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

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Key words: glycemic index, weight loss, energy restriction, body composition, potatoes

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 three 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...
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, excess 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 = 25–31 kg/m²), 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-kcal 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/diets 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 dietician 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
395 individuals made initial study contact

296 individuals screen-failed or were lost to follow-up

126 individuals received blood screening

36 individuals excluded:
- 11 failed blood screening
- 17 opted out after screening
- 8 enrolled but opted out before first study visit

Randomized (n=90)

LGI (n=31)

Withdraw (n=7)

Completed 12 weeks (n=24)
Women (n=19)

HGI (n=30)

Withdraw (n=5)

Completed 12 weeks (n=25)
Women (n=22)

CD (n=29)

Withdraw (n=5)

Completed 12 weeks (n=24)
Women (n=21)

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 ½ 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 Research Center at the UC Davis Medical Center-affiliated Northern California Veterans 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 x g for 15 min at 4°C. Plasma aliquots were frozen at −80°C for later analysis. Insulin and C-peptide concentrations were measured by RIA performed at the University of California, Davis. Glucose and triglycerides were determined by enzymatic colorimetric method using a Vmax Microplate reader (Molecular Devices, Sunnyvale, CA). Insulin was determined by an enzyme-linked immunosorbent assay (PerkinElmer, Boston, MA) at the Norcross 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) x insulin(µU/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 each energy-restricted diet arm providing >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 endpoint was the change 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 sets, which includes only those subjects who completed both 0-week and 12-week procedures. Data were analyzed using SPSS Version 12.2 (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 GI decreased overall from week 0 to week 12 (−10.4 ± 4.6, p = 0.03). Statistical differences for GI 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.
Table 1. Baseline Characteristics of Enrolled Study Participants

<table>
<thead>
<tr>
<th></th>
<th>LGI-ER Diet (n = 31)</th>
<th>HGI-ER Diet (n = 30)</th>
<th>Control Diet (n = 29)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>47.8 ± 14.1</td>
<td>51.4 ± 14.7</td>
<td>43.9 ± 14.5</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>80.5 ± 12.1</td>
<td>82.8 ± 14.4</td>
<td>81.2 ± 9.4</td>
</tr>
<tr>
<td>Height (in)</td>
<td>64.6 ± 12.1</td>
<td>66.0 ± 0.8</td>
<td>66.6 ± 0.7</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>29.5 ± 4.1</td>
<td>29.7 ± 4.0</td>
<td>29.5 ± 3.8</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>85.1 ± 9.1</td>
<td>92.4 ± 12.1</td>
<td>98.1 ± 7.2</td>
</tr>
<tr>
<td>Total cholesterol (mg/dL)</td>
<td>192.8 ± 35.8</td>
<td>189.1 ± 31.9</td>
<td>186.5 ± 32.0</td>
</tr>
<tr>
<td>LDL cholesterol (mg/dL)</td>
<td>122.9 ± 35.8</td>
<td>118.5 ± 28.1</td>
<td>118.1 ± 27.9</td>
</tr>
<tr>
<td>HDL cholesterol (mg/dL)</td>
<td>50.5 ± 11.9</td>
<td>53.8 ± 15.2</td>
<td>54.4 ± 16.0</td>
</tr>
<tr>
<td>Triglyceride (mg/dL)</td>
<td>100.3 ± 41.7</td>
<td>82.2 ± 33.1</td>
<td>78.8 ± 34.6</td>
</tr>
<tr>
<td>Glucose (mg/dL)</td>
<td>92.5 ± 7.1</td>
<td>93.7 ± 12.2</td>
<td>89.0 ± 7.3</td>
</tr>
<tr>
<td>Systolic BP (mmHg)</td>
<td>121.6 ± 2.9</td>
<td>119.3 ± 2.4</td>
<td>119.9 ± 2.4</td>
</tr>
<tr>
<td>Diastolic BP (mmHg)</td>
<td>77.1 ± 2.0</td>
<td>75.4 ± 1.2</td>
<td>76.0 ± 1.4</td>
</tr>
</tbody>
</table>

LGI-ER = low glycemic index energy reduced, HGI-ER = high glycemic index energy reduced, BMI = body mass index, LDL = low-density lipoprotein, HDL = high-density lipoprotein, BP = blood pressure.

Compliance was based on intake of >80% with eating 5–7 servings of potatoes each week; all subjects included in the analysis met this requirement.

