Effects of dietary glycemic index on C-reactive protein concentrations after acute bout of endurance exercise in male athletes

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ABSTRACT

The purpose of this study was to determine the effect of pre-exercise carbohydrate meals with high glycemic index (HGI) or low glycemic index (LGI) on high sensitive C-reactive protein concentrations (hs-CRP) following subsequent endurance exercise. 12 male subjects (age 24.8 ± 0.35 yrs, body mass 76.1 ± 3.5 kg, height 1.77 ± 0.02 m, body fat percentage 11.1 ± 3.23, VO2max 51.18 ± 0.65 mL·kg⁻¹·min⁻¹; mean ± S.E.M.) performed two 90-min runs on a treadmill at 70% VO2max two hours after ingesting a HGI or LGI meal. Each isocaloric test meal contained 1 g·kg⁻¹ body mass of carbohydrate and the glycemic index values were 94 and 40, respectively. Trials were separated by at least 7 days in counterbalanced order. Results were analyzed using a two-factor (trial × time) repeated measures ANOVA with post hoc (Bonferoni) comparison as appropriate. Laboratory data showed that although hs-CRP levels increased insignificantly immediately after exercise compared to pre exercise levels in both HGI and LGI, a slight increase in hs-CRP 1 hour after exercise in each of the groups was not statistically significant in both groups (p=0.399). This paper indicated that ingestion of 1 g·kg⁻¹ body mass of carbohydrate with high or low glycemic index 2 hours before endurance exercise had limited effects on hs-CRP concentration.

Keywords: High Glycemic Index (HGI); Low Glycemic Index (LGI); High Sensitive C-reactive protein (hs-CRP)

INTRODUCTION

Until recently carbohydrates have been classified as ‘simple’ and ‘complex’ based on their degree of polymerization; however, their effects on health may be better described on the basis of their physiological effects (ie ability to raise blood glucose), which depend both on the type of constituent sugars (eg glucose, fructose, galactose) and the physical form of the carbohydrate (eg particle size, degree of hydration). This classification is referred to as the glycemic index (GI). The GI is a quantitative assessment of foods based on postprandial blood glucose response (1). Numerous studies have suggested that a low-GI meal consumed at different times, i.e. 1–4 h, prior to prolonged exercise can maintain higher blood glucose concentrations, decrease plasma lactate concentrations during exercise and/or post-exercise, and cause a relative shift in substrate utilization from CHO to fat compared with a high-GI pre-exercise meal(2). On the other hand, over the past 15 years a variety of studies have demonstrated that exercise induces considerable physiological change in the immune system. The interactions between exercise stress and the immune system provide a unique opportunity to link basic and clinical physiology and to evaluate the role of underlying stress and immunophysiological mechanisms (3). However, it has been suggested that exercise represents a quantifiable model of physical stress. It is well known that intensive exercise is also associated with alterations in several immunoregulatory aspects (4). C-reactive protein (CRP) is a sensitive marker of systemic low grade inflammation and is currently recommended as the principal inflammatory marker in research and clinical practice. Elevated plasma levels of C-reactive protein have been associated with an increased risk of coronary heart disease, ischemic stroke, peripheral artery disease, hypertension, and any cardiovascular
disease, in individuals who have no prior cardiovascular disease (5). Several roles have been postulated for CRP, including binding to phospholipids of damaged cells to activate complement and enhance uptake of these cells by macrophages, as well as activating endothelial cells to express adhesion molecules and decreasing the expression and bioavailability of endothelial nitric oxide synthase (6-8). It is well documented that physical activity has a role in preventing coronary heart disease (9), mediated, in part, by changes in inflammation. Furthermore, studies concerning the effect of exercise on CRP concentrations have indicated that CRP concentrations rise after strenuous exercise when compared to the resting values (10). Several studies have examined the acute phase response (APR) to strenuous exercise (11-13) of 70 male and 20 female runners demonstrated marked but transient increases in the CRP immediately and 24 h after a 42-km marathon race. Values returned to baseline two to six days after exercise. Another study (14) evaluated the hematologic APRs of 18 athletes to 21 km of canoeing, 97 km of cycling, and 42 km of running. C-reactive protein increased 24 h after the race and returned to baseline by 48 h. A study (10) of 55 runners in the 1996 and 1997 Boston marathons noted increases in CRP within 24 h after the event. This APR to exercise seems to be proportional to the amount of activity and muscle injury. The APR also may be related to the type of exercise and the muscle mass involved. Griffith and colleagues showed that quality of dietary carbohydrates (high or low glycemic index) does not appear to be associated with serum hs-CRP levels among 582 healthy middle-aged women (16). The mechanisms mediating the APR to exercise are not defined. So, because of this topic and their conflicting results, further investigation is warranted. Due to the limited number of studies on combination of dietary carbohydrate, C-reactive protein and acute strenuous endurance exercise, the purpose of this study was therefore to examine the effects of carbohydrate meals with different glycemic index on CRP levels in male athletes after a strenuous endurance exercise bout. It was hypothesized that the different glycemic index of meals would elicit significant differences in CRP levels.

