Original Research

Potatoes, Glycemic Index, and Weight Loss in Free-Living Individuals: Practical Implications

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Background: The role of glycemic index (GI) and foods with negative attributes related to GI as part of a weight loss regimen has not been thoroughly assessed in free-living individuals. This study examined the effects of a dietary prescription for energy intake modification, GI, and potato consumption on weight loss, dietary prescription adherence, body composition, and glucose control in a free-living, self-selecting overweight population.

Methods: Ninety overweight (body mass index [BMI] 29.6 ± 3.9) men and women were randomly assigned to one of 3 groups for 12 weeks. Two groups were counseled to reduce their energy intake by 500 kcal/day and consume diets that were predominantly composed of either low- or high-GI foods (low glycemic index energy reduced [LGI-ER] or high glycemic index energy reduced [HGI-ER] diet, respectively). The third group received no energy restriction, GI provision, or nutritional counseling. All groups were instructed to consume 5–7 servings of potatoes per week. Changes in weight, body composition, glucose tolerance, and triglycerides were determined at baseline and 12 weeks.

Results: There were no significant differences in weight loss or changes in body composition between the groups; however, modest weight loss and body composition changes were seen from week 0 to week 12 for all groups ($p < 0.05$). Difficulty achieving the prescribed GI diets was evident in this free-living setting. There were no significant changes within or among treatments for fasting concentrations of triglycerides, glucose tolerance, insulin, or insulin sensitivity.

Conclusions: The results indicate that in a free-living population of men and women, weight loss is associated with energy intake reduction. Potato intake did not cause weight gain and following either a high- or low-GI dietary prescription was difficult for free-living subjects, emphasizing the complex nature of changing dietary patterns.

INTRODUCTION

It is generally recognized that body weight is determined by the balance between the calories consumed and the sum of the energy expended for basal metabolism and for physical activities. Recently, however, this basic proposition has been questioned by proponents of both low-carbohydrate/high-protein diets and diets with a low glycemic index (GI). Both of these diets have been advanced as methods of promoting weight loss in excess of that anticipated by a calorie deficit, suggesting that additional benefits are conferred by their impact upon satiety, energy metabolism, and/or glucose control [1–6]. In this context, certain foods such as potatoes have been identified as being particularly detrimental to weight management efforts due to their high carbohydrate content and designation as a high-GI food [7–9]. The experimental data supporting such a claim are at best equivocal, especially in free-living, self-selecting study subjects [10–17]. Therefore, the purpose of this study was to

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Abbreviations: BMI = body mass index, CD = control diet, DEXA = dual-energy x-ray absorptiometry, GI = glycemic index, GL = glycemic load, HGI = high glycemic index, HGI-ER = high glycemic index energy reduced, HOMA-IR = homeostasis model assessment of insulin resistance, LGI = low glycemic index, LGI-ER = low glycemic index energy reduced, ME = maintenance energy, OGTT = oral glucose tolerance test.

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examine the effects of a dietary prescription for energy intake modification and GI (high or low GI) and potato intake on the background of these diets on measures of body weight, body composition, and metabolic indices in a free-living overweight population and further to assess compliance of prescribed diets based on the GI system in free-living individuals.

MATERIALS AND METHODS

The Human Subjects Research Committee of the University of California (UC), Davis, approved this study. The study was conducted in accordance with the Helsinki Declaration of 1975 as revised in 1983. All participants signed a written informed consent form before any study-related procedures were performed; verbal consent was given during the telephone interview prior to answering study screening questions. This study is registered with ClinicalTrials.gov, identifier: NCT01186393. Participants were recruited through newspapers, posters, and direct contact in the Davis and Sacramento area of Northern California.

Study Design and Participants

The study was a randomized, 12-week, 3-arm, parallel controlled trial. The primary endpoint of interest was the change in body weight from baseline to week 12. Secondary endpoints included change from week 0 to week 12 on body composition as measured by dual-energy x-ray absorptiometry (DEXA), waist circumference, glucose tolerance (as measured by 2-h oral glucose tolerance test, OGTT), fasting triglycerides, energy intake, and diet composition.