Weight Loss and Body Composition

Analyses of changes in body weight using the per protocol data set (n = 73) are shown in Table 3 and Fig. 2. No significant differences in weight change were observed between treatments; however, changes within treatments showed significant reductions in weight from week 0 to week 12 for all groups (Table 2). Weight changes within groups from weeks 0 to 12 ranged from 1.5 to −0.3 for LGI-ER (p = 0.006), 2.6 to −7.4 for HGI-ER (p = 0.0005), and 1.7 to −6.3 for CD (p = 0.0003). There were no gender differences in weight change within or between treatments groups. The percentage of participants losing 5% or more

Table 2. Dietary Intake before and during 12-Week Dietary Intervention

<table>
<thead>
<tr>
<th>Variable</th>
<th>LGI-ER</th>
<th>HGI-ER</th>
<th>CD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants (n = 70)</td>
<td>n = 22</td>
<td>n = 24</td>
<td>n = 24</td>
</tr>
<tr>
<td>Baseline, week 0</td>
<td>1924.3 ± 147.7</td>
<td>1712.3 ± 76.7</td>
<td>1988.3 ± 115.3</td>
</tr>
<tr>
<td>Weeks 3, 6, 9</td>
<td>1624.9 ± 81.4*</td>
<td>1573.9 ± 102.0</td>
<td>1658.3 ± 89.7*</td>
</tr>
<tr>
<td>Baseline, week 0</td>
<td>84.7 ± 6.1 (18.4 ± 1.0)</td>
<td>76.6 ± 5.0 (18.0 ± 0.8)</td>
<td>83.3 ± 5.5 (16.9 ± 0.7)</td>
</tr>
<tr>
<td>Weeks 3, 6, 9</td>
<td>79.2 ± 5.7 (18.6 ± 1.2)</td>
<td>73.4 ± 4.9 (19.0 ± 0.8)</td>
<td>75.1 ± 5.2 (18.1 ± 0.6)</td>
</tr>
<tr>
<td>Baseline, week 0</td>
<td>230.2 ± 20.4 (49.7 ± 1.8)</td>
<td>211.7 ± 8.8 (50.7 ± 2.1)</td>
<td>240.2 ± 16.9 (48.3 ± 1.7)</td>
</tr>
<tr>
<td>Weeks 3, 6, 9</td>
<td>219.1 ± 10.2* (52.3 ± 2.8)</td>
<td>197.4 ± 11.2 (51.6 ± 0.9)</td>
<td>206.2 ± 13.3 (49.6 ± 1.2)</td>
</tr>
<tr>
<td>Baseline, week 0</td>
<td>78.1 ± 7.2 (33.4 ± 1.8)</td>
<td>59.9 ± 5.1 (30.5 ± 1.6)</td>
<td>74.9 ± 6.6 (33.3 ± 1.9)</td>
</tr>
<tr>
<td>Weeks 3, 6, 9</td>
<td>49.1 ± 4.6* (26.6 ± 1.4)</td>
<td>52.6 ± 6.2 (28.8 ± 1.4)</td>
<td>60.0 ± 3.7* (32.7 ± 1.1)</td>
</tr>
<tr>
<td>Baseline, week 0</td>
<td>23.9 ± 2.1</td>
<td>25.2 ± 1.6</td>
<td>23.9 ± 2.0</td>
</tr>
<tr>
<td>Weeks 3, 6, 9</td>
<td>23.8 ± 1.5</td>
<td>23.3 ± 1.7</td>
<td>22.0 ± 2.0</td>
</tr>
<tr>
<td>Baseline, week 0</td>
<td>52.6 ± 1.2</td>
<td>55.4 ± 1.1</td>
<td>53.0 ± 0.8</td>
</tr>
<tr>
<td>Weeks 3, 6, 9</td>
<td>52.3 ± 0.8</td>
<td>53.3 ± 0.8</td>
<td>52.3 ± 0.8</td>
</tr>
<tr>
<td>Baseline, week 0</td>
<td>120.7 ± 9.2*</td>
<td>100.6 ± 8.6</td>
<td>110.8 ± 8.7</td>
</tr>
<tr>
<td>Weeks 3, 6, 9</td>
<td>106.3 ± 7.9*</td>
<td>102.8 ± 7.8*</td>
<td>91.8 ± 7.4*</td>
</tr>
</tbody>
</table>

LGI-ER = low glycemic index energy reduced, HGI-ER = high glycemic index energy reduced, CD = control diet.

*Values are expressed as mean ± SE.

