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The Effects of Pre-Exercise Energy Bar with Varying Glycemic Loads on Glycemic Response and 10 km Running Performance

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ABSTRACT

The purpose of the present study was to analyze the effects of two pre-exercise energy bars on glycemic response and 10 km running performance in recreationally active college-aged females. Fifteen females (age: 20 ± 1 years; BMI: 21 ± 1.9 kg/m²; body fat: 20 ± 3.5%) were assigned to consume one of the energy bars on two separate occasions. Each testing session included an 8 h overnight fast, 24 h dietary recall, consumption of an energy bar (Power Bar: low glycemic index (GI); high glycemic load (GL); Snickers Bar: low GI; low GL) within 30 min of the time trial, 10 km run, fasting, pre 10 km and post 10 km blood glucose measurements. Heart rate (HR), RPE, time, perceived recovery (PR), gut fullness and bar preference was recorded for each trial. Repeated measures ANOVA indicated a significant difference (p=0.007) in blood glucose levels between the two energy bars (Power Bar: 3.7 ± 0.6, 5.5 ± 1.1, 5.6 ± 1.2 mmol/L; Snickers Bar: 3.8 ± 0.4, 4.5 ± 0.4, 5.3 ± 0.9 mmol/L, for fasting, pre 10 km and post 10 km, respectively). There was no significant difference (p=0.65) in average 10 km time (52.25 ± 6.4 and 52.00 ± 6.7 min between Power Bar and Snickers Bar, respectively), first and second 5 km time (p=0.85), post 10 km HR (p=0.99) and RPE (p=0.80). Although, there was a significant difference in metabolic response between the two pre-exercise energy bars lower GL bar did not provide an ergogenic effect over high GL energy bar under the conditions of the present study.

Keywords: Glycemic index, Endurance, Carbohydrate type, Pre-exercise meal

INTRODUCTION

The need for carbohydrates (CHO) as a substrate for endurance performance has long been recognized [1]. However, the type, amount and timing of CHO intake for optimal performance are still unclear. The timing of CHO intake influences its metabolic effects. Blood glucose elevations are positively correlated with CHO intake and proximity to exercise [2]. Several studies have investigated the effects of pre-exercise meal consumed immediately prior or up to 6 h before a time trial, however, no clear conclusion has been identified [3-9].

The GI represents the increase in blood glucose after consumption of CHO and is an indication of CHO digestion rate. GI of the food can be influenced by factors such as the macronutrient content, amount, processing, type of CHO, presence of anti-nutrients and the training status of the individual [10-13]. The glycemic load (GL) on the other hand, represents the glycemic response to the amount of CHO consumed and its glycemic index [14]. Previous research regarding GI has been focused on identifying pre-exercise nutritional strategies to improve athletic performance and enhance recovery post exhaustive exercise [15,16]. Mixed results have been reported in the literature, with some studies reporting no significant difference between low and high GI pre-exercise meals [17] and other studies favoring low GI pre-exercise meals for improved performance, glucose control and increased fat oxidation [18-20]. Whereas, glycemic load is a relatively new concept in sports nutrition, therefore limited research is available compared to investigations on the effects of glycemic index [21].

Energy bars and other CHO supplements are marketed as an optimum nutrition supplementation for competitive athletes and recreationally active individuals. Therefore, the purpose of this study was to evaluate the effects of two pre-exercise energy bars with a low GI and varying GL on glycemic response, performance during a 10 km time trial and perceptual responses among recreationally active college-aged females.

MATERIALS AND METHODS

Participants

Fifteen college aged females (age: 20 ± 1 years; weight 59 ± 8 kg, height 165 ± 6 cm, body mass index (BMI): 21 ± 2 kg/m²; body fat: 21 ± 4%) participated in this study. Prior to participation, participants were asked to complete the informed consent form and pre-screening questionnaires and a 24 h dietary recall. The informed consent form was prepared according to the guidelines and approved by the local Institutional Review Board for the protection of human participants prior to the study. Weight and height were measured using a standard scale. Bioelectrical impedance analysis (BIA) was used to determine relative body fat percentage and BMI. Each participant reported to the laboratory between 06:00-09:30 AM. Participants were asked to fast for at least 8 h prior to the start of each trial. In addition, participants were asked to stay hydrated and to consume at least 2 cups of water (400-500 ml) before each trial. Participants were asked to maintain a similar diet 24 h before each trial. The dietary recall was analyzed using Nutritionist PROTM (Axxya Systems, Woodinville, WA).