MATERIALS AND METHODS

Subjects

12 male exercise-trained men were recruited to participate. Subjects were required to at least three days per week for a minimum of 45 minutes per session for the past 3 months. Subjects were nonsmokers, not using anti-inflammatory or antioxidant agents, and did not report any history of cardiovascular or metabolic disorders. Health history, drug and dietary supplement usage, and physical activity questionnaires were completed by all subjects to determine eligibility. Prior to participation, each subject was informed of all procedures, potential risks, and benefits associated with the study through both verbal and written form in accordance with the approved procedures of the University Institutional Review Board for Human Subjects Research. Potential recruits signed an informed consent form prior to being admitted as a subject (17). Subjects’ height, weight, and body composition via 8 site skinfold test and calculation using ISAK equation was measured. Subject characteristics are shown in Table 1. A full explanation of dietary and physical activity data recording was provided to subjects, along with data collection forms. An overview of study procedures was also provided.

Table 1. The general features of the participants

<table>
<thead>
<tr>
<th>Variables</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)</td>
<td>24.8±0.35</td>
</tr>
<tr>
<td>Body mass (kg)</td>
<td>76.1±3.58</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.77±0.02</td>
</tr>
<tr>
<td>Body fat percentage</td>
<td>11.1±3.23</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>24.18±0.67</td>
</tr>
<tr>
<td>VO₂max (ml·kg⁻¹·min⁻¹)</td>
<td>51.18±0.65</td>
</tr>
</tbody>
</table>

Data are mean ± SD.

Dietary and physical activity records

All subjects were instructed to maintain their normal diet, and record their food and beverage intake during the seven day period prior to each exercise test day. Nutritional records were analyzed for total calories, protein, carbohydrate, fat, and a variety of micronutrients. Subjects were given specific instructions regarding abstinence of alcohol consumption during the 48 hours immediately proceeding the test days. Subjects were instructed to maintain their normal physical activity, with the exception of refraining from activity during the 48 hours preceding and following each test day.

Diet and exercise protocol

Each isocaloric test meal contained 1 g·kg⁻¹ body mass of carbohydrate (18) and the glycemic index values were 94 and 40, for high and low glycemic meal respectively. High glycemic staple-diet consists of mashed potatoes and the staple diet with low glycemic whole grain spaghetti was also included in the same way (Table 2). All subjects
performed two 90-min runs on a treadmill at 70% VO₂max (19) 2 hours after ingesting a HGI or LGI meal. Subjects matched fluid intake to 2 ml of plain water per kg of body weight every 15 minutes of activity was used (20, 21). Subjects who had consumed a high glycemic diet on the first day, consumed low glycemic diet and vice versa. Diet composition is presented in Table 2.

