

THE EFFECT OF GLYCEMIC INDEX ON PLASMA IL-6 IN SUB-MAX EXERCISE

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Abstract. *Purpose:* This study examined the effect of a pre-exercise meal with different glycemic index (GI) on plasma IL-6 concentration and glucose metabolism during sub-max exercise (endurance performance run). *Material:* Ten men completed 1 h running at 70%-75% VO₂max on a level treadmill on three occasions. In each trial, one of the three prescribed beverages as meal, i.e. high GI and low GL or placebo was consumed by the subjects 45 min before exercise. Blood samples were collected before, after, 1h and 24h after exercise. *Result:* Concentration of Plasma IL-6 in LGI group was less than HGI and Pla groups, IL-6 tended to significantly increase after exercise in groups (all P < 0.05), also there was significant difference for plasma IL-6 concentration between placebo and low glycemic groups in after exercise (P=.003) and 1hour after exercise (P=.005). CK was significantly elevated at all- time points after exercise in 3 groups (all P < 0.05). Concentration of serum CK in LGI group was less than HGI and Pla groups but there not significantly. The consumption of the LGI beverage before exercise could minimize the increasing of plasma IL-6 concentration immediately after exercise and during the 1 h recovery period compared with the HGI beverage and Pla. *Conclusion:* This result suggested that the LGI beverage consumed as pre-exercise meal could modify the inflammatory response in prolonged exercise.

Key words: Sub-max, exercise, glycemic, index, plasma.

Introduction

Exercise can induce inflammation by raising the levels of IL-6 (Nieman et al., 2006). Intensity, duration, and the muscle mass involved in the exercise are factors known to influence the quantity of IL-6 found in plasma (Ostrowski et al., 2000). Carbohydrate(CHO) consumption before, during and after exercise can attenuate stress hormone response and improves exercise performance by enhancing blood glucose availability (Bishop et al., 2002; Febbraio et al., 2003; Nieman et al., 2003). Otherwise, CHO feeding before exercise cause a rapid increase in blood glucose and insulin can cause hypoglycemia in some individuals at the start of exercise (Foster et al., 1979; Kuipers et al., 1999).

This observation led to the investigation into the effect of different types and structures of CHO and their comparison on exercise performance (Guezennec et al., 1989, 1993; Koivisto et al., 1981). Numerous studies have suggested that a low glycemic (LGI) meal consumed at different times, to prolonged exercise could maintain higher blood glucose concentrations, decrease plasma lactate concentrations during exercise and/or post-exercise, (Wee et al., 1999; DeMarco et al., 1999). Furthermore in prolonged exercise minimizing the glycemic and insulin response could sustain CHO supply during exercise. These responses could decrease the cortisol response, IL-6, TNF- α and other inflammatory biomarkers (Bishop et al., 2001), also there is some evidences that a diet whit high amount of glucose could increase pro-inflammatory cytokine (Kirwan et al., 2001). High glycemic (HGI) diet is the exacerbation of glucose spike that occurs immediately after eating (Pittas et al., 2006), this spike could alter glucose and insulin dynamics during exercise.

These data suggest that consuming food with different glycemic index could be effect on inflammatory responses in exercise. Despite the recent advances in researches are on the relation between immune suppression and CHO supplementation during prolong exercise or CHO as meal before exercise. Therefore, knowing about that which type of CHO be able to reduce inflammatory responses in exercise, could guide the athletes for choosing beneficial nutrition to improve their performance. More research is necessary to elucidate the relationship between systemic inflammation and GI diets in prolong exercise. Few studies, if any, have directly investigated the influence of a GI beverage on IL-6 response to prolonged exercise. There is clearly a pressing need to clarify the role of GI on IL-6 responses before prolonged exercise. Using an identical design and subject population, this study aimed to examine the effect of a pre-exercise beverage with different GI on IL-6 responses to a sub-max exercise. The aim of this study was determine whether there are differences in plasma IL-6 concentration and glucose metabolism between low and high GI beverage in sub-max exercise.

Materials and Methods

Subjects

Ten healthy endurance male runners (age 21 \pm 2 years; body mass 68 \pm 8 kg; high 176 \pm 6 cm; fat percentage (%)10 \pm 2; VO₂max 56 \pm 21ml/kg per min and training experience 5 \pm 1years) were volunteered to participate in this study which was approved by the Ethical Committee of Qom University of medical science. Written informed consent was obtained from all subjects. They were also required to complete a general health questionnaire and were excluded if any medication had been taken during the 6 weeks prior to the study and if symptoms of upper respiratory infection had been experienced in the 4 weeks training and were accumulating at least 50 km of running distance per week. Subjects were asked to refrain from alcohol consumption 24 hours prior to sample collection.