Mean daily intake from food record data collected during week 0 or weeks 3, 6, 9.

n = 21 due to noncompliance issues.

*p < 0.05 within treatment groups; that is, changes in intake from week 0 to baseline. No significant differences between treatments.

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Table 3. Change in Body Weight and Body Composition

<table>
<thead>
<tr>
<th>Variable</th>
<th>LGI-ER</th>
<th>HGI-ER</th>
<th>CD</th>
<th>LGI-ER</th>
<th>HGI-ER</th>
<th>CD</th>
<th>Within-Treatment</th>
<th>Between-Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants completing protocol (n = 73)</td>
<td>n = 24</td>
<td>n = 25</td>
<td>n = 24</td>
<td>LGI-ER</td>
<td>HGI-ER</td>
<td>CD</td>
<td>p Value</td>
<td>p Value</td>
</tr>
<tr>
<td>Change in weight (kg)</td>
<td>-1.5 ± 0.5**</td>
<td>-2.3 ± 0.6***</td>
<td>-2.1 ± 0.5***</td>
<td>≤0.01</td>
<td>≤0.001</td>
<td>≤0.001</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Weight change (%)</td>
<td>-1.8 ± 0.6**</td>
<td>-2.8 ± 0.7**</td>
<td>-2.5 ± 0.6**</td>
<td>≤0.01</td>
<td>≤0.01</td>
<td>≤0.01</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Change in BMI (kg/m²)</td>
<td>-0.5 ± 0.2**</td>
<td>-0.8 ± 0.2**</td>
<td>-0.8 ± 0.2**</td>
<td>≤0.01</td>
<td>≤0.01</td>
<td>≤0.01</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Subjects with ≥ 5% loss (%)</td>
<td>17</td>
<td>24</td>
<td>25</td>
<td>≤0.05</td>
<td>≤0.01</td>
<td>≤0.01</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Change in fat mass (kg)</td>
<td>-1.0 ± 0.4**</td>
<td>-1.2 ± 0.4**</td>
<td>-1.0 ± 0.4**</td>
<td>≤0.05</td>
<td>≤0.01</td>
<td>≤0.01</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Change in lean mass (kg)</td>
<td>-0.4 ± 0.2</td>
<td>-0.9 ± 0.3**</td>
<td>-0.9 ± 0.3**</td>
<td>≤0.01</td>
<td>≤0.01</td>
<td>≤0.01</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Change in body fat (%)</td>
<td>-0.7 ± 0.3**</td>
<td>-0.6 ± 0.3</td>
<td>-0.4 ± 0.3</td>
<td>≤0.05</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Change in trunk fat (%)</td>
<td>-1.0 ± 0.4**</td>
<td>-0.8 ± 0.4**</td>
<td>-0.3 ± 0.4</td>
<td>≤0.01</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Change in WC (cm)</td>
<td>-1.5 ± 0.6**</td>
<td>-1.6 ± 0.9</td>
<td>-2.2 ± 0.4**</td>
<td>≤0.05</td>
<td>NS</td>
<td>≤0.01</td>
<td>NS</td>
<td></td>
</tr>
</tbody>
</table>

LGI-ER = low glycemic index energy reduced, HGI-ER = high glycemic index energy reduced, CD = control diet. NS = not significant. BMI = body mass index, WC = waist circumference.

*Values are expressed as mean ± SE unless otherwise indicated; all data other than percentage of weight change were adjusted for baseline values.
*Within treatment refers to differences in variable from baseline (week 0) to end of treatment (week 12) for each respective treatment.
*Between treatment refers to differences in the change of variable from baseline (week 0) to end of treatment (week 12) among treatments.
*p < 0.05, **p < 0.01, ***p < 0.001.

Fig. 2. Change in weight over 12-week dietary intervention. Weight changes observed in each group, measured every 2 weeks in kilograms, during the 12-week dietary intervention.
of their initial body weight was 17%, 24%, and 25% in LGI-ER, HGI-ER, and CD groups, respectively, although this was not significantly different between groups. Analysis of the intent-to-treat data set (n = 90) showed a similar pattern of weight change within and among groups (data not shown).