Table 2. Nutritional composition of pre-exercise meals (for a 70 kg participant)

<table>
<thead>
<tr>
<th>Meal Description</th>
<th>Estimated GI</th>
<th>GI Macronutrient content</th>
</tr>
</thead>
<tbody>
<tr>
<td>HGI 420 gr g potatoes (baked)</td>
<td>94</td>
<td>368 kcal</td>
</tr>
<tr>
<td>155 gr tomato sauce</td>
<td></td>
<td>70 gr carbohydrate</td>
</tr>
<tr>
<td>625 ml water</td>
<td></td>
<td>13.8 gr protein</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.3 gram fat</td>
</tr>
<tr>
<td>LGI 420 gr macaroni (cooked)</td>
<td>40</td>
<td>368 kcal</td>
</tr>
<tr>
<td>155 gr tomato sauce</td>
<td></td>
<td>70 gr carbohydrate</td>
</tr>
<tr>
<td>625 ml water</td>
<td></td>
<td>13.8 gr protein</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.3 gram fat</td>
</tr>
</tbody>
</table>

Results and Discussion

Variable changes shown in table3.

Table3. Effects of high and low glycemic index on blood variables before, after and 1 hour after 90 min running at 70% VO₂max

<table>
<thead>
<tr>
<th>Group</th>
<th>HGI</th>
<th>LGI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage</td>
<td>PRE</td>
<td>POST</td>
</tr>
<tr>
<td>hs-CRP (ul)</td>
<td>0.5±0.43</td>
<td>0.7±0.43</td>
</tr>
</tbody>
</table>

At rest all subjects had total and differential hs-CRP within the normal ranges for healthy adults. Increased circulating hs-CRP was observed immediately after exercise compared to pre-exercise levels in both HGI and LGI (Table3). However, no differences were found in all the hs-CRP levels between the HGI and LGI trials (p=0.399) (Figure 1).
The data from the present study indicated that pre-exercise CHO ingestion with a low glycemic index compared with high glycemic index (1 g CHO/kg body mass) 2 hour before strenuous endurance activity (90 minutes at 70% \(V_{\text{o2}}\)max) did not alter hs-CRP concentrations in athletes. CRP is an inflammatory index in the human body and a predictor of heart disease risk at rest and it is a circulating marker of inflammation produced predominantly by the liver in response to IL-6. Very high concentrations of CRP are seen in acute infectious and systemic inflammatory states, but more modest elevations of CRP, measured as high-sensitivity CRP, can occur chronically, providing a relatively stable indicator of low-grade inflammation over months to years (23, 24). With regard to the effect of exercise on CRP, the results from the current study are similar to those of previous studies (10, 14), i.e. CRP increased after acute bout of exercise. Some previous studies suggest that acute bout of exercise causes energy crisis in contractile myofibrils and increases the expression and blood levels of leukocyte adhesion molecules, facilitates interactions between monocytes and endothelial cells, increases the production of proinflammatory cytokines, and decreases the production of anti-inflammatory cytokines by mononuclear cells, eliminates balance between the production of pro-inflammatory and anti-inflammatory cytokines in skeletal muscles, inhibits antioxidative defenses, and reduces the susceptibility of LDL to oxidation. These events increase phagocyte cells and IL-6 and consequently hepatocytes production of CRP is stimulated. We previous showed that carbohydrate meals with low glycemic index did not alter IL-6 concentration in male athletes after strenuous endurance exercise and we decided other factors related to some inflammatory variables (25). Carbohydrate ingestion has been shown to improve glucose availability. It has therefore been suggested that exogenous CHO feeding during exercise may influence the immune response to exercise by maintaining blood glucose levels and thereby reducing IL-6 and reduces CRP secretion from liver and other tissues. Low glycemic index carbohydrate meals lowers insulin secretion, so glucose maintains longer during prolonged exercise rather than high glycemic index carbohydrates.

CONCLUSION

The data from the present study indicate that pre-exercise CHO ingestion with a low glycemic index compared with high glycemic index (1 g CHO/kg body mass) 2 hour before strenuous endurance activity (90 minutes at 70% \(V_{\text{o2}}\)max) did not alter hs-CRP concentrations between groups and it seemed that responses of blood hs-CRP concentrations were independent from glycemic index of carbohydrate meals.

Acknowledgements

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REFERENCES