The effects of low and high glycemic index foods on high-intensity intermittent exercise

Original Investigation

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ABSTRACT
The glycemic index (GI) of a pre-exercise meal may affect substrate utilization and performance during continuous exercise. PURPOSE: To examine the effects of low and high GI foods on metabolism and performance during high-intensity, intermittent exercise. METHODS: Seven male athletes participated in 3 experimental trials (low GI, high GI, and fasted control) separated by ~7 days. Foods were consumed 3 hours before (~1.3 g·kg\(^{-1}\) carbohydrate) and halfway through (~0.2 g·kg\(^{-1}\) carbohydrate) 90 minutes of intermittent treadmill running designed to simulate the activity pattern of soccer. Expired gas was collected during exercise to estimate substrate oxidation. Performance was assessed by the distance covered on five 1-minute sprints during the last 15 minutes of exercise. RESULTS: Respiratory exchange ratio was higher and fat oxidation lower during exercise in the high GI condition compared to fasting (p<0.05). The mean difference in total distance covered on the repeated sprint test between low GI and fasting (247 m; 90% confidence limits ±352 m) represented an 81% (likely, probable) chance that the low GI condition improved performance over fasting. The mean difference between high GI and fasted control (223 m; ±385 m) represented a 76% (likely, probable) chance of improved performance. There were no differences between low and high GI. CONCLUSIONS: When compared to fasting, both low and high GI foods consumed 3 hours before and halfway through prolonged, high-intensity intermittent exercise improved repeated sprint performance. High GI foods impaired fat oxidation during exercise but the GI did not appear to influence high-intensity, intermittent exercise performance.

KEY WORDS: carbohydrates, pre-exercise meals, repeated sprint performance, sport nutrition
INTRODUCTION

Athletes are advised that consuming carbohydrate meals prior to exercise improves endurance; however, the characteristics of the ideal pre-exercise meal remain largely unknown. The glycemic index (GI) of carbohydrates ingested before exercise influences substrate utilization during exercise and may affect performance. High GI foods are digested quickly, resulting in large increases in blood glucose and insulin. In contrast, low GI foods are digested slowly, resulting in a slight rise in blood glucose and insulin. The exaggerated insulin response after consumption of high GI food may lead to accelerated muscle glucose uptake as well as decreased mobilization and oxidation of free fatty acids during subsequent exercise. As a result, carbohydrate oxidation is higher and fat oxidation lower during exercise following a high GI compared to low GI meal. Increased rate of carbohydrate oxidation after a high GI meal may be detrimental to performance because depletion of endogenous carbohydrate stores contributes to fatigue during endurance exercise. Low GI pre-exercise meals may be beneficial because the ongoing absorption of glucose could provide fuel for exercising skeletal muscle. This has led to the suggestion that athletes consume a pre-exercise meal with a low GI.

Despite the theoretical benefits of low GI pre-exercise meals, research in this area is mixed. Thomas et al. showed that cycling time to exhaustion at ~70% maximal oxygen uptake (VO2max) was improved over 20% when low GI lentils were consumed before exercise compared to high GI carbohydrates. Subsequent research has produced mixed results with some reporting improved performance following low GI meals but most reporting no effect of the GI on performance. The applicability of previous research is limited to endurance cycling and running as the vast majority of studies examined the influence of the GI on continuous exercise of this nature. Many team sports (e.g., soccer, rugby, and hockey) involve prolonged, high-intensity intermittent exercise. The effect of low and high GI pre-exercise meals on this type of exercise has not been studied. The influence of pre-exercise meals on substrate utilization has important implications for team sports because depletion of endogenous carbohydrate stores (i.e. muscle glycogen) contributes to fatigue in the late stages of a game. Lipids are also an important fuel source during intermittent sprinting as fat oxidation predominates during the low intensity rest and recovery periods. A greater relative utilization of fats during low intensity or rest periods would spare carbohydrates for the high-intensity periods. Therefore, the impact of the GI on substrate utilization could influence fuel availability and affect performance. The purpose of this study was to examine the effects of low and high GI foods on metabolism and performance during high-intensity intermittent exercise designed to mimic the activity pattern of a soccer match. We hypothesized that consuming a low GI food 3 hours before and halfway through 90 minutes of high-intensity intermittent exercise would result in improved maintenance of blood glucose and promote higher fat oxidation during exercise compared to a high GI food. As a result, performance at the end of exercise would be improved in the low GI condition because of increased endogenous carbohydrate availability.