Experimental design

Participants were randomly assigned to one of the two energy bars with the two testing sessions separated by 7-14 days. After arriving to the laboratory, participant fasting blood glucose was measured, and thirst and gut fullness were recorded. Participants then consumed one of the assigned energy bars and were provided with 500 ml of water to consume *ad libitum*. A time trial was performed on an outdoor 5 km course, heart rate and RPE were measured before and after the time trial. Following the 10 km time trial, perceived recovery, blood glucose, thirst, gut fullness and subjective preference responses were recorded.

Energy bars

Energy bar macronutrient composition and energy per serving is presented in Table 1. The glycemic responses of the two different bars were examined: Snickers Marathon Bar (Snickers Bar) (Mars Inc., Hackettstown, NJ) with estimated GI~34 and GL~9 (Low GI; Low GL) and Power Bar (Power Bar Inc., Boise, ID) with estimated GI~53 and GL~23 (Low GI; High GL) [14]. Both bars were the same consistency and flavor (peanut butter). Any identifying information was removed and both energy bars were placed into the clear plastic bag.

Table 1: Energy bar characteristics

Energy Bar	Serving Size	Calories	Total CHO	Sugar	Fiber	Protein	Total Fat
	(g)	(Kcal)	(g)	(g)	(g)	(g)	(g)
Power Bar	65	240	44	26	1	9	4
Snickers Bar	55	210	26	15	5	14	7

CHO: Carbohydrates; g: grams; Kcal: Kilocalories

Physiological measurements

Participants completed each 10 km time trial on an outdoor 5 km paved and well-marked course. Each participant was familiarized with the course before the first time trial. Each 5 km lap and total 10 km time was recorded. Participants were asked to wear a heart rate monitor chest strap and a wrist watch (Polar® Team2, Finland). Heart Rate (HR) was measured at rest and throughout the time trial using the Polar Team2 system. Blood glucose was measured before each time trial (fasting), 20 min post energy bar consumption (pre 10 km) and immediately after each 10 km time trial (post 10 km). A sample of blood was obtained via a fingerpick, and 15 µl of blood was collected and analyzed using the Cardiocheck™ PA blood chemistry analyzer (Cardiocheck™ PA, San Diego, CA).

Perceptual measurements

Participants perceived recovery (PR) and ratings of perceived exertion (RPE) were measured pre and post 10 km time trial on a scale 0-10 (0- "very poorly recovered/extremely tired", 10- "very well recovered, highly energetic") [22] and on a scale 6-20 (6 "no exertion", 20 "maximal exertion") [23]. Thirst and gut fullness levels were measured at fasting, pre and post 10 km time trial on a scale 1-7 (1- "not thirsty at all, 7- "very, very thirsty") [24] and on a scale 0-10 (0-"empty", 10- "extremely full"). A subjective energy bar preference survey was assessed 10 min after each time trial. Preferences were measured on a 10 point scale (0- "definitely not", 9- "absolutely") and reviewed participant's likability of each energy bar, preference for training and competition and perception of improved performance.

Statistical analysis

A 2 × 3 (condition by time) repeated measures analysis of variance (ANOVA) was to analyze blood glucose, thirst and gut fullness. A 2 × 2 (condition by time) repeated measures ANOVA was used to analyze HR, RPE and PR. A repeated measures one-way ANOVA was used to compare 5 km, 10 km time and energy bar subjective preferences between experimental trials. All statistical analyses were conducted using SPSS statistical package (v. 24) (IBM®, Armonk, New York). Participant data is expressed as means ± SD. Significance was determined at $p<0.05$. Polar software (Polar® Team2, Finland) was used to extract performance data for 1st 5 km and 2nd of 5 km HR.

RESULTS

There were no differences in total energy, carbohydrate, protein, or fat consumed before both experimental trials. The analysis of the 24 h dietary recall indicated that an average of 1582 ± 504 kcal/d was consumed (208.4 ± 78.2 g/d carbohydrate, 71.2 ± 36.4 g/d protein and 54.3 ± 17.4 g/d fat). CHO content for Snickers Bar and Power Bar were 0.45 ± 0.07 g/kg and 0.76 ± 0.11 g/kg of body mass, respectively.

