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ABSTRACT

The purpose of this study was to examine the influences of carbohydrate (CHO) mouth rinse on self-selected running speeds, heart rate and psychological response during a 30-min treadmill run. Twelve endurance-collegiate male athletes (N=12) age 22.33 ± 0.63, mean height 169 ± 5.89 m, and mean body weight 62.57 ± 7.69 kg performed two trials that have one-week interval of crossover study. Each trial involved a 10-min warm-up at 60% HRmax followed by a 30-min run. The run was performed on an automated treadmill that allowed the spontaneous selection of speeds without manual input. Participants were asked to mouth rinsing with either a 6% CHO or taste-matched placebo (PLA) solution. Parameters measured include self-selected speed during treadmill running, heart rate and psychological responses (feeling arousal scale, feeling scale, gastrointestinal scale). Significant interaction between groups across experimental sessions were noted on three parameters ($p<.05$). The CHO mouth rinse group showed improvements of heart rate, feeling scale and feeling arousal scale compare to control group during treadmill running. These findings demonstrated that 6% CHO mouth rinse is effective in improving performance of moderate intensity running physiologically and psychologically.

Keywords. *CHO mouth rinse, moderate intensity running, physiology, psychology*

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INTRODUCTION

The role of carbohydrate (CHO) has been highlighted as the important energy source for sports performance and recovery especially for endurance sport (Thomas, Erdman, Burke, 2016). The ergogenic mechanism of CHO is believed to promote significant sparing effect in muscle glycogen utilization (Baltazar-Martins & Del Coso, 2019; Brietzke et al., 2019; Tsintzas et al., 1996; Hargreaves et al., 1984) and enhancement of cognitive function by improving mood states during prolonged exercise (Sun, Cooper & Tse, 2020; Colardeau et al., 2001; Keith et al., 1991). Plausibly, the improvement in cognitive function can be explained by alteration in neurotransmitter activity that could positively influence cognition, mood, motivation and motor skill performance (Dobbin et al., 2022; Backhouse et al., 2007).

There are a number of evidences to show that CHO intake can also enhances the exercise capacity by regulating glucose oxidation in the later stage of exercise performance where the muscle glycogen concentration is low (Baltazar-Martins & Del Coso, 2019; Thomas et al, 2016; Coyle, 1992; Hargreaves & Briggs, 1988; Coyle et al, 1986). Besides that, the beneficial effect of CHO is also theorized to be associate with the changes in metabolite of muscle fibers and the reduction in glycogen utilization in the type I muscle with CHO ingestion (Baltazar-Martins & Del Coso, 2019; Brietzke et al., 2019; Tsintzas et al., 1996; Backhouse et al., 2005; Neufer et al, 1987). This leads to the delay onset of fatigue during exercise performance (Baur et al, 2019). CHO ingestion maintains plasma glucose level, saves glycogen storage and prolonged exercise performance (Brietzke et al., 2019; Tsintzas et al., 1996).

However, gastrointestinal (GI) discomfort caused by the consumption of CHO in both solid and liquid form is one of the challenges faced by athletes during competition and performance (Amstrong, 2021; Rehrer, 2001; Rehrer et al., 1989) Several studies (Rehrer et al, 1989, Beelan et al., 2009) revealed that CHO ingestion can lead to nausea, vomiting, abdominal cramps and diarrhea among 37-47% of marathon runner. According to Amstrong (2021) and Rehrer et al. (1989) , the ergogenic effect from consuming the CHO during competition not able to benefit some of the athletes due to GI distress.

One of the alternative nutritional intervention that can potentially negate this GI issue of CHO ingestion is carbohydrate mouth rinse. CHO mouth rinse is an intervention which involves spitting expulsion as fluid distribute around the mouth for 5 to 10 seconds (Chambers, Bridge & Jones, 2009). Several studies observed improvement in endurance performance (long duration cycling and running) following CHO mouth rinse regimen protocol (Baltazar-Martins & Del Coso, 2019; Brietzke et al., 2019; Rollo & Williams, 2011; Chambers et al., 2009). The exact mechanism which explained CHO mouth rinse superiority is still lacking, but past studies have speculated that a group of receptor in oral cavity connected with reward areas in the brain (e.g. insula operculum, orbitofrontal cortex and striatum) potentially lower the perception of exertion during performance (Chambers et al., 2009; Backhouse et al., 2007).