METHODS

Seven male athletes (age 23.3±3.8 y, body mass 76.1±7.9 kg, VO2max 56.7±5.0 mL·kg⁻¹·min⁻¹) volunteered to participate. All had experience in sports involving intermittent or interval-type exercise (e.g., soccer, hockey, and distance running) and were familiar with treadmill running. Subjects provided written informed consent. The study was approved by the University of Saskatchewan Research Ethics Board.
Each subject made five weekly visits to the laboratory. Visits one and two consisted of a VO\textsubscript{2}max test and a familiarization trial with the high-intensity intermittent exercise protocol (details described below). Subjects then participated in three experimental trials (low GI, high GI, and control) in a counter-balanced, randomized fashion separated by approximately seven days. The study was single-blind. All personnel conducting the exercise tests and evaluating results were blinded to experimental conditions but the subjects knew which food they consumed.

The low GI food was boiled decorticated unsplit ‘CDC Robin’ red lentils (SaskCan Pulse Trading, Regina, SK) and had a GI of ~29. The high GI foods were matched for macronutrient profile and consisted of instant mashed potatoes, egg whites and ketchup with a GI of ~81 (GI values from Foster-Powell et al. \textsuperscript{22} using the mixed-meal method of Wolever and Jenkins \textsuperscript{23}). Food was consumed three hours before exercise and a smaller amount was consumed during a 15-minute break after 45 minutes of exercise (designed to mimic halftime of a soccer match). The pre-exercise feeding was designed to provide 2.0 g total carbohydrate·kg\textsuperscript{-1} in order to meet current sport nutrition guidelines for pre-exercise carbohydrate consumption. \textsuperscript{1, 2} The “halftime” feeding was designed to provide 0.25 g total carbohydrate·kg\textsuperscript{-1} (i.e., ~20 grams carbohydrate) which is slightly below current guidelines for carbohydrate consumption during exercise (30-60 g/hr) but was chosen to decrease the chances for gastrointestinal distress. In spite of this, most subjects were unable to consume their allotted food. In order to match total energy and carbohydrate content the portion of food consumed on each subject’s first feeding trial was recorded and the subsequent food adjusted accordingly. On average, subjects consumed 64±22% of the pre-game food and 79±31% of the “halftime” food. Therefore, the average total carbohydrate consumption was 1.3 ± 0.43 g·kg\textsuperscript{-1} (range 0.65-1.59 g·kg\textsuperscript{-1}) or 78 ± 26 g (range 51-118 g) before exercise, and 0.19 ± 0.08 g·kg\textsuperscript{-1} (range 0.06-0.25 g·kg\textsuperscript{-1}) or 14 ± 7 g (range 4-22 g) at “halftime” (full macronutrient profile is listed in Table 1).

Two weeks before the experimental trials began each subject performed an incremental running test to exhaustion on a treadmill (Vacu Med, Model 13622, Ventura, CA) to determine VO\textsubscript{2}max, velocity at VO\textsubscript{2}max (Vmax), and maximal heart rate. \textsuperscript{24} The test began at a speed of 10 km·hr\textsuperscript{-1} and was increased by 1 km·hr\textsuperscript{-1} every minute until exhaustion. Oxygen uptake (VO\textsubscript{2}) was measured breath-by-breath using open circuit indirect calorimetry (Sensor Medics, Vmax Series 29, Anaheim, CA). Heart rate was measured continuously using a Polar 610i heart rate monitor (Polar Elecrto Oy, Kemepele, Finland). VO\textsubscript{2}max was calculated as the highest 20-second average for VO\textsubscript{2} and maximal heart rate was determined using the highest 5-second average. Vmax was defined as the highest treadmill speed that was maintained for one complete minute. \textsuperscript{24}