Performance measurements

There was no significant difference ($p=0.65$) in average 10 km time, first and second 5 km time ($p=0.85$), post-10 km HR ($p=0.99$) and RPE ($p=0.80$) between pre-exercise energy bars (Table 2). At the end of the time trial, participants RPE response indicated that they were working "hard" and HR response indicated that they were working near maximal effort at 92.5% and 94% of their HRmax following Power Bar and Snickers Bar, respectively. There was no significant differences in PR between the pre-exercise energy bars ($p=0.37$). However there was a significant time effect ($p=0.008$) as PR decreased from the beginning to post-10 km time trial.

Table 2: Perceptual and physiological measures of 10 km time trial between energy bars (n=15)

Measures	Power Bar	Snickers Bar	P-value (Energy bar)
10 km time (min)	52.3 ± 6.35	52.0 ± 6.70	0.64
1st 5 km (min)	25.9 ± 3.05	25.9 ± 3.60	0.49
2nd 5 km (min)	26.8 ± 3.20	26.4 ± 3.43	0.49
Pre 10 km RPE	7.1 ± 0.7	6.9 ± 0.7	0.8
Post 10 km RPE	15.3 ± 1.5	15.7 ± 1.9	0.8
Pre 10 km HP (b/min)	94 ± 19	92 ± 20	0.99
Post 10 km HR (b/min)	185 ± 17	188 ± 14	0.99
Average 10 km HR (b/min)	180 ± 10	178 ± 15	0.31
Pre 10 km PR (0-10)	7.1 ± 2.8	7.9 ± 1.5	0.37
Post 10 km PR (0-10)	5. 3 ± 2.5	5.5 ± 2.0	0.37

Min: Minutes; Km: Kilometers; B/Min: Beats per Minute; Rpe: Ratings of Perceived Exertion; Hr: Heart Rate; Pr: Perceived Recovery

Blood sampling

The changes in blood glucose levels in response to consumption of the pre-exercise energy bars are displayed in Figure 1. Fasting blood glucose levels were similar between pre-exercise energy bars (Power Bar: 3.7 ± 0.6 vs. 3.8 ± 0.4 mmol/L). A significant condition by time interaction was observed (p=0.005) for blood glucose levels between pre-exercise energy bars. Higher blood glucose levels were observed following Power Bar compared to Snickers Bar at pre-10 km (5.5 ± 1.1 vs. 4.5 ± 0.4 mmol/L) and post 10 km (5.6 ± 1.2 vs. 5.3 ± 0.9 mmol/L). Significant time (p<0.001) and condition effects (p=0.007) were observed for blood glucose levels between pre-exercise energy bars.

Perceptual responses to energy bars

Perceptual assessments revealed no significant condition by time effects for fullness (p=0.345) and thirst (p=0.628). Although there were no condition effects for fullness (p=0.819) and thirst (p=0.232), significant time effects were observed for fullness (p<0.001) and thirst (p=0.001). Feelings of fullness increased in response to consumption of the energy bars (p<0.001) and participants felt fuller post 10 km time trial (p<0.001) (Figure 2). Thirst significantly decreased after consumption of the bar during the 20 min prior to the 10 km time trial (P=0.013) but significantly increased post 10 km (p=0.001) (Figure 3).The energy bar subjective preference responses post-10 km time trial are presented in Table 3. There were no significant differences between energy bars in likability and preference for training and competition, or perception of improved performance.

Table 3: Energy bar subjective preference responses following 10 km time trial (n=15)

Measure (scale 0-9)	Power Bar	Snickers Bar	P-value (energy bar)
Did you like this energy bar?	3.9 ± 2.0	3.6 ± 1.9	0.75
Did this energy bar help you improve your performance?	4.1 ± 2.2	3.9 ± 2.5	0.78
Would you choose this energy bar before your next training session?	4.4 ± 3.0	4.5 ± 2.9	0.87
Would you choose this energy bar before your next race?	4.3 ± 3.0	4.2 ± 3.0	0.93
Would you choose this energy bar if you knew it will help improve your performance?	7.1 ± 2.2	7.0 ± 2.7	0.78

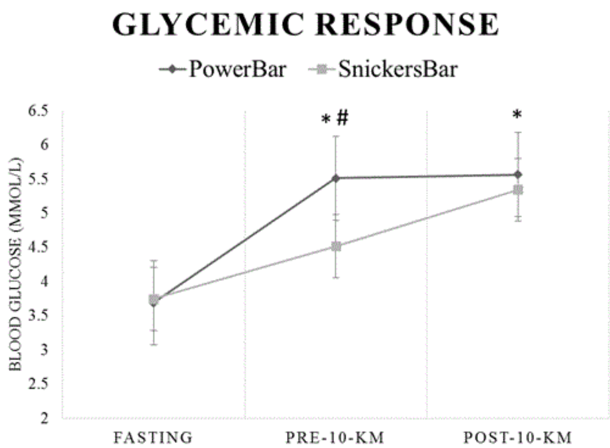

Figure 1: Glycemic response over time for power bar and snickers bar (n=15)

