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Effect of pre-exercise meals with different glycemic indices on cortisol and circulating leucocytes to an endurance performance run 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 circulating leucocytes and plasma cortisol concentrations 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.Reduced circulating lymphocytes concentrations were observed immediately after exercise compared to pre exercise levels in both HGI and LGI. However, no differences were found in all the lymphocytes counts between the HGI and LGI trials (p=0.443). Indeed, Results indicated a slight increase in the number of neutrophils in each of the groups, but this increase was not statistically significant in both groups (p=0.376). Although During the LGI trial, there was a progressive increase in monocyte concentrations immediately after exercise (p=0.013), Results indicated insignificant differences between HGI and LGI groups (p=0.583).Serum cortisol concentrations increased after the onset of exercise in both HGI and LGI (p=0.11), but no differences were found among the trials throughout the exercise period (p=0.594).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 circulating leucocytes and cortisol concentration.

Keywords: High Glycemic Index (HGI); Low Glycemic Index (LGI);cortisol; circulating leucocytes

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INTRODUCTION

Over the past 15 years a variety of studies have demonstrated that exercise induces considerable physiologicalchange 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(1). Indeed, there is both scientific and anecdotal evidence that athletes suffer from an increased number of infections after a single intensive competitive event. It is well known that intensive exercise is also associated with alterations in several immunoregulatory hormones (2).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 hormones.Responses of blood leukocyte subpopulations to an episode of acute exercise are highly stereotyped. Neutrophil concentrations increase during and after exercise, whereas lymphocyte concentrations increase during exercise and fall below pre-values after long-duration physical work. One of the more pronounced features of physical activity on immuneparameters is the prolonged neutrocytosis after acutelong-term exercise. With regard to the function of neutrophils, exercisehas both short- and long-term effects.

Acute, intense muscular exercise increasesthe concentrations of a number of stress hormones in theblood, including epinephrine, norepinephrine, growthhormone, β-endorphins, testosterone, estrogen, and cortisol,whereas the concentration of insulin slightly decreases.The plasma concentrations of cortisol increase onlyin relation to exercise of long duration. It has been shown that corticosteroids given intravenouslyto humans cause lymphocytopenia, monocytopenia,eosinopenia, and neutrophilia that reach theirmaximum 4 h after administration (1). We hypothesize that cortisol likely has a role in maintaining the neutrophilia and lymphopenia after prolonged, intense exercise such as a marathon (1).

On the other hand, Although the mechanisms are unclear, it has been reported that carbohydrate (CHO) feeding at regular intervals during prolonged, strenuous exercise is associated with smaller perturbations in the total and differential circulating leucocyte counts and attenuated reduction in functional responses in a number of immune cells and mediators, including lymphocytes, neutrophils and inflammatory cytokines(2). However, the limited data still suggested that pre-exercise low-CHO meals increased the magnitude of leucocytosis and a rise in the neutrophils in the blood. It seems likely that part of the underlying mechanism behind these responses is an attenuation of the cortisol response to the exercise and maintenance of plasma glucose concentrations (1). Indeed, 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 (3). 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(). Despite the inconsistency on improvement in exercise performance after the ingestion of GI meals, most findings indicate that a pre-exercise low-GI meal may have potential benefits over a high-GI meal because of the promotion of the sustained CHO availability during exercise (5).

Yan Chen and colleagues showed both a quiet time run after 10 km of running on a treadmill with a 70% peak aerobic power with Consumption of meals with different glycemic index, leads to a reduction in the number of leukocytes, neutrophils and T lymphocytes in circulation (6). In another study Yan Chen and colleagues showed that carbohydrates with high and low glycemic index supplementation during 5 km run at 70% peak aerobic power and the desired speed of 16 km two hours before exercise, resulting in reduced cortisol responses during recovery in the groups containing low GI meal compared to groups consuming meals with a high glycemic index and control groups (5). In addition, Lee T Zeel and colleagues showed carbohydrate supplementation with low versus high glycemic index, affects Leukocyte accumulation after 90 minutes of running at 70% peak aerobic power and the responses of stress hormones and cytokines are also reduced (7).Despite the recent advances in research regarding immunosuppression and CHO supplementation, few studies, if any, have directly investigated the influence of a GI meal on immune response to prolonged exercise. There is clearly a need to clarify the role of GI on some immune responses during and/or after prolonged exercise (5). Using an identical design and subject population and also provide simple and accessible diets for the athletes in the country, this study aimed to examine the effect of a 2 h pre-exercise meal with different GI on immune responses to an endurance performance run. It was hypothesized that compared with a high-GI meal, the consumption of a low-GI meal 2 h before exercise would result in a reduced cortisol response to exercise, which in turn would allow the maintenance of the immune function during exercise and recovery.