Seven days later, subjects completed a familiarization trial for the high-intensity intermittent exercise protocol. This protocol was designed to mimic the activity pattern of a soccer match and consisted of two 45-minute exercise periods separated by a 15-minute break (i.e., halftime). Software (Vacu Med, TurboFit 5.05, Ventura, CA) controlled the speed of the treadmill to alternate between periods of rest, walking, jogging, running, and sprinting. The proportion of time spent at each speed was based on time-motion analysis of professional soccer players which found that players spend ~7% of the game standing still, ~56% of the game walking (~5-6 km·hr\textsuperscript{-1}), ~30% of the game jogging (~10-11 km·hr\textsuperscript{-1}), ~4% of the game running (~15-17 km·hr\textsuperscript{-1}), and ~3% of the game sprinting (~21-23 km·hr\textsuperscript{-1}) \textsuperscript{25}. The speed of the treadmill was adjusted if these speeds were too fast or slow and the speeds chosen were kept constant for each experimental trial. The treadmill simulation was based on the protocol of Drust et al. \textsuperscript{26} with
slight modifications to account for the treadmill and software package used in our laboratory. The protocol was administered in standardized 15-minute blocks consisting of 6 walking intervals, 6 jogging intervals, 3 running intervals, and 8 sprints. The average time spent during each interval, including speed transitions, was 75 s (walking), 40 s (jogging), 20 s (running), and 12 s (sprinting). A 90 s standing period was incorporated into the protocol at the end of each 15-minute block for blood sampling. The first 45 minutes of the protocol included three identical 15-minute blocks and the second 45 minutes included two identical 15-minute blocks and a repeated sprint test during the last 15 minutes. The repeated sprint test consisted of five 1-minute sprints with two minutes and thirty seconds of walking recovery between each sprint. At the start of each sprint the speed of the treadmill was immediately increased to individual Vmax and the subject was allowed to select the speed for the remainder of the sprint by instructing a researcher to increase or decrease the speed. Subjects were kept blind to the treadmill speed and distance covered but allowed to see the time display. The distance displayed on the treadmill console was recorded by a researcher who was blinded to the experimental condition. The coefficient of variation for the repeated sprint test was 3.3% when a sample of 6 subjects completed two repeated sprint tests separated by seven days.

Subjects reported to the laboratory at 0700 in the morning after an overnight (≥10 hr) fast. A baseline finger prick blood glucose sample was obtained using a commercial monitor (Precision Q.I.D.Blood Glucose Monitoring System, MediSense, Bedford, MA). After the baseline blood sample, subjects had 20 minutes to consume one of the pre-game foods. Blood glucose was measured at 15, 30, 45, 60, 120, and 180 minutes after completion of the feeding. In the first trial, subjects were allowed to drink water *ad libitum* during this period and the volume of water consumed was matched in subsequent trials. In the event that a subject could not consume the entire pre-game food in their first trial, the portion consumed was recorded and the subsequent feeding was adjusted in order to keep the macronutrient and total energy content the same. Three hours after completion of the feeding subjects were fitted with a heart rate monitor and completed a 5-minute warm-up on the treadmill at 8-10 km·hr⁻¹. A blood sample was collected after each 15-minute block and expired gas samples were collected during the last three minutes of each standardized 15-minute block. Carbohydrate and fat oxidation rates were estimated according to the equations of Jeukendrup and Wallis which are adapted for higher intensity exercise. Ratings of perceived exertion (RPE; 6-20 scale) were obtained at the end of each 15-minute block. A small amount of food from the same source as the pre-game feeding was consumed during the 15-minute break after 45 minutes of exercise. Water was provided *ad libitum* during the break in the first trial and was matched in subsequent trials. The same procedures were followed for the first and second 45 minute sections of high-intensity intermittent exercise except that expired gas was not collected during the repeated sprint test.

To limit any influence of nutrition and physical activity habits on exercise performance, subjects kept a 24-hour diet and physical activity record on the day before the first testing day. These records were photocopied and given back to the participants with instructions to follow the same dietary and physical activity patterns for the 24-hour period before each testing day. Subjects were instructed to maintain their typical training schedules throughout the study.

Performance data were analyzed using magnitude-based inferences. 90% confidence limits were calculated for the difference between low GI and control, high GI and control, and low and high GI using a spreadsheet available online (www.newstats.org/xcrossover.xls). An improvement in sprinting performance that could influence the outcome of a soccer match is likely quite small, however determining a value for this improvement is inherently difficult and
we are unaware of any data in this regard. A significant 5.5% increase in the distance covered during a high-intensity intermittent running test is observed when soccer players consumed a high versus low carbohydrate diet.\(^{30}\) We therefore used a 5.5% increase in the distance covered as a conservative estimate for calculating the practical significance of an improvement in performance. Blood glucose, RPE, respiratory exchange ratio (RER), and carbohydrate and fat oxidation were analyzed with a two-factor (food condition × time) repeated measures ANOVA with Tukey’s post hoc tests. Significance was set at \(p \leq 0.05\). All results are presented as means ± S.D. Statistical analyses were carried out using Statistica, version 5.0 (StatsSoft Inc., Chicago, IL).