However, the magnitude of improvement between studies looking at ergogenic effect of CHO mouth rinse have been inconsistent (Sinclair et al., 2014; Rollo & Williams, 2011;

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Beelan et al, 2009). Notably, in addition, a large amount of published studies has either investigate the CHO mouth rinse effect on elite or untrained participants (Sinclair et al., 2014; Rollo & Williams, 2011; Beelan et al, 2009). Whether a similar or greater improvement can be realized on moderately trained collegiate athletes with CHO mouth rinse intervention is relatively unknown. Therefore, the present study aims to investigate the effect of CHO mouth rinse on self-selected speed, heart rate and psychological response during 30 min treadmill run in collegiate athletes' population.

METHODS

Subjects

Twelve endurance-collegiate male athletes (N=12) age 22.33 ± 0.63 were recruited for this study. The inclusion criterion for the potential participant were include; training at least 3 to 5 days per week, healthy and free from injury and non-smoker. Written informed consent was obtained from all participants prior to the commencement of the study following detailed explanation of the experimental protocol, associated risks, and potential benefits of participation. All procedures were conducted in accordance with the Declaration of Helsinki and approved by the Institution's Ethics Committee.

Experimental Protocol

All subjects participated in a crossover study with an interval of one week between each trial day (2 trial sessions). The 30 minutes trials on treadmill consists of: (1) 2 min walk; (2) 10 min warm-up 60% of HRmax; (3) 30 min treadmill self-selected speed running and (4) cooling down. On the day of the trial, subjects arrived at gymnasium between 8.00 a.m. and 8.30 a.m. after having fasted for 10 hours. During the main trials, subject start with 2 min walk on the treadmill before undergoes the 10 minutes warm up with 60% HRmax and 30 minutes self-selected speed running and finished with 2 minutes of cooling down. The heart rate monitor (Magene) was used to monitor the subject heart rate throughout the trials to achieve target exercise intensity.

The trials consist of moderate intensity of treadmill running. Subject undertook treadmill running protocol which includes 2 min walk and 10 minutes warm up (60% HRmax) prior to 30 minutes self-selected speed run. Preceding the test, 2 minutes cooling down were allocated to each participant. The heart rate, Feeling Scale (Hardy & Rejeski, 1989), Feeling Arousal Scale (Svebak & Mugatroyd, 1985) and Gastrointestinal Scale (Revicki, 1998) were recorded at 3-, 6- and 9-min of 10 minutes' warm-up and also during 5- and 30-min treadmill running protocol.

During the main trials, each subject was required to mouth-rinse the oral cavity with liquid for 5 secs containing either 6.0g/100ml CHO solution or taste-matched placebo (PLA). Each mouth rinse was provided immediately within the 10 minutes warm-up with 60% HRmax,

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at 3-min, 6-min and in 9-min. Additionally, the CHO intervention was also provided at every 5 minutes during the 30-min treadmill running. Self-selected running speed of the subjects were taken at every 5-min of the 30-min running protocol.

Measurements

Heart Rate and Body Composition.

Specific formula has been used to determine maximum heart rate of individual (220-age = Maximum Heart Rate). Heart rate was continuously recorded and supervised during the test using an HR monitor (Magene, CHINA). Screening session was conducted to determine body composition and anthropometric measurements. Body mass index (BMI) and body fat percentage of participants were recorded. Bioelectrical impedance analysis (BIA) (Omron, USA) was used to measure the body fat percentage.

Psychological Indices.

The Feeling Scale (FS) (Hardy and Rejeski, 1989) was used to assess subject's emotions as the affectionate characteristic of pleasure disappointment. This FS scale is a rating scale of 11-point single item ranging from -5 to +5. Anchors range from very good (+5) to very bad (-5) at 0 level (neutral). The participants were instructed to mark the scale, based on their feelings at the time of completion. The Feeling Arousal Scale (FAS) is the level of perceived activation arousal scales that consist single item with 6 points. The scale ranges from 1 to 6, with anchors at 1 (low arousal) and 6 (high arousal) and has been utilized in preceding exercise research. Both the FS and FAS has opportunity of most other self-report scales of existence well conducted during exercise. Gastrointestinal (GI) scale assess the discomfort level during running which measures in 12 points scale, with 0 neutral, 4 unpleasant, 8 very unpleasant and 12 painful anchors.

Statistical Analysis

Statistical analysis was carried out using Statistical Packaging for Social Sciences (SPSS)Statistics version 24. Repeated measure ANOVA was used to assess the differences in self-selected speed, heart rate and the psychological indices. Descriptive statistics (mean ± SD) was used to report the demographic data of the study. Statistical significance level was accepted at $p<0.05$.