Fig. 3 shows the change in body composition by treatment and by week. All groups lost a significant amount (kg) of fat mass from 0 to 12 weeks: LGI-ER, −1.0 ± 0.4 (p = 0.02); HGI-ER, −1.2 ± 0.4 (p = 0.006); CD, −1.0 ± 0.4 (p = 0.01). Significant reductions in fat-free mass (lean tissue) were apparent after 12 weeks' intervention for the HGI-ER and CD groups: −0.9 ± 0.3 kg (p = 0.005) and −0.9 ± 0.3 kg (p = 0.002), respectively, but not in LGI-ER group (−0.4 ± 0.2, p > 0.05). As a percentage of weight loss, fat loss was ~58%, 53%, and 72% in the HGI-ER, CD, and LGI-ER groups, respectively (p < 0.05). A significant decrease in total percentage body fat and trunk fat was observed in the LGI-ER group (Table 3; −0.7 ± 0.3, p = 0.05, and −1.0 ± 0.4, p = 0.01, respectively). Significant changes in waist circumference (n = 73) from week 0 to week 12 were evident in the LGI-ER and CD groups (−1.5 ± 0.6, p = 0.02, and −2.2 ± 0.4, p = 0.0005, respectively).

Cardiovascular and Metabolic Risk Factors

Fasting concentrations of triglycerides, glucose, and insulin did not change significantly in response to dietary interventions, either within or between groups (see Table 4). Similar results were observed in the glucose and insulin responses obtained during the 2-h OGTT. Insulin sensitivity, determined by HOMA-IR, also did not change significantly among treatments.

Table 4. Change in Cardiovascular and Metabolic Risk Factors

<table>
<thead>
<tr>
<th>Variable</th>
<th>LGI-ER</th>
<th>HGI-ER</th>
<th>CD</th>
<th>Within-Treatment p Value</th>
<th>Between-Treatment p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants completing protocol (n = 73)</td>
<td>n = 24</td>
<td>n = 25</td>
<td>n = 24</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Triglycerides (mmol/L)</td>
<td>−0.1 ± 0.2</td>
<td>−0.2 ± 0.2</td>
<td>−0.26 ± 0.2</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Fasting glucose (mmol/L)</td>
<td>0.1 ± 0.2</td>
<td>−0.1 ± 0.2</td>
<td>−0.4 ± 0.2</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Glucose, 2-h OGTT, (mg/dL)</td>
<td>0.2 ± 0.9</td>
<td>−0.9 ± 0.9</td>
<td>−1.8 ± 0.9</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Fasting insulin (pmol/L)</td>
<td>−2.8 ± 15.3</td>
<td>−11.1 ± 16.0</td>
<td>−20.8 ± 16.7</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Insulin, 2-h OGTT, (AUC (mmol/L* h))</td>
<td>137.5 ± 131.3</td>
<td>−125.5 ± 131.3</td>
<td>55.6 ± 125.0</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>−1.1 ± 1.1</td>
<td>0.2 ± 1.5</td>
<td>0.6 ± 1.8</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>−0.5 ± 1.6</td>
<td>1.3 ± 1.1</td>
<td>−0.9 ± 1.6</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>HOMA-IR</td>
<td>−0.1 ± 0.6</td>
<td>−0.5 ± 0.6</td>
<td>−0.9 ± 0.6</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

LGI-ER = low glycemic index energy reduced, HGI-ER = high glycemic index energy reduced, CD = control diet, NS = not significant, OGTT = oral glucose tolerance test, AUC = incremental area under the curve, HOMA-IR = homeostasis model assessment of insulin resistance.

Values are expressed as mean ± SE unless otherwise indicated.

Within treatment refers to the differences in variable from baseline (week 0) to end of treatment (week 12) for each respective treatment.

Between treatment refers to differences in the change of variable from baseline (week 0) to end of treatment (week 12) among treatments.
DISCUSSION

In the current study, macronutrient characteristics (e.g., GI) were tested in an energy-restricted free-living setting along with consumption of a particular food of current interest (i.e., potatoes) and compared to a control/reference group who were provided limited dietary advice and no advice on body weight management. The results indicated that (1) a modest energy restriction is associated with a modest amount of body weight loss; (2) potatoes do not interfere with weight loss or cause weight gain; and (3) the study of dietary prescriptions in free-living people provide practical insight to the challenges for implementation and expectations for performance in the real world.