RESULTS

Total distance covered on the repeated sprint test is presented in Figure 1. The mean difference between low GI and fasted control was 247 m; 90% confidence limits ±352 m. Compared to fasted control, there is an 81% (likely, probable) chance that the low GI condition improved performance, a 12% chance (unlikely, probably not) chance that there is a trivial effect of the low GI condition, and a 6% (unlikely, probably not) chance that the low GI condition has a negative effect. The mean difference between high GI and control was 223 m; 90% confidence limits ±385 m. Compared to fasted control, there is a 76% (likely, probable) chance that the high GI condition improved performance, a 15% (unlikely, probably not) chance that there is a trivial effect of the high GI condition, and a 9% (unlikely, probably not) chance that the low GI condition has a negative effect. There were no differences between low and high GI (mean difference = 24 m; 90% confidence limits ±62 m; 91% [likely, probably] chance of a trivial effect).

\(\text{VO}_2\) averaged ~58% of \(\text{VO}_2\)max during the soccer match simulation with no differences between conditions (\(p>0.05\)). There was a main effect of food condition for RER (\(p=0.039\), with the high GI condition (0.98 ± 0.03) resulting in a higher RER compared to control (0.94 ± 0.05). There were no differences between low GI (0.97 ± 0.02) and high GI or low GI and control. Estimated rate of fat oxidation was lower in the high GI condition compared to control (\(p=0.042\); Figure 2a). A food condition × time interaction was seen for rate of carbohydrate oxidation (\(p=0.043\), with a greater rate in the high GI condition compared to control at all time points and a greater rate in the low GI condition compared to control at 15, 75, and 90 minutes (Figure 2b). A time main effect (\(p=0.032\)) was evident with RPE higher at 90 compared to 15 minutes and higher at 105 minutes (i.e., after the repeated sprint test) compared to all other time points. There were no differences between food conditions for RPE. Heart rate averaged ~70% of maximum during the soccer match simulation with no differences between food conditions.

Blood glucose rose after the high GI feeding such that it was greater than low GI and control from 165 to 135 minutes before exercise (\(p<0.001\), Figure 3) and also greater compared to control at 120 minutes before exercise. Blood glucose was not different between high GI, low GI, or control at any other time point.

Most subjects were unable to consume their allotted food. On average, subjects consumed 64% of their pre-game food and 79% of their halftime food. Therefore, the average amounts of carbohydrate, protein, and fat consumed were 1.3 ± 0.43, 0.5 ± 0.17, and 0.03 ± 0.01 g·kg\(^{-1}\), respectively for the pre-game food. The halftime food provided, on average, 0.19 ± 0.08, 0.08 ± 0.03, and 0.005 ± 0.002 g·kg\(^{-1}\) of carbohydrate, protein and fat. The amounts of low GI and high GI foods consumed (Table 1) were not different within subjects (\(p=0.29\) and \(p=0.45\) for pre-game and halftime foods, respectively).
There were no differences in the amounts of carbohydrate (4.8 ± 1.2 g·kg⁻¹), protein (1.5 ± 0.9 g·kg⁻¹), fat (1.4 ± 0.3 g·kg⁻¹), and total energy (37 ± 8 kcal·kg⁻¹) consumed in the 24 hours before each trial.

**DISCUSSION**

Consuming low and high GI carbohydrates before and during prolonged high-intensity intermittent exercise improved repeated sprint performance compared to a fasted control condition. Although it is widely accepted that endurance capacity improves following high carbohydrate pre-exercise meals,

3-5, this study is the first to examine the effects of pre-exercise carbohydrate foods of different GIs on prolonged high-intensity intermittent exercise performance. Similar to moderate-intensity, continuous exercise,

6-11, high GI carbohydrates impaired fat oxidation during intermittent exercise. Despite these effects on metabolism, the GI did not affect repeated sprint performance at the end of prolonged, intermittent exercise characteristic of a soccer match.

