The Effects of Glycemic Load and Exercise on Overweight/Obesity in College Students

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Abstract

We sought to assess the effect of glycemic load consumption and exercise in healthy college students. Participants (N=10) were screened on physiological measures then randomly assigned to experimental and control groups. Both groups participated in the walking program. Those in the experimental group were given the ADA diet exchange list modified to low glycemic load. At the end of 12 weeks, participants were reassessed. Members of the experimental group saw significant changes in total cholesterol and blood glucose. Changes in body mass index and waist circumference were not significant but some changes were noted. The glycemic load does have a positive effect on blood chemistries and physiological measures.

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Introduction

Never before has there been such a focus on diet and exercise in America and yet the obesity rate continues to escalate. This epidemic affects millions of adults and children and is linked to numerous diseases. It has become clear that the fight against obesity will not be won by energy balance alone. Not all calories are created equal and it is time to examine the quality of calories Americans are consuming, specifically carbohydrates. Carbohydrate consumption appears to have a strong relationship with overweight/obesity. This study investigated the question; does modifying the quality of carbohydrates consumed affect body mass index (BMI), waist circumference, and blood chemistry levels?

Review of Literature

Researchers (Bouchard, 1994; Dishman & Buckworth, 1996; Haapenen et al., 2000; Pate et al., 1995) have documented the prevalence of obesity and its relationship with inactivity and diet. In the United States, one in two adults are overweight (Augustin et al., 2002). Total carbohydrate consumption in the American diet has increased over the last 30 years due primarily to a focus on lower fat intake and an increased consumption of refined carbohydrates (Bell & Sears, 2003). Carbohydrates in the American diet come mainly from refined grains, starches, and sugar. These food sources (known as high glycemic index foods) are rapidly absorbed upon digestion and stimulate a large insulin rise followed by a rapid blood glucose fall. This leads to a release of free fatty acids that create an insulin resistant environment and reduced glucose tolerance (Augustin et al, 2002; Bell & Sears, 2003;Ludwig, 2002).

Consumption of low glycemic index foods tends to normalize blood glucose levels and promote weight loss. The glycemic index (GI) of food represents the relative rate of entry of glucose into the bloodstream compared with the reference carbohydrate. The glycemic load (GL) is a product of the GI and the quantity of carbohydrate consumed (Lui et al., 2001). Both the quantity and quality of carbohydrates consumed must be considered in an eating pattern to reduce overweight/obesity. In a meta-analysis by Ludwig (2002), it was concluded that high-GI meals cause initial periods of high blood glucose and insulin levels. This is then typically followed by reactive hypoglycemia, counter regulatory hormone secretion, and elevated serum free fatty acid concentration. These conditions may then promote excessive food intake, beta cell dysfunction, dyslipidemia, and endothelial dysfunction. Therefore, consistent consumption of high-GI foods may increase the risk for obesity, non-insulin dependent diabetes mellitus (NIDDM), and heart disease.

In a study by Spieth et al. (2000), GI was used as the independent variable in dietary modification for the treatment of pediatric obesity. The researchers concluded that a low-GI diet could be a potential alternative to typical reduced-fat diets for the treatment of obesity in children. The group on the low-GI diet was found to have a mean decrease of 1.53 in BMI and a mean reduction of 2.03 kg in body weight over a period of four months. In another study concerning GL, Salmeron et al. (1997) determined that diets with high GL and low cereal fiber are positively associated with the risk of NIDDM. This is believed to occur because a diet of this nature is likely to lead to a chronic demand for insulin, which, in turn, exacerbates insulin resistance. Glycemic index and glycemic load interventions with college students have not been documented.

Exercise has been strongly recommended as a preventive and ancillary treatment for chronic diseases (Haapenen et al., 2000; Erlichman, Kerber & James, 2002). Physical inactivity and a low level of physical fitness were found to be risk factors for all causes of early death, specifically cardiovascular disease (CVD) mortality, and overweight/obesity (Erlichman, Kerber & James, 2002). Dunn et al. (1999) found that moderate physical activity improved blood pressure and high-density lipoproteins (HDL) over a two-year period. Moderate physical activity included brisk walking, jogging, and other aerobic activities. Keller and Trevino (2001) found that compliance with a three day per week program in overweight, sedentary women was greater than a five day per week program. Effective weight management programs incorporate behavior modification, exercise, and diet. Many (Brekke, Jansson, Mansson & Lenner, 2003; Krebs & Jacobson, 2003; Miller, Kojeca & Hamilton, 1997; Miller, 1999; Pate et al., 2000; Prochaska & Sallis, 2004; Saris et al., 2003; Volek et al., 2002; Willett, Manson & Liu, 2002) have determined that diet modification and exercise produce the greatest changes. Thus, researchers indicate that exercise is an appropriate method for reducing cardiovascular risk factors and maintenance of body weight.

