The Effects of a Low-Carbohydrate Ketogenic Diet and a Low-Fat Diet on Mood, Hunger, and Other Self-Reported Symptoms

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Abstract

MCCLERNON, F. JOSEPH, WILLIAM S. YANCY, JR., JACQUELINE A. EBERSTEIN, ROBERT C. ATKINS, AND ERIC C. WESTMAN. The effects of a low-carbohydrate ketogenic diet and a low-fat diet on mood, hunger, and other self-reported symptoms. *Obesity.* 2007; 15:182–187.

Objective: To investigate the effects of weight loss diets on mood, food cravings, and other self-reported symptoms.

Research Methods and Procedures: Mood and other symptoms were evaluated by participant self-report using the Atkins Health Indicator Test (AHIT) in individuals undergoing weight loss following either a low-carbohydrate, ketogenic diet (LCKD) or a low-fat diet (LFD). Participants were 119 overweight community volunteers randomized to an LCKD or an LFD. An additional 51 participants who had completed an earlier trial contributed data for the psychometric analyses but were not included in the prospective analyses. Self-reported symptom levels on seven scales factor-analytically derived from the AHIT (negative affect, fatigue, somatic symptoms, physical effects of hunger, insomnia, hunger, and stomach problems) were acquired during 12 visits.

Results: After adjusting for the change in BMI over the course of the trial, participants experienced significant improvements in most symptoms regardless of diet. Diet group × visit interactions were observed for negative affect [$F(9,803) = 2.30$, $p = 0.015$] and hunger [$F(9,803) = 3.62$, $p < 0.0002$]. Examination of means indicated that the LCKD group reported less negative affect and hunger, compared with the LFD group.

Discussion: Regardless of diet, participants experienced significant improvement in a broad range of symptoms. Symptoms of negative affect and hunger improved to a greater degree in patients following an LCKD compared with those following an LFD. Whether these symptom changes explain the greater short-term weight loss generally experienced by LCKD followers deserves further research.

Key words: diet, low-carbohydrate diet, mood, hunger

Introduction

The psychological effects of dieting and weight loss are variable. Some studies have shown that weight loss from diets or surgery can lead to improved quality of life and positive emotional responses (1–3), others have shown dieting to be associated with increased negative affect (4,5), while at least one study has shown no effect (6). Differences in these outcomes may be attributable to a broad range of factors (7,8), including type of treatment (e.g., supported vs. unsupported), research sample (e.g., obese dieters vs. volunteers put on diets), and the focus of research measures (e.g., outcome vs. process). Weight loss resulting from dieting among obese individuals, for instance, has been shown to reliably result in positive outcomes (2).

In several randomized controlled trials, a low-carbohydrate, ketogenic diet (LCKD)[1] has resulted in significant weight loss over a 6- to 12-month period (9–11). Although the weight loss effects of an LCKD have been repeatedly

Received for review December 19, 2005.
Accepted in final form September 12, 2006.
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[1] Nonstandard abbreviations: LCKD, low-carbohydrate, ketogenic diet; LFD, low-fat diet; AHIT, Atkins Health Indicator Test.

demonstrated, little is known about the effects of the diet on mood, hunger, somatic symptoms, and other self-reported symptoms. Two recent studies suggest that an LCKD leads to self-reported lower appetite, although other self-reported symptoms have not been assessed (12,13).

The purpose of the present analysis was to evaluate and compare the effects of an LCKD and a low-fat, low-calorie diet (LFD) on mood, hunger, somatic, and other self-reported symptoms from two weight loss diet studies. Questionnaire data were obtained during a single-arm prospective study and during a randomized controlled trial comparing an LCKD with an LFD (14,15). The data collected during the baseline period of both studies were combined to evaluate the factor structure of a measure of self-reported symptoms: the Atkins Health Indicator Test (AHIT). The scales derived from this analysis were then used as the dependent variables in analyses of the data from the randomized trial. To evaluate the effects of the diet on symptoms and to control for the fact that weight loss might have variable effects on mood and other symptoms, the total amount of weight loss over the course of the trial (as expressed in BMI values) was used as a covariate. We hypothesized that both diets would improve self-reported symptoms and that, compared with an LFD, an LCKD would specifically result in reduced appetite and improved mood.