Exercise familiarization

At least 1 week prior to main trial all subjects reported to the laboratory for becoming familiar with treadmill running and the experimental procedures, they were required to undertake vo2 max test via Bruce protocol. Before the main trials, participant kept a 3-day diary of their dietary intake before the main trial and energy intake and dietary composition were subsequently analyzed (The Food Processor 10.0, Esha). They were required to repeat the same diet before each main trial to minimize the variation in muscle and liver glycogen concentrations.

Experimental procedure

A standardized prolong exercise protocol, 1 h constant running at 70% -75% VO2max was used in this study (Fig. 1). This study is a counterbalanced cross-over design and the order of three trials were randomized, separated by at least 14 days. Subjects were randomized to consume GI beverage High-GI (1 g of glucose/kg body mass in 400 ml water, GI = 83), Low-GI (1 g of fructose/kg body mass in 400 ml water, GI = 36) or placebo (an equal volume of flavor- and color-matched artificially sweetened placebo) (Gleeson et al., 1986) for 45 min pre-exercise. Blood samples (10 mL) were collected at baseline, before and immediately after exercise, 1 and 24 h after exercise.

On the day of the main trial, subjects reported to the laboratory at about 8:00 am after an overnight fast of 12 h. After collection of the baseline blood samples the participants were consumed either the GI beverage (High-GI, Low-GI) or placebo. They remained seated in a quiet section of the laboratory for 45 min with minimal level of activity and after 45 min resting period, they were started training: standardized 5 min warm-up at 60% VO2 max was performed. Then subjects were run on the treadmill at a fixed speed of 70% -75%VO2 max for 1 h. All of the trials were performed under similar conditions of barometric pressure, temperature, and relative humidity. No food was been allowed until after the final blood sample were be taken.

Blood sampling:

10 ml venous blood was drawn from an antecubital vein in the forearm at each time point : 1- Fast blood sample (F.B.S) , 2 - Pre-exercise (PRE-ex) , 3-Immediately post-exercise (POST) 4- 1 h after exercise (POST-60 min) 5- 24 hour after exercise, into two different evacuated collection tubes (Vacutainer; Becton Dickinson, Mountain View, CA). The first (5 ml) venous blood sample was drawn into a vacuum tube with clot activator and serum separator for collection of serum to analyze glucose by BIOSEN C (EKF Diagnostic GmbH, West Germany) and CK by SYNCHRON® System(s) (Beckman Coulter, Inc.USA). The second (5 ml) venous blood sample was taken in to K3 EDTA vacutainers .5ml blood sample was spun at 1500 g for 10 min at 4°C to obtain plasma which was immediately stored at -70 °C before being analyzed for IL-6 . IL-6 was determined with the use of quantitative sandwich type enzyme-linked immunosorbant assay (ELISA) kits from R&D systems (Minneapolis, MN). All standards and solutions were prepared, and procedures were followed according to the kit specifications. Samples were diluted when necessary to ensure that the measurement fell within the range of the standard curve.

Data analysis

All collected data will be presented as mean and standard deviation (Mean ± SD). Repeated measures 5 × 3 (time × groups) ANOVAs was used to assess metabolic and immune differences between groups. Any significant F ratios shown were assessed using Bonferroni correction test. Assumptions of homogeneity and sphericity in the data were checked. Statistical significance was accepted at p < 0.05. The data was analyzed by using the statistical package SPSS, PC program, version 19.0 (SPSS Inc., USA).

Results:

10 Subjects completed 3 sessions of endurance exercise (Table 1) running at a fixed speed of 70% -75%VO2 max for 1 h on the treadmill.

Table 1. Individual characteristic: N = 10. Values = mean ± SD. VO2max = predicted maximal oxygen consumption.