Exclusions for study participation were the following: food allergies or intolerances to potatoes, cigarette smoker, currently modifying diet or exercise patterns to gain or lose weight, excessive exercisers or trained athletes, taking any medications that would affect glucose metabolism, or the presence of other health problems requiring ongoing intervention by their personal physician. Eligible men and women were overweight based on their body mass index (BMI = 25–37 kg/m^2), over 18 years old, light to moderate exercisers and had normal fasting plasma glucose and were able to meet the time and effort requirements required for study participation.

Recruitment and enrollment occurred continuously during the study with an aim of randomizing 30 subjects per arm. In total, 395 individuals contacted study personnel requesting further information between July 2008 and June 2010. During subsequent telephone screening, 269 screen-failed based on inclusion–exclusion criteria or were lost to contact. One hundred and twenty-six (n = 126; 92 women and 34 men) individuals met inclusion criteria and were invited for blood screening. Of these individuals, 11 failed the blood screen, 17 changed their mind after screening, and 8 enrolled but withdrew before attending the first study day. The remaining 90 individuals meeting study criteria were enrolled (women n = 73, men n = 17). After study commencement, 17 individuals (women n = 11, men n = 6) withdrew from the study for the following reasons: 3 cited changes in work schedule, 3 needed to provide care to ill family members, 2 developed non-study-related health problems, 8 were lost to follow-up after the first study visit, and 1 could not provide adequate blood samples during the OGTT. The remaining 73 individuals completed all aspects of the study protocol (women n = 62, men n = 11). Fig. 1 depicts the flow of participants through the study.

Dietary Intervention

Participants were randomized to one of 3 dietary intervention groups. One group served as the reference group and received limited dietary advice, including no GI or daily energy intake goals (control diet [CD] group). Two groups, however, were counseled to reduce energy intake by 500 kcal/d (energy reduced, ER) and to consume diets composed predominantly of low- or high-GI foods (LGI-ER or HGI-ER diet, respectively). Energy reduction prescriptions for participants randomized to the LGI-ER and HGI-ER were based on maintenance energy requirements and subtracting 500 kcal, calculated using the Harris-Benedict equation [18]. All subjects received a new energy prescription with each 5-kg drop in weight. The targeted average GI for each of the dietary interventions was 30 for LGI-ER and 80 for the HGI-ER, providing a 50-point separation between groups.

Subjects were counseled to consume diets composed mostly of foods that were either low or high GI without describing the foods or the diets as low or high GI. The purpose of this strategy was 2-fold: to (1) reduce the influence of negative media messaging about high-GI foods/diet on subjects' compliance when randomized to the high-GI diet and (2) determine the practicality of implementing a low- or high-GI diet in the free-living setting under a condition where prior or newly gained knowledge (e.g., from surfing the Internet) about diets is detached from the setting. Dietary intervention procedures included weekly counseling visits with a registered dietitian for the first 6 weeks and then every other week thereafter until week 12. A weight management manual designed by our laboratory and customized for this trial was utilized to standardize counseling visits within and across randomized intervention groups, as appropriate. Subjects randomized to the LGI-ER and HGI-ER groups received specific counseling instructions and handouts for including (or substituting) high- or low-GI foods in their diet while also meeting energy prescriptions. Minimal dietary advice was provided to the control group, which included a description of the dietary guidelines and information about portion control. All groups were provided potatoes (6 russet and 3 red potato varieties) on a weekly basis; compliance was ascertained by review of food records and verbal interview. All groups were expected to