Research Methods and Procedures

Two studies were combined for the analysis, and the primary outcome data have been published previously (14,15). In brief, healthy individuals motivated to lose weight were recruited from the community for a study of dietary treatments for obesity and hyperlipidemia. Subjects were required to be between the ages of 18 and 65 years, have a BMI between 22 and 33 kg/m^2 (single-arm trial) or between 30 and 60 kg/m^2 (two-arm trial), and have no serious medical condition. In the first study, 51 subjects were placed on an LCKD; in the second study, 119 subjects were randomized to an LCKD (initially <20 g of carbohydrate/d) and nutritional supplements, or an LFD [<30% of daily energy intake from fat, 500 to 1000 kcal (2.1 to 4.2 MJ) restriction from daily maintenance energy intake]. In both studies, subjects returned for group meetings on a biweekly basis for 3 months, then monthly for 3 months, for a total of 11 visits (treatment began with the second visit). Nutritional supplementation was given to the LCKD group only; it consisted of a multivitamin, chromium picolinate, diet formula, and essential oils. Data at baseline from both studies were used to evaluate the factor structure of a symptom questionnaire (see below); only data from the larger randomized controlled trial were used to evaluate the effects of diet on mood and other symptoms.

AHIT

The AHIT is a symptom checklist developed by LCKD practitioners for use in evaluating and managing individuals undergoing LCKD treatment. The AHIT asks about the presence of 56 symptoms on the following four-point Likert scale: 0 = "never have the symptom," 1 = "mild when it occurs or occurs occasionally," 2 = "moderate or occurring at least once a week," 3 = "severe or occurring frequently." Principal components analysis of the AHIT was conducted to 1) evaluate the underlying factor structure, and 2) aid in the development of scales that could serve as dependent variables in subsequent analyses. Thus, principal components analysis with varimax rotation was conducted on the 56 items from the AHIT, using SPSS software (version 12.0; SPSS, Inc., Chicago, IL), on a sample of 170 patients. All data were from baseline pre-treatment sessions. A seven-factor solution accounted for the most variance while resulting in an interpretable factor structure (Table 1). The seven factors were: negative affect (13 items, 13.65% of variance), fatigue (6 items; 10.51% of variance), somatic symptoms (4 items; 7.28% of variance), physical effects of hunger (3 items; 5.55% of variance), insomnia (3 items; 5.15% of variance), hunger (2 items; 4.89% of variance), and stomach problems (2 items; 3.33% of variance). Twenty-three items did not load onto any factor, likely owing to very low rates of responding on these items. Scale scores created by averaging the responses to each item on each scale served as the dependent variables in the analyses described below.

Statistical Analysis

Using SAS software (version 9.1; SAS Institute, Inc., Cary, NC), linear mixed-effects models (SAS PROC MIXED) were used to examine the change in each of the seven scales over the course of treatment in patients participating in the two-arm randomized trial. The first of two baseline visits was not included in the analyses, as we assumed that data from the second baseline visit and, thus, second completion of the measure, would represent more accurate responding. Fixed effects included visits (10 visits) and group assignment (LFD vs. LCKD) with linear time × group interaction terms. Weight loss at each visit (expressed as BMI) was calculated for each participant and used as a covariate to factor out the effects of weight loss on mood and other symptoms. Post hoc tests were Bonferroni-corrected.

Results

Full results of the trials can be obtained elsewhere (14,15). In the randomized trial, in the LCKD and LFD diet groups, respectively, the baseline mean (standard deviation) weights were 97.8 kg (15.0) and 96.8 kg (19.2); baseline BMIs were 34.5 kg/m^2 (4.8) and 34.0 kg/m^2 (18.9), and weight losses at 6 months were −12.9 kg and −6.7 kg ($p <$ 0.001).