Characteristics	M± SD
Age (yrs)	21±2
Height (cm)	176±6
Body mass (kg)	68±8
Fat percentage (%)	10±2
VO ₂ max (ml.kg ⁻¹ .min ⁻¹)	56±2
Training experience (yrs)	5±1

Markers of inflammation

Plasma IL-6 concentration and CK were measured as indicators of inflammation as a result of muscle damage. At the baseline, there was no significant difference for IL-6 between trials. Concentration of Plasma IL-6 in LGI group was less than HGI and Pla groups, IL-6 tended to significantly increase after exercise in 3 groups (all P < 0.05), also there was significant difference for plasma IL-6 concentration between placebo and low glycemic groups in after exercise (P=.003) and 1hour after exercise (P=.005) The IL-6 data are presented in figure (Fig.1). For CK at the baseline, there was no significant difference between trials. Concentration of serum CK in LGI group was less than HGI and Pla groups. CK was significantly elevated above baseline values at all- time points after exercise in 3 groups (all P < 0.05), but there was no significant difference for CK between 3 groups (Fig.2).

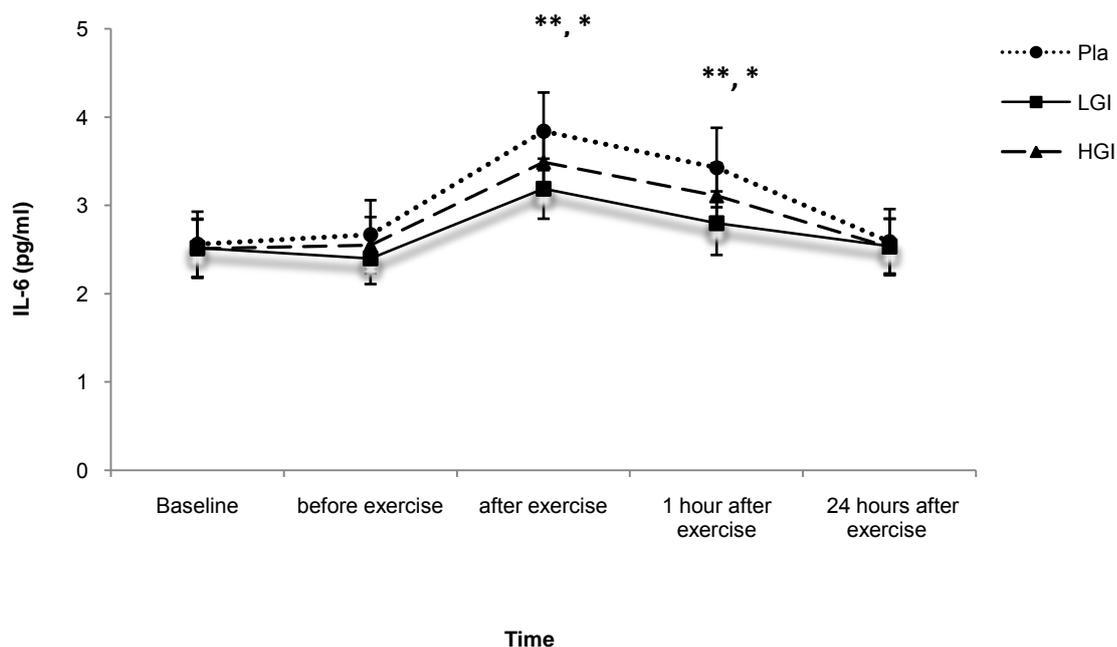


Fig. 1 Mean concentration of plasma IL-6 for Pla, LGI and HGI diet groups at the various time points. Significant differences between Pla and LGI (treatment effect) are indicated with (**) where $P < 0.05$; where $P < 0.05$; Significant differences from baseline (time effect) are denoted by (*) where $P < 0.05$. Solid black bar represents resistance exercise bout; Pla = placebo, LGI = Low glycemic index, HGI = High glycemic index. Values are mean \pm SE.