Exploratory Study

An exploratory study conducted at a local university with a convenience sample of students found that GL was a predictor of waist circumference and BMI. Participants (N=132) were interviewed and data was collected from a 24-hour dietary recall, demographic information, physical activity recall, and dichotomous family medical and ethnic history. The interviewers also gathered anthropometric information by measuring the participants. Overweight/obesity was evaluated by BMI and visceral fat as measured by waist circumference (Newby et al., 2003). The outcome measure was to evaluate obesity based on GL ingested.

Data was reduced to 72 participants who reported consuming the minimum requirements of 40% of total energy from carbohydrates and 70% of their estimated energy requirement based on age, gender, and physical activity level. Those eliminated had diets lacking in sufficient Kilocalories and normalized distribution of macronutrients. The remaining 72 ranged in age from 18 to 49; forty-four participants were Hispanic and twenty-six were white. BMI ranged 18.02 to 36.9. Waist circumference range was 26.75 to 43.75 inches.

The results indicated that carbohydrate intake was significantly correlated with BMI ($r=.247$, $p<.05$) and waist circumference ($r=.340$, $p<.001$). Waist circumference and BMI were also significantly correlated, $r=.890$, $p<.01$). A regression to determine the relationship between waist, BMI, and GL was also computed. The resulting ANOVA indicated waist circumference was the dependent variable on which GL had a significant relationship ($F=8.543$, $df=1, 70$, $p<.01$). The ANOVA resulting from the regression of GL as independent and BMI as dependent was also significant, but not as profound ($F=4.227$, $df=1, 70$, $p<.05$). A regression with physical activity and waist circumference was not significant. However, a regression with BMI as the dependent variable and physical activity as the independent variable showed a trend toward significance ($F=3.11$, $df=1, 70$, $p<.01$). Total caloric intake was highly correlated with waist circumference ($r=.303$, $p<.01$) but not BMI ($r=.17$, $p>.10$). A linear regression was computed using total caloric intake as the independent variable and waist circumference as the dependent variable. The resulting ANOVA was significant ($F=7.099$, $df=1,70$, $p<.01$). Therefore, there is an apparent relationship between GL, total caloric intake, and physical activity with BMI and waist circumference.

Pilot Study

From this information, a pilot study was designed to examine this relationship and to determine appropriate interventions for individuals who are overweight or obese. The goal of the study was to determine if following an eating pattern of low GL foods would reduce visceral fat and BMI and to investigate whether a low GL diet had an effect on body composition, blood glucose, triglyceride, and cholesterol levels. The exercise program provided a method for personal contact with participants on a regular basis and also allowed the researcher to monitor dietary compliance.

Methodology

After approval from the institution's Review Board for the protection of human subjects, individuals were recruited from the university community to participate in the 12-week study. They were screened on blood glucose levels, height and weight (to calculate BMI), waist circumference, and resting blood pressure. Those having a BMI between 26 and 33, normal blood glucose levels (<160 ml/dl), and who were non-exercisers were invited to participate. Those who had BMIs greater than 33 or above normal blood glucose levels were excluded on the basis of medical concerns. Regular exercisers were also excluded to maintain the exercise component of the study. The participants (n=10) were matched on age, gender, and BMI and then assigned to an experimental or control group.

Those in the control group were given the American Diabetes Association Exchange Lists for Meal Planning (1995) to follow. Those in the experimental group were given the American Diabetic Association food plan modified to low GL following guidelines by Foster-Powell, Holt & Brand-Miller (2002). Based on physiological screening results, average daily kilocalories for basal metabolic rate were set for each individual in both groups. Daily food journals were collected from all participants for weeks 1, 2, 4, 8, and 12. Twenty-four hour food recalls were conducted randomly over the entire 12 weeks to crosscheck food journals. Additionally, participants in the modified eating program met with a dietician at the end of weeks 1, 2, 4, 8 and 12 to discuss any challenges encountered. All data from food journals was entered into a nutritional analysis software program (Diet Analysis+) and analyzed on macronutrients and kilocalories. GL was computed from this data using the formula from Liu et al (2001).