*p<0.05, significantly different from fasting

# p<0.05, significantly different between two pre-exercise energy bars

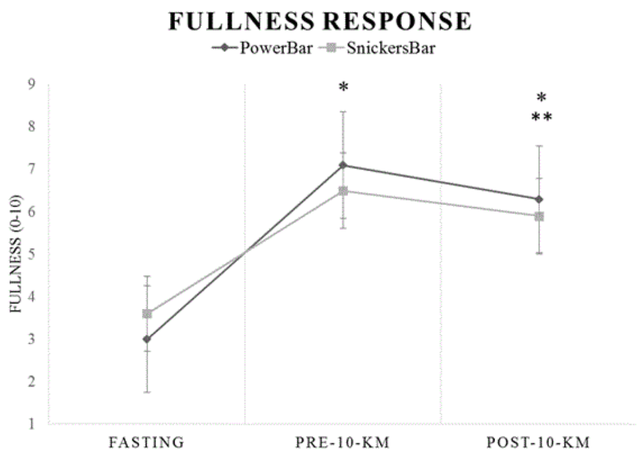

Figure 2: Gut fullness response over time for power bar and snickers bar (n=15)

*p<0.05, significantly different from fasting

**p<0.05, significantly different between

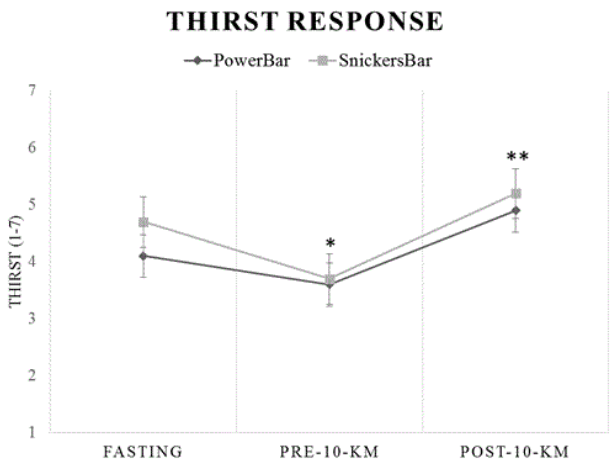

Figure 3: Thirst response over time for power bar and snickers bar (n=15)

*p<0.05, significantly different from fasting

**p<0.05, significantly different between

DISCUSSION

The purpose of the present study was to evaluate the effects of two pre-exercise energy bars, Snickers Bar (Low GI; Low GL) and Power Bar (Low GI; High GL) on glycemic response, 10 km time and perceptual responses. This is one of the few studies examining the effects of varying glycemic load pre-exercise meal on outdoor race simulated running performance instead of in a laboratory setting. The findings of the present study demonstrate that Snickers Bar induced a lower glycemic response during the postprandial period compared to the Power Bar. However, there were no significant differences observed in the time trial performance, HR or RPE between the two bars. Gut fullness significantly increased and thirst decreased in response to both bars but there was no effect on likability and perceived improvements in performance.

In the present study, although glycemic response was lower during the postprandial period after consuming the Snickers Bar, as would be expected due to lower CHO content, as well as the higher protein and fat content, it had no effect on average 10 km time, first 5 km and second 5 km time. This finding is in agreement with similar studies [9,17]. In addition, no significant difference in RPE, PR or HR response was observed between the two bars which are consistent with previous investigations [20,25,26]. In contrast to our study, only one study looked at GL and its effect on performance [25] compared to the majority of previous research that evaluated the effects of GI of pre-exercise meals. For example, Little et al. [8] and Benett et al. [17] observed no significant difference in distance covered during repeated sprints after consuming low GI compared to high GI pre-exercise meal. Similarly, Wong et al. [3] observed no difference in 10 km performance time after running for 1 h at 70% VO_{2max} and Little et al. [7] observed no difference in 1 km performance time after 90 min of simulated football practice following consumption of high compared to low GI pre-exercise meals. In addition, Ghiasvand et al. [25] observed no significant difference in running time to exhaustion after consuming two pre-exercise meals with different glycemic loads. Thus, the findings of the previous and present study may suggest that composition of pre-exercise meal may not have a significant impact on moderate distance (≤ 10 km) running performance regardless of whether it is a time trial or submaximal exercise performed prior to a time trial.