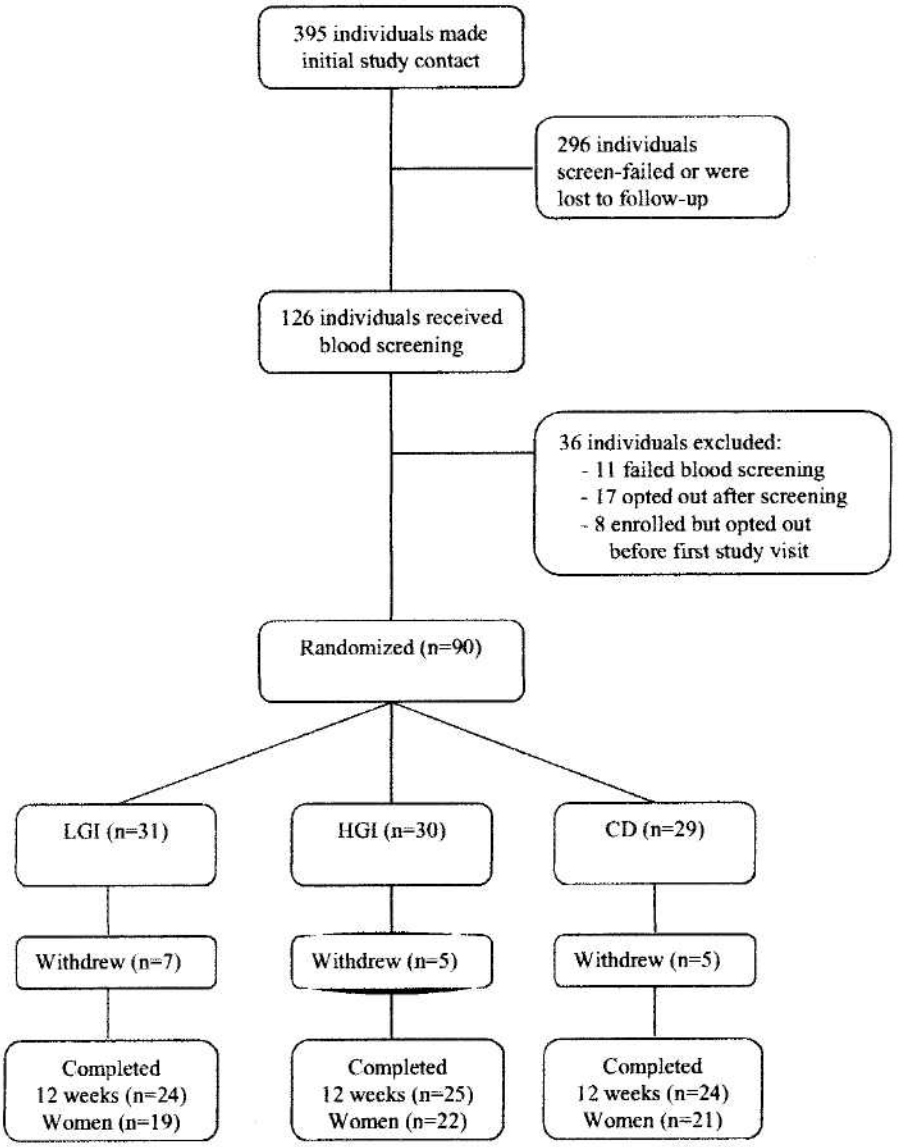

Fig. 1. Study progress. Consort diagram showing the participant flow ($n = 90$) through the study protocol.

consume 5–7 servings of potatoes each week, such as one medium potato or $\frac{1}{2}$ cup cooked potato, providing approximately 110 kcal of potato/serving. Customized foods lists composed of high- and low-GI foods for subjects to include in their diets were provided according to participants' randomization. Additionally, subjects received a customized recipe booklet for potato preparation, cooking methods, and specific recipes according to participants' randomization to comply with either the high- or low-GI dietary prescription. No specific advice for preparing potatoes was provided to the control group. The purpose of providing potatoes to the control group was to explore effects of unprompted usage and, more important, to determine whether they would cause weight gain, which might be argued to interfere with the performance of the LGI-ER diet, due to their high-GI designation.

Food record analysis was performed on nonconsecutive days, which included 2 weekdays and one weekend day. Food records were assigned weekly for the first 6 weeks and then every other week for the second half of the study. The data presented in the article include weeks 0, 3, 6, 9. No significant differences between 3, 6, 9 weeks were indicated, so the data were pooled to reflect mean intake while on study. Food Processor SQL Edition (Version 10.1.0, ESHA Research, Salem, OR) was used to analyze food records. GI was assigned to each food based on published work of Brand-Miller and colleagues [19,20]. Overall dietary GI was assessed by applying GI values to each food item

recorded by the participants on their food records and calculating a daily average. For participants' unique recipes, the closest version of combined food was used from published data. If GI information was unavailable for a combination food, it was first analyzed for the percentage that each ingredient contributed to the overall weight of the recipe. Individual components were then assigned a GI value and weighted by their contribution to the combined food to arrive at a GI value. Glycemic load (GL) was calculated as the product of GI and available carbohydrate divided by 100. Summed daily scores were averaged among days per week [19, 21].