High GI foods impair fat oxidation during continuous, moderate-intensity endurance exercise

6-11 and, our results show that this is also the case during high-intensity intermittent exercise (Figure 2a). High GI foods result in a greater increase in postprandial blood glucose concentration (Figure 3) and presumably a larger insulin response. A large increase in insulin inhibits adipose tissue lipolysis, limiting the availability and oxidation of free fatty acids.

13 Impairing fat oxidation following high GI carbohydrate ingestion may increase reliance on muscle glycogen.

10 This may have been the case in our study because there was an increased carbohydrate oxidation at all time points in the high GI compared to control (Figure 2b) with no difference in blood glucose levels during exercise between conditions. Minor alterations in carbohydrate oxidation during exercise were apparent in low GI compared to control but there were no effects of the low GI food on fat oxidation, indicating that there was a greater metabolic perturbation in the high GI condition.

Muscle glycogen availability is important for high intensity exercise.

14 Compared to players with low glycogen, players with high glycogen before and at halftime of a soccer match covered more distance and performed more high speed running and sprinting, especially during the last 15 minutes of the match.

14 Therefore, strategies that delay muscle glycogen degradation may enhance soccer-related performance. Carbohydrate consumption during high-intensity, intermittent exercise decreased net muscle glycogen utilization and improved sprinting performance.

31 We hypothesized that the slow release of glucose following ingestion of low GI food may act in a similar manner to improve repeated sprint performance during the late stages of exercise. The mechanism by which low GI foods improved performance over fasting control cannot be ascertained in the present study but it is possible that sustained release of glucose may have increased carbohydrate availability, reduced reliance on muscle glycogen, and delayed the development of fatigue.

When compared to low GI pre-exercise meals, high GI meals increase muscle glycogen utilization during exercise,

10 likely because of insulin-mediated impairment in fat oxidation and increased reliance on carbohydrate. We hypothesized that sustained release of glucose and lower insulin following low GI feeding would improve performance compared to high GI foods. This was not the case as there were no differences in repeated sprint performance between the low and high GI conditions. A previous study examined the effects of low and high GI recovery diets consumed over 22 hours following a bout of exercise on subsequent performance during intermittent shuttle running and found no effect of the GI.

32 However, this study did not examine
the effect of the GI of foods consumed immediately prior to, or during, intermittent exercise as subjects exercised in the morning following an overnight fast.22

In contrast to studies examining low and high GI meals before continuous, moderate-intensity exercise, there were no differences in substrate oxidation 6-11 or blood glucose concentration 6,8 during exercise between low and high GI conditions in our study. The high-intensity exercise may have overridden small differences in the metabolic environment experienced after low and high GI meals. The slight impairment in fat oxidation during exercise in the high GI condition versus fasting was likely compensated for by greater carbohydrate availability, increasing performance in high GI compared to fasted control. Our experimental design, which included a small amount of food midway through exercise, may have masked any benefit that the low GI pre-exercise food might have conferred during prolonged exercise. Consuming a high GI carbohydrate source during exercise would have provided a more rapidly accessible energy source for exercising skeletal muscle and might have offset any increase in muscle glycogen utilization during the initial stages of exercise. However, the small amount of carbohydrate consumed during exercise (~14 grams) was likely not enough to have a significant effect on metabolism or performance.

Limitations

Despite following sport nutrition guidelines, most subjects were unable to consume their allotted food portions. To match energy and carbohydrate intake, the proportion of food consumed on a subject’s first trial was recorded and matched on the subsequent trial. A few subjects did not match their consumption exactly between conditions but there were no significant differences between high and low GI for energy or carbohydrate consumed (see Table 1). Despite this limitation, our findings highlight the benefit of carbohydrate consumption on intermittent exercise as performance improvements were seen in both GI conditions even when the amount of carbohydrate failed to meet guidelines.

Since we provided food before exercise and at halftime, it cannot be determined if one or both led to the performance improvements. We chose this design because the effects of pre-game foods on soccer performance have not been addressed, and soccer players are able to consume carbohydrates during halftime. We felt the practicality of our results would be improved if a halftime meal were included. The halftime feedings were small in an attempt to prevent gastrointestinal distress associated with running after eating but it would be more practical for athletes to consume sports drinks or gels at halftime to enable ingestion of more carbohydrate. Since subjects consumed such a small amount of carbohydrate at halftime (~14 grams) it is likely that the foods consumed before exercise had a more substantial effect on performance and metabolism.