MATERIALS AND METHODOS

Subjects

12 male athletes selected in this study which was approved by the University Clinical Research Ethical Committee. They were also required to complete a general health questionnaire and were excluded if any medication had been taken during the 4 weeks prior to the study and if symptoms of any infections had been experienced in the 4 weeks prior to the study. Moreover, at the time of the study, all subjects were involved in normal training. Subjects were instructed to keep their daily exercise to a minimum and to standardize their diet during the 72 h preceding each main trial. Each subject kept a 3 d diary of their dietary intake before the main trial and energy intake and dietary composition were subsequently analyzed (The Food Processor 10.0, Esha). Subjects' characteristics are presented in Table 1.

Table1. The general features of the participants, the data are given based on the mean and standard deviation

VO2max (ml·kg-1·min-1)	BMI (kg/ m^2)	body fat percentage	Height (m)	Body mass (kg)	Age (year)
51.18±0.65	24.18±0.67	11.1±3.23	1.77±0.02	76.1±3.58	24.8±0.35

Physiological measures

After selection procedure, subjects were asked to assess the physiological characteristics refer to the University sports physiology laboratory. Subcutaneous fat using caliper (model YAGAMI) with instructions based on an eight-point, Body mass index (BMI) using a body composition analyzer (model biospace) making South Korea And maximum oxygen consumption using the instructions Elstad and colleagues was measured on a treadmill(8).

Diet and exercise protocol

Each isocaloric test meal contained 1 g·kg-1 body mass of carbohydrate (9) and the glycemic index values were 94 and 40, for high and low glycemic meal respectively (Table 1). 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(10) 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(11,12). 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.

† Calculated by a method described in the work of Wolever et al (1991), with GI values. Taken from the work of Foster-Powell et al (2002).

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(13). 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.Plasma cortisol was measured by RIA kit (IMMUN-TECK, France) and IL-6 also measured by Assay (ELISA) kit (Diaclone, Besancon, France). Blood glucose assay kit was PARSAZMOON (Iran) and a measure of immune system cells CELL COUNTER CYSMIX-KX21 method was used.

Statistical Analysis

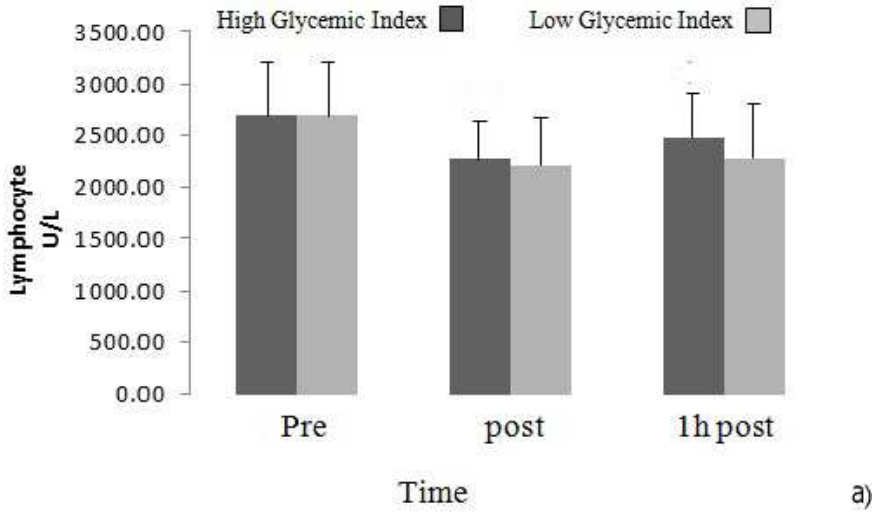
Statistical Analysis First normal data distribution and homogeneity of groups in order to test the Kolmogorov – Smirnov and Leuven was determined. All statistical calculations were performed using SPSS version 15. A two-way ANOVA (trial and time) with repeated-measures design was used to assess metabolic 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