Table 1. Principal components analysis-identified scales of the 56-item AHIT

Factor and symptoms						
Factor 1 Negative affect/cognitive problems	**Factor 2 Fatigue**	**Factor 3 Somatic symptoms**	**Factor 4 Physical effects of hunger**	**Factor 5 Insomnia**	**Factor 6 Hunger**	**Factor 7 Stomach problems**
Depressed	Tired	Heart palpitations	Irritable before meals	Insomnia	Hungry	Stomach cramps
Fearful	Sleepy during day	Blurred vision	Shaky if hungry	Wake up after a few hours of sleep	Crave high-sugar foods	Ulcers or other intestinal problems
Cannot decide easily	Sleepy after meals	Sweating excessively	Faint if meal delayed	Frequent urination		
Cannot concentrate	Lack of energy	Muscle twitching or cramps				
Poor memory	Reduced initiative					
Worry frequently	Cannot get started in morning					
Feel insecure						
Highly emotional						
Moody						
Cry easily						
Fits of anger						
Magnify insignificant details						
Cannot work well under pressure						

Items not loading on any factor: eat high-sugar foods, eat high-carbohydrate foods, consume alcohol, drink >3 caffeinated beverages daily, headaches, eat when nervous, allergic reactions, fatigue relieved by eating, suicidal ideation or hopelessness, bored, bad dreams, cold hands or feet, trembling of hands, bleeding gums, dizziness or light-headedness, breathing heavily, bruise easily, reduced sex drive, incoordination, unsocial behavior, excessive thirst, phobias, weight change.