Sports that involve halftime or intermissions present a unique situation for carbohydrate ingestion. It is thought that carbohydrates ingested during exercise should be high GI to provide an immediate source of energy.15,16,33 There are no differences between low and high GI pre-exercise meals when high GI carbohydrate drinks are consumed during exercise.17 However, subjects in this study also ingested a high GI beverage 15 minutes prior to exercise, raising the possibility that the “pre-exercise” high GI drink masked any affect of the pre-exercise meals.17 Since athletes rest during halftime or intermissions, ingestion of high GI carbohydrate sources could act similar to a pre-exercise meal, resulting in increased insulin, decreased free fatty acid availability and oxidation, and increased reliance on muscle glycogen.10 We chose to match the GI of the “halftime” food with the pre-game food to eliminate the possibility of the carbohydrates ingested during exercise masking the effects of the pre-exercise foods. Since
subjects were unable to consume a substantial amount of carbohydrate in this form, it is difficult to draw conclusions about the affect of the “halftime” foods. Future research should investigate combinations of low and high GI carbohydrate foods or gels consumed before and during high-intensity, intermittent exercise, especially in sports involving rest periods.

A final limitation is our use of one-minute sprint intervals as a performance measure. Although this test was reproducible, it most likely does not simulate the shorter sprint lengths of actual soccer matches.  

Conclusions

This is the first study to examine the performance and metabolic effects of low and high GI foods on long duration, high-intensity intermittent exercise. Consuming low and high GI carbohydrate foods three hours before and halfway through exercise designed to simulate the activity pattern of soccer matches improves repeated sprinting performance compared to fasted control. High GI foods impaired fat oxidation compared to fasting but there were no differences in performance between low and high GI.

Practical Applications

The ability to cover more distance during the latter stages of a soccer game is important and can be limited by carbohydrate availability. Carbohydrate consumption should be considered a crucial element of a soccer player’s match preparation. Soccer players and other team sport athletes primarily rely on nutrition information from studies involving continuous endurance exercise. This study shows that consuming low and high GI carbohydrates before and during high-intensity-intermittent exercise improves repeated sprint ability during the late stages of exercise. Soccer players and team sport athletes should consume a carbohydrate-rich meal approximately three hours before competition and during breaks or intermissions. The GI of the carbohydrates does not influence performance; therefore both low and high GI carbohydrates can be consumed.
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Figure captions

Figure 1. Distance covered (m) on the repeated sprint test in the control, low GI, and high GI conditions. *90% confidence limits for the mean difference between low GI and control and high GI and control indicate a “likely, probable” improvement in performance. Data are means ± SEM.

Figure 2. Rate of fat oxidation (A) and rate of carbohydrate oxidation (B) throughout high-intensity, intermittent exercise. Expired gas was collected for the last 3 minutes of each standardized 15-minute block. *High GI significantly different from control (p<0.05). †Low GI significantly different from control (p<0.05). Data are means ± SEM. Data points are offset slightly for clarity.

Figure 3. Blood glucose concentration (mmol.l⁻¹) at baseline (-180 minutes), during the postprandial period (-180 to 0 minutes), and throughout exercise (0 to 105 minutes). *High GI significantly different from control (p<0.05). †High GI significantly different from low GI (p<0.05). Data are means ± SEM. Data points are offset slightly for clarity.
Figure 1

![Graph showing distance covered (m) for Control, Low GI, and High GI conditions. The graph indicates that High GI led to a statistically significant increase in distance covered compared to Control and Low GI.](image-url)
Figure 2

A)  
Fat oxidation (g.min⁻¹)

B)  
Carbohydrate oxidation (g.min⁻¹)
Figure 3

![Graph showing blood glucose levels over time for Control, Low GI, and High GI groups during exercise.](image-url)
Table 1. Average energy content and macronutrient profile of the low and high GI foods that were consumed before and during exercise. A control condition (no food) was also employed. GI values for individual foods are from Foster-Powell et al. GI values for the high GI feedings were calculated using the mixed meal method of Wolever and Jenkins.

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<td>Low GI</td>
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Values are mean ± SD. There were no differences between low and high GI on any variable.