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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, VO_2max 51.18 ± 0.65 mL·kg^{-1}·min^{-1}; mean ± S.E.M.) performed two 90-min runs on a treadmill at 70% VO_2max 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-CRP1hour 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 theeffect of exercise on CRP concentrations have indicatedthat CRP concentrations rise after strenuousexercise when compared to the resting values (10). Several studies have examined theacute phase response(APR) to strenuous exercise (11-13) of 70 male and 20 femalerunners demonstrated marked but transient increases in the CRPimmediately and 24 h after a 42-km marathon race.Values returned to baseline two to six daysafter exercise. Another study (14) evaluated the hematologicand APRs of 18 athletes to 21 km of canoeing, 97 km ofcycling, and 42 km of running. C-reactive protein increased24 h after the race and returned to baselineby 48 h. A study(10) of 55 runners in the 1996 and 1997 Boston marathonsnoted increases in CRP within 4 h after the event.This APR to exercise seems to be proportional to theamount of activity and muscle injury. The APR also may berelated to the type of exercise and the muscle mass involved.Griffithand colleagues showedQuality of dietary carbohydrates (high or low glycemic index) does not appear to be associated with serum hs-CRP levels among 582 obese (15). In other studyLio andcolleaguesconcluded that Dietary glycemic control is significantly and positively associated with plasma hs-CRP in 244 healthy middle-aged women (16).The mechanisms mediating the APR to exercise are not defined. So, because ofthis 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 examinethe 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.

Table1. The general features of the participants

Variables	value
Age(year)	24.8±0.35
Body mass (kg)	76.1±3.58
Height (m)	1.77±0.02
body fat percentage	11.1±3.23
BMI (kg/ m2)	24.18±0.67
$VO_2max(ml \cdot kg^{-1} \cdot min^{-1})$	51.18±0.65

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 $g \cdot kg^{-1}$ 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% VO_2max (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)

Meal	Description	Estimated GI	Macronutrient content
HGI	420 gr g potatoes (baked) 155 gr tomato sauce 625 ml water	94	368kcal 70 gr carbohydrate 13.8 gr protein 2.3 gram fat
LGI	420 gr macaroni (cooked) 155 gr tomato sauce 625 ml water	40	368kcal 70 gr carbohydrate 13.8 gr protein 2.3 gram fat

GI, glycemic index; CHO, carbohydrate.

Blood Samplingand variable analysis

In order to reduce the effect of circadian rhythm on immune function tests were performed in midday and In order to reduce disturbing effect on test variables, this study as a double blind, crossover design was conducted in two sessions a week away in counterbalanced order. Temperature approximately 20 ° C and humidity about 55% was calculated. In the morning of test session, the subjects sat on the chair and then blood samples from fasting participants were taken through the left brachial vein. In the next stage of diets with different glycemic distributed among subjects. Subjects had 15 minutes' to intake their diets then, they were given 2 hours to rest (22). A second blood sample was taken immediately after the activity. Then 5 ml of plain water per kilogram of body weight consumed by subjects. Thereafter subjects were not allowed to drink water or consume any food to an hour after the third and final sampling. Following collection, blood samples were processed accordingly, and the plasma/serum was immediately stored at -80°C until analyzed. As markers of inflammation, CRP was analyzed in serum using an ultra-sensitive enzyme linked immunosorbent assay (ELISA) procedure as described by the manufacturer (PARSAZMOON KIT).

Statistical Analysis

Statistical Analysis First normal data distribution and homogeneity of groups in order to test the Kolmogorov – Smirnov and Leuven was determined. All statistical calculations were performed using SPSS version 15. A two-way ANOVA (trial and time) with repeated-measures design was used to assess metabolic and immune differences between groups. Any significant F ratios were assessed using a Holm–Bonferroni stepwise post hoc test to determine the locations of variance. All statistical calculations were performed using SPSS version 15. All data were presented as means with their standard errors, with the significance set at $P<0.05$.

RESULTS AND DISCUSSION

Variable changes shown in table3.

Table3. Effects of high and low glycemic index on blood variables before, after and 1hour after 90min running at 70% vo_2max

Group	HGI			LGI		
Stage	PRE	POST	1hPOST	PRE	POST	1hPOST
hs-CRP (ul)	**0.5± 0.43**	**0.72± 0.43**	**0.764± 0.57**	**0.5± 0.43**	**0.832±0.31**	**0.7± 0.24**

At rest all subjects had total and differential hs-CRP within the normal ranges for healthy adults. Increased circulating hs-CRPwas observed immediately after exercise compared to pre exercise levels in both HGI and LGI (Table3). However, no differences were found in all the hs-CRPlevels between the HGI and LGI trials (p=0.399) (Figure 1).

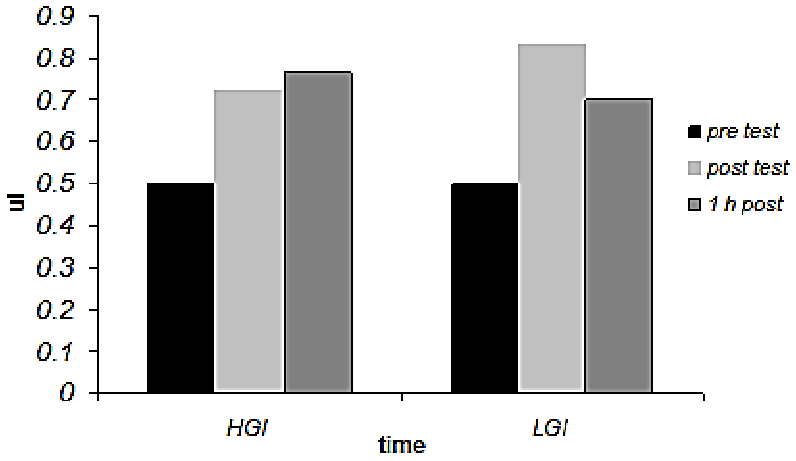

Fig1. Plasma CRP concentrations at rest, immediately after(post)and 1 hour after prolonged strenuous exercise with the ingestion of a high-glycemic index (HGI), low-glycemic index (LGI) meal.

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% Vo_2max) 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 increasesthe expression and blood levels of leukocyte adhesionmolecules, facilitates interactions between monocytes andendothelial cells, increases the production of proinflammatorycytokines, and decreased the production ofanti-inflammatory cytokines by mononuclear cells, eliminates balance between the production of pro-inflammatoryand anti-inflammatory cytokines in skeletal muscles,inhibitantioxidative defenses, and reduces the susceptibilityof LDL to oxidation. These eventsincreasePhagocyte 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% Vo_2max) did not alter hs-CRP concentrations between groupsand it seemed that responses of bloodhs-CRP concentrations were independent from glycemic index of carbohydrate meals

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