Energy intake was reduced in all dietary groups and accordingly weight loss was observed. However, the dietary prescription for the 2 energy-reduced groups should have imposed a theoretical weight loss of ~5.5 kg over 12 weeks, based on a 500 kcal/d energy reduction from maintenance requirements. Instead, these groups lost ~2 kg and mean changes in energy intake were on the order of ~140 to 300 kcal/d for HGI-ER and LGI-ER groups with mean energy intake of ~1600 kcal/d while on study. Such a failure to achieve calorie restriction targets is not uncommon when subjects are in a free-living or moderate control setting [13, 23–25]. Indeed, unless subjects are housed within a metabolic ward or provided all food to meet the specifications of the dietary prescription, adherence varies [13, 26] and weight loss results are impacted [15, 24]. Likewise, subjects in this study had difficulty following a diet that was composed mostly of high- or low-GI foods to achieve extremes in GI (high vs low). Because potatoes were provided to subjects randomized to the LGI-ER group, one argument for subjects not achieving a low-GI diet may be due to their potato intake. Adding potatoes would increase their daily scores (we calculated a GI increase of ~5%); however, they would also increase the scores of the high-GI group. Regardless, subjects' dietary GI tended to hover between 50 and 60; this is typical when GI prescriptions are studied in the free-living setting [27–29]; hence, our results are in agreement with previous reports. We did observe significant, albeit modest, dietary reductions in GI for subjects randomized to the LGI-ER group (~15 ± 8), whereas subjects randomized to the HGI-ER group had no change in mean dietary GI (~2 ± 8). These data suggest relative compliance with dietary prescriptions, yet tendency to resist wide deviations from usual GI and GL intake, even when potatoes are included regularly in the diet. From a practical standpoint, the performance of dietary prescriptions should always be tested in the free-living setting, thus providing insight to the nuances of the prescription and expectations for adoption, long-term adherence, and weight loss/management in the real world. The results of our study reiterate what is already known about human behavior, in general and with regards to food intake specifically, in that change is difficult and the best strategy for weight loss/management is to counsel individuals to reduce energy intake within the context of their usual intake and lifestyle patterns.

It is noteworthy that the control group also significantly decreased energy intake, despite receiving no instructions to do so and being given ~1100 extra kcal/week to consume (~15% kcal/d) in the form of potatoes. This reduction in energy intake was ~300 kcal/d and induced a weight change over the course of the 12-week study that was not different from the groups counseled to restrict energy intake. One interpretation of these results is that the potatoes induced a relative satiety effect resulting in an overall reduction in ad libitum energy intake [30] and induced weight loss.

Potatoes have recently been the subject of negative publicity due to their designation as a high-GI food and the implication that they cause weight gain both in the scientific literature [10] and in the lay press [31–33]. Accordingly, they are often restricted or eliminated from the diet plans/programs of a number of popular weight loss diets, particularly those that focus on GI [20, 34–36]. The question is whether this is warranted. A recent study examining the relationship between the intake of certain foods and weight change at 4-year intervals in 3 separate cohorts totaling 120,877 men and women reported that weight change was most strongly associated with consumption of potatoes (0.76 kg) and potatoes (2.82 kg). These values, however, are misleading with respect to the potato in its nonfried form. The potato eaten as baked, boiled, roasted, or microwaved accounted for a tenth of the weight gain (0.3 kg) reported and would likely not be significant. The results of other studies have indirectly examined the role of potatoes on body weight and have not found any association between potato consumption and weight gain or interference with weight loss [37, 38]. The results of the present study are consistent with these studies in that potatoes do not appear to cause weight gain and may even aid in modest weight loss.

CONCLUSION

The results of this study reiterated findings of others indicating that a reduction in energy intake, rather than a particular food or characteristic of food, is associated with weight loss. The study design included potato consumption in all treatment arms, which did not allow for potato-specific comparisons; however, the negative press about potatoes implies weight gain and we wanted to include this possibility for purposes of making comparison with the GI-focused dietary groups. The reference/control group receiving minimal dietary advice and potatoes to consume regularly did not result in weight gain; rather, this resulted in weight loss that was not different from the energy restricted groups. Future work should explore these findings related to weight loss and regular potato inclusion in the diet in more depth. Further, we found no evidence indicating that low- or high-GI diets are superior in inducing weight loss; however, the ability of participants to adhere to extremes in LGI or HGI
was difficult in the free-living self-selecting setting. Both energy-restricted diets produced weight loss; modest weight loss or no weight loss for most but clinically important weight loss (>5% of their starting body weight) for other participants (~25% of study population) in a usual life, free-living setting.

ACKNOWLEDGMENTS

The authors thank Kelcie Vilain and Kelly Fuhr for their dedication to analyzing food records for this study and Eunyoung Park for statistical consultation.

FUNDING

Funding for this project was provided by the United States Potato Board.

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Received December 21, 2012; revision accepted November 26, 2013.