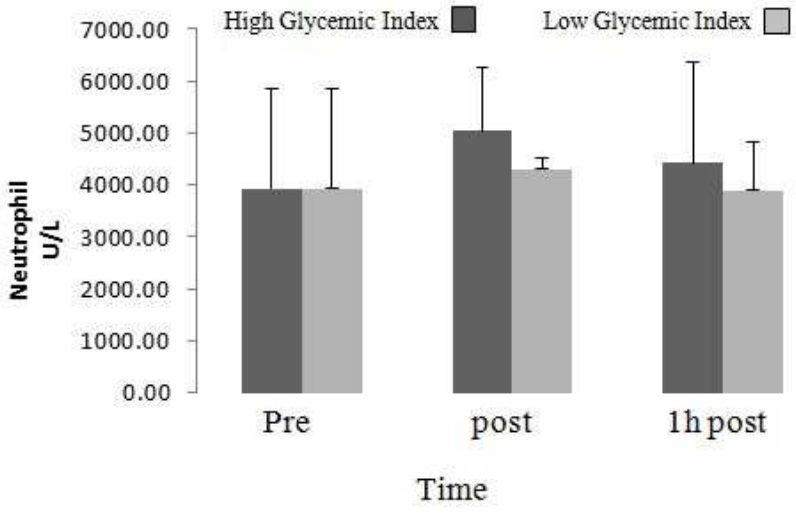
Variable changes shown in table3.

Table 3. Effects of high and low glycemic index on blood variables before, after and 1hour after 90min running at 70% vo_2max

		Monocyte (UL)	Lymphocyte (UL)	Neutrophil (UL)	Cortisol (UL)
High Glycemic Index (HGI)	pre	248.8± 168.11	2693.6± 521.67	3934.1± 1899.10	14.15± 9.35
	post	284.7± 189.17	2281.2± 357.43	5029.8± 1219.29	20.7± 4.42
	1h post	340.2± 146.09	2472.5± 427	4430.7± 1926.85	17.68± 4.42
Low Glycemic Index (LGI)	pre	248.8± 168.11	2693.6± 521.67	3934.1± 1899.10	14.15± 9.35
	post	309.5± 77.02	2221.9± 443.34	4309.4± 196.10	18.45± 5.35
	1h post	367.6± 218.38	2289.5± 516.59	3899.2± 920.55	17.05± 7.32



a)



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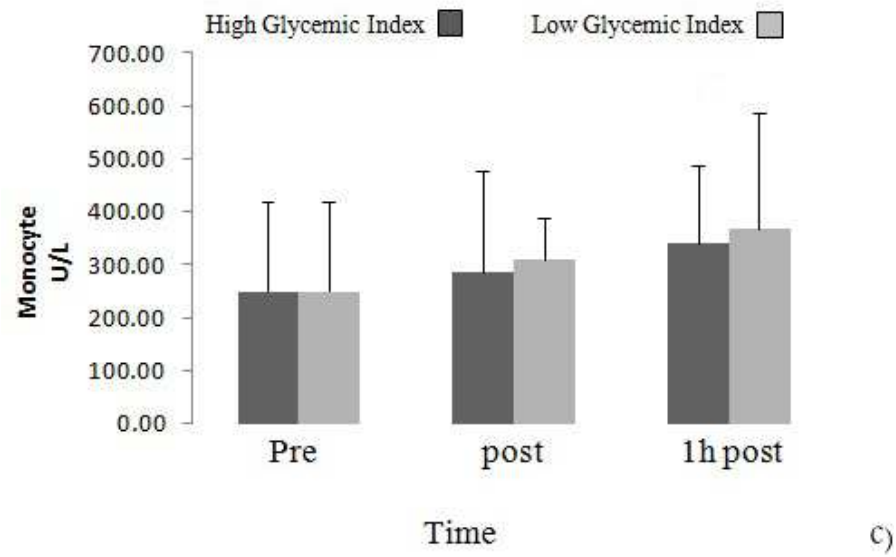

Fig 2. Plasma lymphocytes (a), neutrophils (b) and monocytes(c) concentrations at rest, immediately after(post)and 1 hour after prolonged strenuous exercise with the ingestion of a high-glycemic index (HGI), low-glycemic index (LGI) meal.