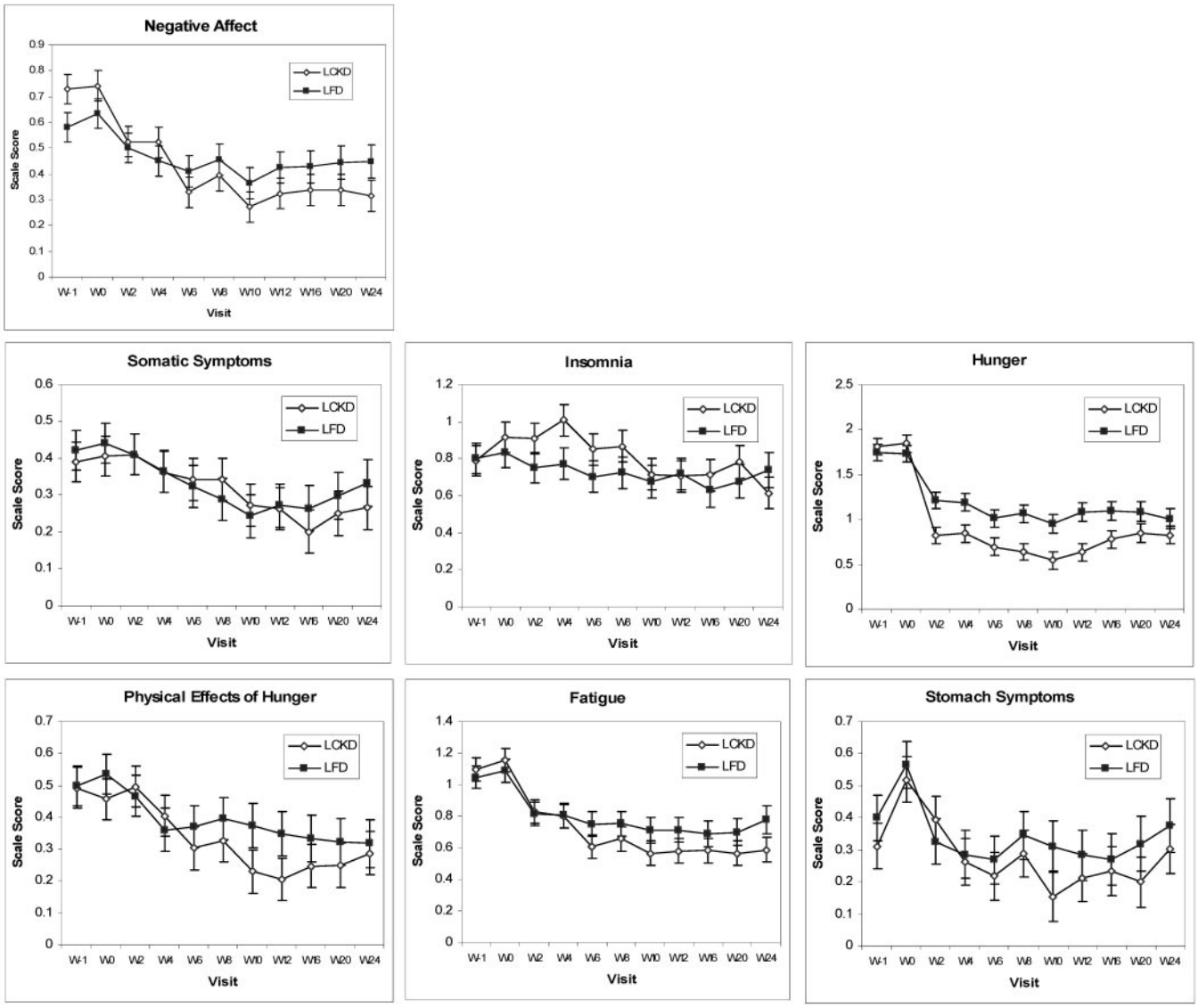

Figure 1: Effects of an LCKD and an LFD on self-reported symptoms during a 6-month trial. Patients attended visits on a biweekly basis for 3 months, then monthly for 3 months, for a total of 11 visits. Treatment began after Visit 2. Estimated marginal means and standard errors are shown for factor analytically derived scales of the AHIT (see Table 1 for scale composition). Higher numbers indicate greater symptomatology for each scale.

To evaluate the effect of diet on self-reported symptoms, data from the 119 participants in the randomized trial were analyzed using 2 (diet group) × 10 (visit) analyses of covariance, controlling for weight loss at each visit. After adjustment by the covariate, statistically significant main effects of the visit were found for negative affect [$F(9,808) = 9.46$, $p < 0.0001$]; fatigue [$F(9,808) = 6.65$, $p < 0.0001$]; physical effects of hunger [$F(9,808) = 1.91$, $p = 0.05$]; hunger [$F(9,808) = 28.27$, $p < 0.0001$]; and stomach problems [$F(9,808) = 3.91$, $p < 0.0001$]. For negative affect and hunger, baseline scores were significantly higher than scores on all other visits (p values ranging from <0.01 to <0.0001). For fatigue, scores were significantly lower than baseline at all but Week 24 ($p < 0.01$). For stomach problems, scores were significantly lower than baseline at Weeks 4, 6, and 10 ($p < 0.02$). Despite the main effect of visits on the physical effects of hunger, no differences from baseline scores were observed.

Across visits, hunger was significantly lower in the LCKD group, as evidenced by a main effect of diet group [$F(1,117) = 5.15$, $p = 0.025$]. Diet group significantly interacted with visit for negative affect [$F(9,808) = 2.30$, $p = 0.015$] and hunger [$F(9,808) = 3.62$, $p = 0.0002$]. As can be seen in Figure 1, examination of estimated marginal means showed greater decreases in negative affect in the LCKD group over the course of the trial, although post hoc

comparisons of the two groups at each time-point were not significant. A similar pattern emerged for hunger. Post hoc tests indicated significantly lower scores for hunger in the LCKD compared with the LFD group at Weeks 2, 4, 8, 10, and 12 ($p < 0.05$). A trend for a diet group × visit interaction was observed for insomnia [$F(9,808) = 1.70$, $p = 0.09$], and post hoc tests indicated significantly greater insomnia in the LCKD group at Week 4 ($p = 0.025$).

Discussion

In the present study, we observed significant improvements in a broad range of self-reported symptoms in a sample of adults who followed two different diets; we controlled for weight loss during the course of the trial. Furthermore, compared with an LFD, an LCKD was found to result in significantly less hunger and negative affect. These effects differed in magnitude and over time. Hunger was significantly lessened in the LCKD group for as long as 3 months. Group differences in negative affect were not as strong but seemed to persist over the duration of the trial.