All participants took part in the walking program, which met three days per week during the length of the study. The walking program began with 15 minutes per session and increased no more than 10% of total exercise time each week for a final 45 minutes per session in the 12th week. At the end of 12 weeks, all participants were reevaluated on measures of height and weight, waist circumference, blood chemistries, body fat percentages, and 24-hour diet recall. Data analyses were performed to determine changes from baseline.

Results

The study was designed to determine if GL had an effect on blood chemistries, waist circumference, and BMI. Over the course of the 12 weeks, all participants in the control group self-eliminated. One individual in the experimental group chose to pursue extra-curricular activities and withdrew from the study. The remaining four completed the 12-week study and post-tests. Blood chemistry levels showed some dramatic decreases in cholesterol and glucose. In 12 weeks, individuals' blood cholesterol and glucose levels changed significantly ($p<.05$). Cholesterol levels dropped an average of 40 points. The group mean pre-intervention was 211 mg/dl and at post intervention it was 165 mg/dl. While significant changes in weight, BMI, or waist circumference did not occur, a group average of five pounds was lost. Individuals reported that during the final two weeks of the study they did not adhere as closely to the dietary guidelines as they had in the earlier weeks. Because of attrition and the resulting small N, the following descriptions of individual participant results provide more information on exact physiological changes. Names have been changed to de-identify the participants.

Imelda was a 21-year-old female. She was 65.5 inches tall and at the start of the study weighed 247.2 pounds. Her BMI was 40.51 and she had a waist circumference of 47.45 inches. During the 12-week intervention, Imelda logged 1164 minutes of walking and consumed a diet with an average GL of 76.38. She lost 15.2 pounds, BMI decreased by 2.49, body fat decreased by 1 %, and waist circumference decreased by 1.77 inches. All blood chemistry measures decreased as well; triglycerides decreased by 61 mg/dl; total cholesterol decreased by 24 mg/dl; glucose decreased by 17; HDL decreased by 4 mg/dl; low density lipoproteins (LDL) decreased by 7.4 mg/dl; very low density lipoproteins (VLDL) decreased by 12.6 mg/dl; and total cholesterol/HDL ratio decreased by 0.15.

Consuela was a 26-year-old female. She was 70.5 inches tall and at the start of the study weighed 209.2 pounds. Her BMI was 29.59 and she had a waist circumference of 41.34 inches. During the 12-week intervention she accumulated 1012 minutes in the walking program and consumed a diet with an average GL of 59.63. She lost 8.2 pounds, BMI decreased by 1.16, body fat decreased by 0.3 %, and waist circumference decreased by 1.97 inches. She experienced blood chemistry decreases as well; triglycerides decreased by 52 mg/dl; total cholesterol decreased by 49 mg/dl; glucose decreased by 10; HDL decreased by 18 mg/dl; LDL decreased by 20.6 mg/dl; VLDL decreased by 10.4 mg/dl; and total cholesterol/HDL ratio decreased by 0.25.

Maria was a 20-year-old female. She was 67.25 inches tall and at the start of the study weighed 183.5 pounds. Her BMI was 28.52 and she had a waist circumference of 34.33 inches. During the 12-week intervention, she logged a total of 969 minutes in the walking program and consumed a diet with an average GL of 95.73. She gained one pound, BMI increased by 0.91, body fat increased by 0.1 %, and waist circumference increased by .71 inches. Blood chemistry changes were also noted; triglycerides decreased by 26 mg/dl; total cholesterol decreased by 41 mg/dl; glucose decreased by 2; HDL decreased by 13 mg/dl; LDL decreased by 23 mg/dl; VLDL decreased by 5 mg/dl; and total cholesterol/HDL ratio increased by 0.28.

Veronica was a 19-year-old female. She was 62.5 inches tall and at the start of the study weighed 176.2 pounds. Her BMI was 31.71 and she had a waist circumference of 34.33 inches. At the end of the 12-week intervention, Veronica had accumulated 874 minutes of walking in the program and had consumed a diet with an average GL of 92.00. She gained 3.8 pounds, BMI increased by 0.68, body fat increased by 0.4 %, and waist circumference increased by 1.5 inches. She also experienced blood chemistry changes; triglycerides increased by 5 mg/dl; total cholesterol decreased by 72 mg/dl; glucose decreased by 14; HDL decreased by 27 mg/dl; LDL decreased by 46.4 mg/dl; VLDL increased by 1.4 mg/dl; and total cholesterol/HDL ratio increased by 0.17.

