restraint that may override hunger signals (26). The relationship among physical activity, macronutrient preferences and needs, hunger, and cognitive eating restraint are complex (27); future studies that evaluate the effects of all of these components on weight changes are vital.

In summary, our hypothesis that the low-carbohydrate/high-protein diet would result in greater BW loss and lower self-rated hunger score over 6 weeks compared with the high-carbohydrate/low-fat diet in overweight premenopausal women was supported. Contrary to expectations, however, differences in cognitive eating restraint scores between groups across time were not observed.

CONCLUSIONS

A low-carbohydrate/high-protein diet intervention seems to be effective for BW reduction over a 6-week period, as does a high-carbohydrate/low-fat diet. Overweight premenopausal women who comply with a low-carbohydrate/high-protein diet compared with a high-carbohydrate/low-fat diet may lose proportionately more BW over a short-term period, however. Maintenance of BW loss facilitated by a low-carbohydrate/high-protein diet must be further evaluated and compared with other weight-loss diets with varied macronutrient compositions, particularly in relation to hunger and cognitive eating restraint ratings. Overweight premenopausal women who comply with a low-carbohydrate/high-protein diet self-report less hunger, but similar cognitive eating restraint, over a 6-week dieting period compared with women who follow a high-carbohydrate/low-fat diet. This perception of less hunger and equivalent restraint with a low-carbohydrate/high-protein diet may explain the greater BW loss compared with the high-carbohydrate/low-fat diet. The impact of hunger and cognitive eating restraint on compliance with dietary interventions for BW loss and continued weight-loss maintenance must be considered and included in weight-loss programs.

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