The present findings are consistent with previous reports demonstrating positive psychological effects of weight loss generally (1–3,7). A range of mechanisms have been suggested to explain such changes, including the satisfaction of achieving goals and improved physical health and mobility. Participation in weight loss plans that include social support components is also associated with positive emotional outcomes (2). Because we controlled for weight loss in our statistical models, the present findings suggest that weight loss alone cannot account for improvements in mood and other symptoms during dieting.

Furthermore, the present findings represent a replication and extension of previous studies demonstrating significant appetite suppression during an LCKD. In one study, perceived hunger was significantly lower in pre-menopausal women undergoing a low-carbohydrate/high-protein diet compared with a high-carbohydrate/low-fat diet through 6 weeks of the diet (13). In another study, obese patients with type 2 diabetes spontaneously reduced caloric intake on a low-carbohydrate diet but did not report an increase in hunger (12). A number of mechanisms might be responsible for the hunger-suppressing effects of an LCKD. Because LCKD diets lead to a reduction in the intake of only one class of food (instead of multiple classes, as in a typical caloric restriction diet), dieters may experience fewer food cravings and greater satiety after meals. Moreover, there is evidence that an LCKD leads to a stabilization of blood glucose levels; this stabilization might reduce craving for food as well as an improvement in energy levels (12).

The observed reductions in negative affect while following an LCKD are novel. Although weight loss has been previously associated with improvements in affect, and although the LCKD group lost more weight than the LFD group, our statistical models controlled for weight loss. Thus, the observed greater reductions in negative affect in the LCKD group are likely attributable to the diet. The mechanisms for mood improvement during an LCKD are not clear, but a recent study demonstrated antidepressant effects of a ketogenic diet on an animal model of depression (16), and it has been suggested that a ketogenic diet might be used as a mood stabilizer in affective disorders (17). Further research characterizing both the extent and causes of mood enhancement by an LCKD are warranted.

Our findings of decreased fatigue in both diet groups and a trend for an increase in insomnia in the LCKD group are consistent with our findings in a previous pilot study of an LCKD for narcolepsy (18). In nine patients with narcolepsy, an LCKD was shown to decrease sleepiness over the course of 8 weeks of treatment, supporting the idea that the diet may influence fatigue and sleep.

The present study is characterized by a number of limitations. Although patients were randomized to a diet, a greater proportion of patients in the LCKD group than in the LFD group completed the treatment (76% vs. 57%, respectively). Also, patients in the LCKD group, in addition to dieting, also received nutritional supplements provided only to that group. Even though these supplements are not generally known to lead to these improvements, group differences in symptoms cannot be definitively distinguished as diet vs. nutritional supplement effects.

Several characteristics of the AHIT limit our findings. Because the AHIT symptoms were originally collected in a practice using a low-carbohydrate diet for weight loss, it is possible that the selection of symptoms on the measure used was somehow biased toward the positive effects of an LCKD as opposed to an LFD. Furthermore, the AHIT confounds the frequency and severity of symptoms by not asking about these dimensions on separate scales. Thus, the AHIT may not accurately capture information about symptoms that occur infrequently but are severe and, conversely, symptoms that happen frequently but are of less significance. Moreover, despite our empirical approach to derive factors, some of the factors had very few items (e.g., hunger) and, thus, may be less reliable than scales with more items. Future versions of the AHIT will take these limitations into account.

Despite these limitations, the present study confirms that weight loss can result in significant improvement in a broad range of self-report symptoms and that, compared with an LFD, an LCKD results in specific improvements in mood and decreased hunger. Further trials seeking to understand the mechanisms underlying these effects are warranted.

Acknowledgments

Funding for this study was provided by the Robert C. Atkins Foundation. W.S.Y. is supported by a Veterans Administration Health Services Research Career Development Award (RCD 02-183-1). F.J.M. is supported by Grant K23 DA017261 from the National Institute on Drug Abuse.

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