Lymphocytes, monocytes and neutrophils

At rest all subjects had total and differential leucocyte counts well within the normal ranges for healthy adults. Reduced circulating lymphocytes concentrations were observed immediately after exercise compared to pre exercise levels in both HGI and LGI (Table3). However, no differences were found in all the lymphocytes counts between the HGI and LGI trials (p=0.443) (Figure 2a). Indeed, Results indicated a slight increase in the number of neutrophils in each of the groups, but this increase was not statistically significant in both groups (p=0.376) (Figure 2b). Although During the LGI trial, there was a progressive increase in monocyte concentrations immediately after exercise (p=0.013), Results indicated insignificant differences between HGI and LGI groups (p=0.583) (Figure 2c).

Serum cortisol

Serum cortisol concentrations increased after the onset of exercise in both HGI and LGI (p=0.11) (Table3), but no differences were found among the trials throughout the exercise period (p=0.594) (Fig. 3).

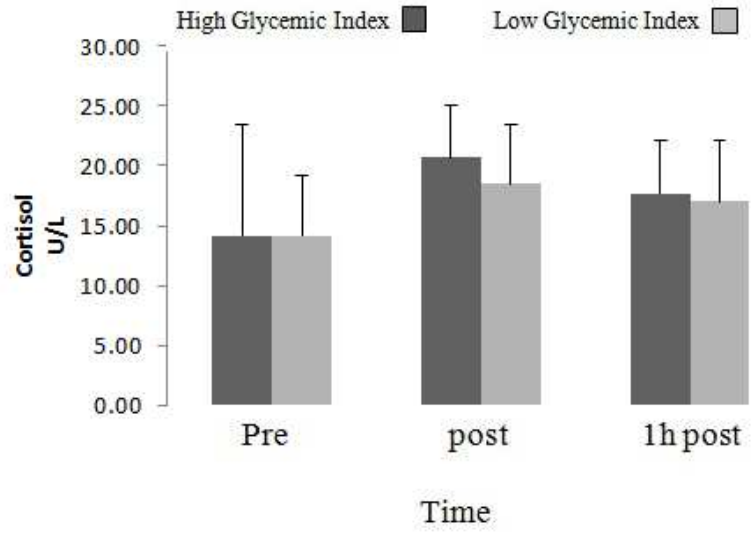

Fig 3. Plasma cortisol concentrations at rest, immediately after(post)and 1 hour after prolonged strenuous exercise with the ingestion of a high-glycemic index (HGI), low-glycemic index (LGI) meal.

The data from the present study 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% Vo2max) has maintained plasma glucose concentrations but did not alter leukocytes count, interleukin 6 and cortisol concentrations.

According to present study, blood leucocytes and Neutrophils and Cortisol concentrations, had no significant changes, which are in disagreement with result of Ya-jun Chen et al(5,6) and Lee T Zil et al(7) . It seems that amount of CHO ingestion was not sufficient for immune response changes. The direct effect of hyperglycemia on the immune system is acceptable. Reduction in blood glucose concentration stimulates secretion of plasma cortisol in circulation that as a part of the body's natural negative-feedback system, proinflammatory cytokines activate the HPA axis and the sympathoadrenergicsystem, exerting strong anti-inflammatory actions. Release of adrenocorticotropic hormone and cortisol during exercisehas been linked, in part, to decreases in blood glucose concentrations, with a variable effect on IL_6.

Carbohydrate (CHO) ingestion during exercise has been shown to reduce perturbations in immune cell numbers and function, possibly through a reduction in the cortisol response to exercise.It has been reported that CHO feeding during long-duration intense exercise results in reduced perturbations to both immunoregulatory hormones and immune indexes, including cell numbers and T-lymphocyte function. It is widely reported that exercise stimulates the hypothalamic pituitary adrenal axis and results in elevated blood cortisollevels. In addition to exercise stimuli, cortisol levels are heightened in response to a decrease in blood glucose levels. CHO 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 cortisol.

CONCLUSION

The low glycemic index meal was associated with the better maintains of blood glucose during and after sub maximal endurance exercise, which may be explained by lower responses of insulin not cortisol and IL_6. Indeed, it seemed that responses of blood leukocytes, cortisol concentrations were independent from glycemic index of carbohydrate meals

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