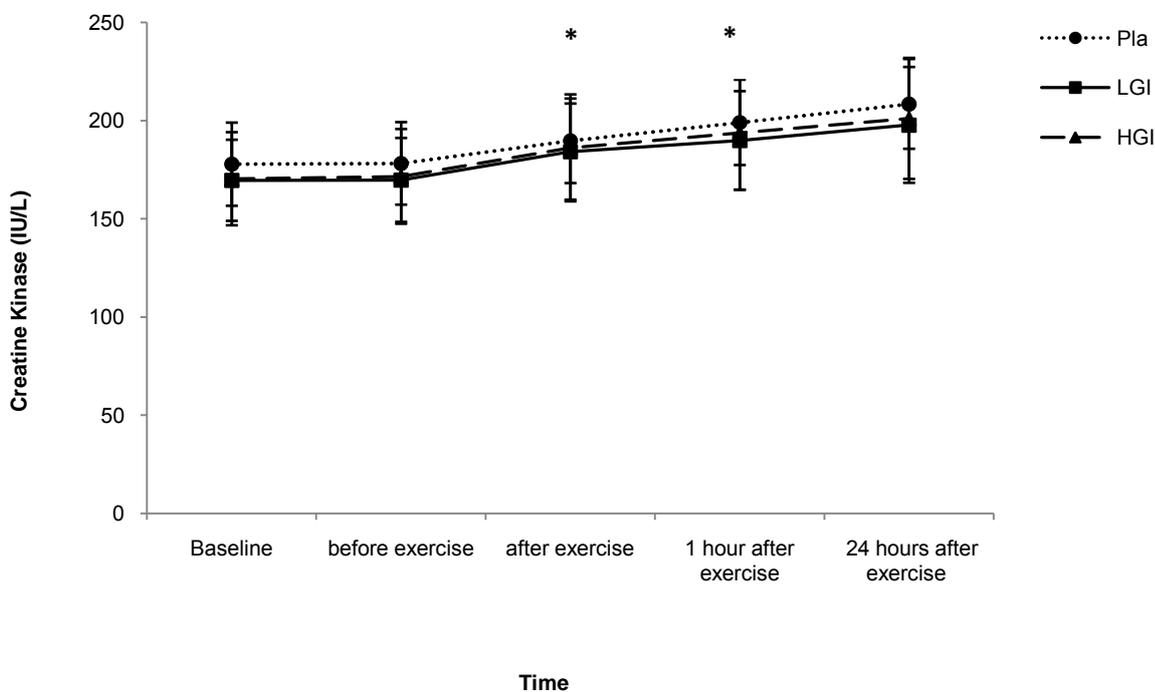


Fig. 2. Mean concentration of serum CK for Pla, LGI and HGI diet groups at the various time points. Significant differences from baseline (time effect) are denoted by (*) where $P < 0.05$. Values are mean \pm SE. Pla = placebo, LGI = Low glycemic index, HGI = High glycemic index.

Blood glucose

At the baseline, there was no significant difference for glucose between trials. Concentration of glucose in HGI group was more than LGI and Pla groups, the serum concentration of glucose increased significantly above baseline values at before exercise and decrease significantly after exercise in LGI and HGI groups (all $P < 0.05$). Furthermore there was significant difference for glucose between placebo with low glycemic groups ($P=0.00$) and placebo with high glycemic in before exercise ($P=0.00$), also placebo with low glycemic groups ($P=0.00$) and placebo with high glycemic in after exercise ($P = 0.01$) (Fig.3).