Study Procedures

Study participants visited the National Institutes of Health–sponsored UC Davis Clinical and Translational Science Center Clinical Research Center at the UC Davis Medical Center–affiliated Northern California Veteran's Affairs Medical Center in Mather, California, at weeks 0 and 12. Measurements were collected for height, weight, waist circumference, vital signs, and body composition (DEXA; Discovery W, Hologic, Bedford, MA). Subjects were instructed to arrive after a 10-h overnight fast, after having consumed a usual meal the night before and avoiding alcoholic beverages 24 h prior to the study visit. Testing was conducted between 7 AM and 9 AM after confirmation of adherence to prestudy instructions. Oral glucose tolerance testing included placement of an indwelling catheter in the nondominant arm of each participant for multiple blood sampling. After the initial fasting blood draw, participants consumed a 75-g dextrose beverage (NERL Diagnostics, East Providence, RI) within 5 min. Subsequent blood samples were collected at 30, 60, and 120 min. Blood samples were collected in EDTA-coated Vacutainer tubes (Becton Dickinson, Franklin Lakes, NJ), immediately cooled in ice, and plasma was obtained by centrifugation at 1800 × *g* for 15 min at 4°C. Plasma aliquots were frozen at −80°C for determination of glucose, insulin, and fasting triglycerides. Glucose and triglycerides were determined by enzymatic colorimetric method using a Randox Daytona auto analyzer (Randox Laboratories, London, UK). Insulin was determined by AlphaLISA Insulin assay kit (PerkinElmer, Boston, MA) at the Illinois Institute of Technology, Institute for Food Safety and Health, Bedford Park, Illinois. Homeostasis model assessment of insulin resistance (HOMA-IR) was calculated using fasting glucose and insulin: HOMA-IR = [glucose(mg/dL) * insulin(uU/mL)]/405 [22].

Statistical Analysis

Power calculations were based on the comparison of and detecting differences between the HGI-ER vs LGI-ER arms. These calculations indicated 27 subjects completing in each energy-restricted diet arm provided >80% power to detect a 2-kg difference in body weight change using significance of <0.05 and standard deviation of 2.4. The control arm was included for reference and an equal number of subjects were enrolled. The primary end point was the change from baseline in body weight at week 12. Pair-wise comparisons were conducted within treatments and unpaired *t*-tests were used to determine differences between changes at week 12. Chi-square and Fisher's exact test were used to compare the proportion of subjects in each group who achieved 5% or more weight loss. Secondary endpoints included change in fat and fat-free mass as determined by DEXA; changes in fasting insulin, glucose, and triglycerides, and 2-h response to oral glucose tolerance test; and blood pressure after 12-week treatments. Univariate and repeated-measures analyses of variance were used to assess the changes in weight, body composition, and blood parameters. Missing data were replaced with the last known value for the intention-to-treat analysis for body weight only. All other results are based on the per protocol data set, which includes only those subjects who completed both 0-week and 12-week procedures. Data were analyzed using PC-SAS (Version 9.2; SAS Institute Inc, Cary, NC). Statistical significance was indicated by $p < 0.05$.

RESULTS

Subject Characteristics

Characteristics of study participants ($n = 90$), per randomization, are shown in Table 1. The study population consisted of men ($n = 17$) and women ($n = 73$) who were overweight (mean BMI ± SD = 29.9 ± 4.9) with a mean age of 47.8 ± 13.3 years.

Dietary Intake and Compliance

The results of the dietary analysis are shown in Table 2. There were no significant differences among groups for energy or macronutrient intake; however, within treatments, significant differences were noted for the CD ($p < 0.01$) and LGI-ER treatments ($p < 0.05$). Subjects randomized to the CD or LGI-ER dietary groups experienced an approximately 15% decrease in energy intake over the course of the study compared to week 0 ($p < 0.05$), whereas subjects randomized to the HGI-ER group reduced intake by approximately 8% ($p > 0.05$). Overall, the higher the starting energy intake the greater the reduction observed while on study. Analysis of GI indicated no significant differences among or within treatments, although GL decreased overall from week 0 to week 12 (−10.4 ± 4.6, $p = 0.03$). Statistical differences for GL were not indicated between treatments; however, changes in GL while on study for each of the dietary groups (baseline [week 0] to week 12) were as follows: CD, −19.0 ± 7.8, $p = 0.02$; LGI-ER, −14.5 ± 8.3, $p = 0.08$; and HGI, −2.2 ± 8.1, $p = 0.78$. Weekly potato consumption was based on review of food records and verbal interview.