On the other hand, an improvement in 21 km running time [3], running time to exhaustion [20] and a 40 km cycling time [18,19] have been observed after consuming low GI pre-exercise meal compared to high GI. Thus it appears, the GI composition of pre-exercise meal may have greater impact on longer distance (>10 km) endurance performance. In addition, a shift to higher free fatty acid and lower carbohydrate oxidation was observed following low GI meal and improvements were attributed to decreased muscle glycogen and increased fat oxidation rates at the end of exercise. This shift in substrate utilization in response to low GI pre-exercise meals during long distance performance may explain the discrepancies among the aforementioned studies and the present study. In the present study, the 10 km distance may not have been long enough to deplete muscle glycogen, thus participants may not have benefited from lower GL bar as suggested by previous studies. Additionally, the above mentioned studies used male participants only. Gender differences may play a role in substrate utilization and availability due to hormonal differences [27]. Women tend to favor fat oxidation over CHO compared to men during submaximal exercise at a similar percent of VO^{2max}. In addition, an increase in fat oxidation was observed during submaximal exercise in women after consuming low GI compared to high GI pre-exercise meal [16]. However, increased fat oxidation during high intensity exercise may not be as beneficial and may limit exercise performance. Furthermore, increased availability of free fatty acids after consuming a low GL pre-exercise meal may have been more beneficial to a well-trained athlete with an increased capacity of using fat as fuel [5]. However, we used recreationally active females that may not have been trained enough to benefit from consuming a low GL pre-exercise meal. In addition, greater performance variability and changes in fitness between performance time trials were observed among non-athletes compared to athletes [28], thus due to greater individual variability in our study we may not have observed the effects of pre-exercise energy bars on performance.

Other methodological differences that should be considered include the timing and size of pre-exercise meals prior to exercise. Under certain circumstances, it may be difficult to consume a full size meal before a race, especially when most running races occur early in the morning and athletes may not have 2-3 h to allow for food to digest. In addition, some people may experience gastrointestinal distress after a full size meal and thus avoid eating before early morning races. Therefore a smaller size meal or snack maybe is an ideal option. Furthermore, consumption of each pre-exercise energy bar 30 min before exercise may have been too short, thus blunting the ergogenic effect of low GL bar due to limiting CHO availability after absorption and it's oxidation during exercise [29]. In addition, the amount of calories provided by the pre-exercise bar in the present study may have been insufficient for a 10 km race, thus, greater endogenous glucose had to be supplied. Typically, higher doses of CHO 1-4 g/kg of body mass in the pre-exercise meal are recommended [29], thus, the lower dose of CHO used in the present study may have been insufficient. Burdon suggested that higher CHO doses >2 g/kg of body mass may have a greater effect and should be further investigated.

In addition exercise modes and environmental conditions need to be considered. Most of these studies employed a submaximal exercise prior to a time trial or time to exhaustion protocols; however, most athletes are required to perform in the shortest time possible. Furthermore, most of the previous studies were performed in a laboratory setting on a cycling ergometer or a motorized treadmill which may be difficult to simulate race environment and motivate participants. Thus highlighting strength of the present study as it was performed on an outdoor course simulating a typical road race.

No difference in preference or likability was observed between the two pre-exercise bars. Gut fullness increased following pre-exercise bar consumption as would be expected, however was not different between bars. Previously, higher gut fullness was observed immediately after and during postprandial period following a low GI compared to high GI meal [16]. However, a full size meal (~730 cal) that was consumed 180 min before exercise was used, therefore, it is difficult to make a direct comparison between the studies. Thirst sensation decreased following energy bar consumption due to participants consuming water along with an energy bar ad libitum. In addition, thirst perception increased at the end of 10 km time trial as would be expected due participants sweating and losing water during exercise.

CONCLUSION

In conclusion, no performance or perceptual benefits were observed following consumption of low and high GL pre-exercise meal 30 min before 10 km time trial. Therefore, this suggests that glycemic load may not have an effect on moderate distance running performance among recreationally active female runners under the conditions of the present study. Additionally, although the study is not without its limitation, the results of the study can be generalized to the real-world application. Participants completed a simulated 10 km race on an outdoor course and consumed a commercially available energy bar that's heavily marketed towards athletes and recreationally active individuals. No adverse effects or gastrointestinal distress were reported, thus pre-exercise energy bar can be used as a pre-exercise meal option for an early morning race.

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