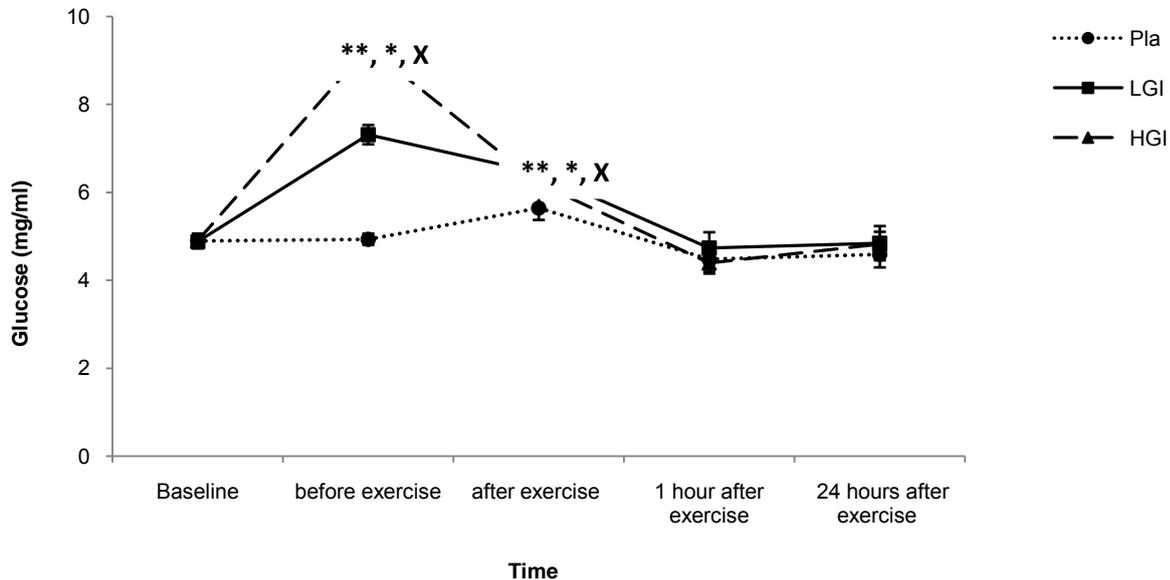


Fig. 3. Mean concentration of serum glucose for Pla, LGI and HGI diet groups at the various time points. Significant differences between Pla and LGI (treatment effect) are indicated with (**) where $P < 0.05$; Significant differences between Pla and HGI (treatment effect) are indicated with (X) where $P < 0.05$ Significant differences from baseline (time effect) are denoted by (*) where $P < 0.05$. Solid black bar represents resistance exercise bout; Pla = placebo, LGI = Low glycemic index, HGI = High glycemic index. Values are mean \pm SE.

Discussion

To our knowledge, this may be the first study that directly determined the role of GI as beverage on immune responses during endurance exercise. The major finding of the present study revealed that the consumption of a LGI beverage, before endurance exercise decreased the elevation of plasma IL-6 concentrations immediately after exercise and during the 1 h recovery period compared with the HGI and Pla groups. These responses were accompanied by an attenuated increase in serum CK concentrations in LGI group compared with the HGI and Pla groups at the end of the 1 h recovery period.

It has been reported that the noticeable increase in circulating IL-6 concentrations are related to exercise intensity, duration, mass of muscle involved, and endurance capacity (Bishop et al., 2001; Matthys et al., 1995). In the present study, IL-6 increased immediately after exercise significantly. Recent studies demonstrate that IL-6 is produced by skeletal muscles contraction during exercise and this release also related to contraction and low muscle glycogen (Bishop et al., 1999). On the other hand most studies of CHO intervention have used continuous prolonged exercise of fixed intensity (%VO₂max) and duration and CHO ingestion in this situation is effective in minimizing perturbations in circulating stress hormones and immune responses (Bishop et al., 2001; Li et al., 2004). CHO ingestion attenuated elevations in plasma IL-6 during both running and cycling mainly because of its effect at the post-transcriptional level of IL-6 (Nieman et al., 1998; Pedersen et al., 2008; Nehlsen et al., 1997), whereas low muscle glycogen concentrations further enhanced IL-6mRNA and the transcription rate for IL-6 (Steensberg et al., 2003). Therefore, muscle glycogen content appears to be an important stimulus for IL-6 which acts as an energy sensor. However, in our finding IL-6 in LGI group was significantly less than HGI and Pla groups. In endurance exercise minimizing the glycemic response could sustain CHO supply during exercise, that cause to decrease the cortisol response, IL-6 and other inflammatory biomarkers (Bishop et al., 2001), however a HGI diet could increase pro-inflammatory cytokine (Kirwan et al., 2001). HGI diet is the exacerbation of glucose spike that occurs immediately after eating this spike could alter glucose and insulin dynamics during exercise (Pittas et al., 2006), which was in agreement with the findings in our present study.

Creatine kinas (CK) is an enzyme normally found only in skeletal muscle that used as an indirect marker of muscle damage in the present study. CK was measured during the time in three conditions and increasing observed over the time. Concentration of serum CK in LGI group was less than HGI and Pla groups but there were no significant changes in CK between conditions. The phenomena of peak CK at 48 hours post-exercise as seen in the LGI group is also not uncommon (Malm et al. 2004). This difference could be a result of a gradually increase in insulin following

consumption of a LGI diet versus the HGI diet before exercise. Insulin is a powerful promoter of protein synthesis (Cockburn et al., 2010). On the other hand CK can be elevated for several days in individuals (Miles et al., 2010) because of this our protocol couldn't have significant effect on CK concentration.

Conclusion

The consumption of the LGI beverage before exercise could minimize the increasing of plasma IL-6 concentration immediately after exercise and during the 1 h recovery period compared with the HGI beverage and Pla. This acute improvement is consistent with studies that have noticed the benefits of a LGI diet as most evident in individuals who follow this diet long-term. This result suggested that the LGI beverage consumed as pre-exercise meal could modify the inflammatory response in prolonged exercise. Further research is needed to establish the connection between glucose kinetics of GI meal and immune function.

Conflict interests

The authors declare they have no conflict interests.

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