Table 1 displays the individual measures from pre- to posttest. There was not enough data to calculate significance of changes across subjects. However, those most compliant in following the GL diet showed what appeared to be greater results.

Table 1
Measures used in pre and post tests*

	Imelda	Consuela	Maria	Veronica
BMI	*40.51*	*29.6*	*28.5*	*31.7*
	38.02	**28.4**	**28.6**	**32.4**
Waist Circ. in	*47.45*	*41.34*	*34.33*	*34.33*
	45.68	**39.37**	**35.04**	**35.83**
%fat	*57.7*	*46.4*	*39.4*	*45.1*
	56.7	**46.1**	**39.8**	**45.5**
TRG	*153*	*110*	*106*	*127*
	92	**58**	**80**	**132**
TC	*194*	*192*	*208*	*253*
	170	**143**	**167**	**181**
HDL	*47*	*66*	*76*	*86*
	43	**48**	**63**	**59**
LDL	*116*	*104*	*111*	*142*
	108.6	**83.4**	**88**	**95.6**
VLDL	*31*	*22*	*21*	*25*
	18.4	**11.6**	**16**	**26.4**
C/HDL	*4.1*	*2.9*	*2.7*	*2.9*
	3.95	**2.65**	**2.9**	**3.07**
GLU	*114*	*98*	*91*	*93*
	97	**88**	**89**	**79**

Italics* represents pre tests, **bold represents post tests.

Discussion

In this study, the two individuals who consumed a lower average GL diet experienced positive changes in body composition and blood chemistries. The two participants who consumed a diet with an average GL over 90 experienced increases in BMI and waist circumference even though they participated in the walking program. All of the participants had decreased glucose levels, which may be related to the exercise component. Although all of the participants had decreases in total cholesterol, the ratio between total cholesterol and HDL improved only in the two subjects with lower average GL consumption. Three of the participants had their triglyceride levels decrease and the one that had an increased triglyceride level consumed a higher GL diet and accumulated the fewest walking minutes. This tentatively indicates support for the utilization of the GL in a weight management program. Ludwig (2002) reported success with a weight management program utilizing GL in controlled settings.

The lack of compliance with the eating program during the last two weeks of the study was partly attributable to the end of the semester effect where students focus more on completing class work and less on outside influences. As physiological results do not show immediately, it was theorized that a 12-week program would be sufficient to show change in blood chemistries. This trend was evidenced in our results. However, without full compliance with the eating program, we were unable to see positive physiological changes across all participants.

Limitations

Monetary incentives ($100.00) were offered to participants upon completion of the study. Participants who discontinued the study did not receive any compensation. Because of limited funds for incentives, the groups were limited to five in each. The loss of all participants in the control group was not expected and cannot be explained. The limited feedback received had little to do with the study and more to do with personal reasons. The feedback from the experimental group was positive.

The food journals were completed daily for weeks one, two, four, eight, and 12. We anticipated that compliance would be better with this method versus weekly journals for the entire study. Instead, we found that it was confusing and did not allow a complete picture of food consumption over the course of the study. We also had to remind participants regularly to turn in their journals on time, which was another problem we did not anticipate. Timeliness of the journals may have limited the accuracy of the journals. No participant complained that the eating program was restricted. However, actual compliance with the program was not 100%.

Only one participant succeeded in attending all the walking sessions. Others missed for a variety of reasons, including work, assignments, forgetting, and oversleeping. In inclement weather, the group walked inside. The majority of participants actually preferred walking indoors to walking outside.

The small number of participants limits the usability of this data. Future experimental studies are planned with a larger number of participants.

Conclusion

Although this study was limited due to the number of participants and the loss of the control group, there is evidence that low GL had a beneficial effect on BMI, waist circumference, blood glucose, and lipid levels. A much larger study of this nature that examines the effects of the independent variables of GL and exercise is needed to determine the effects of a quality carbohydrate diet. Additionally, more research is needed in typical settings to determine if this is a feasible methodology in weight management and in combating the obesity epidemic.

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