RESULTS

Total of twelve (N=12) male collegiate endurance athletes were participated in this study. The mean age of the subjects were 22.33 ± 0.63 years old, mean height was 169 ± 5.89 m, and mean body weight was 62.57 ± 7.69 kg.The Greenhouse-Geisser corrected degrees of freedom value

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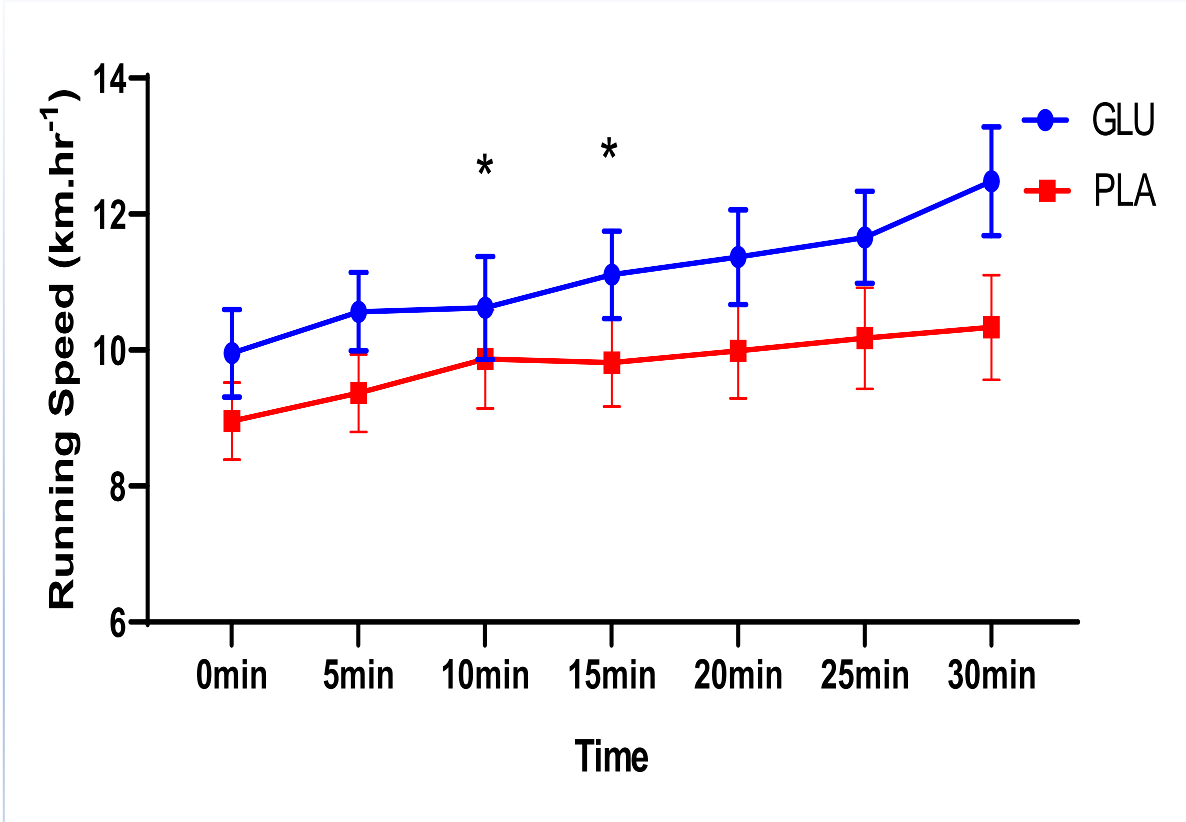
was used for the within-subject factor analysis when the homogeneity of assumption was violated.

Running Speed

Based on the results, no significant interaction between the experimental groups across the experimental sessions was found for running speed (F (1,22 = 2.38, p>.05) . However, the experimental groups showed improvement in the running speed within time trials. Figure 1 presents the descriptive statistics for running speed parameters.



*Significant difference between groups across experimental sessions

Figure 1: Mean ± SD Values of Running Speed

Heart Rate.

The results of repeated measures within between-interaction ANOVA revealed a significant interaction (F(1,22 = 6.83, p<.05) between experimental groups across experimental sessions for heart rate. Pairwise comparisons showed that intervention group reported higher heart rate response based on the mean differences. Figure 2 presents the mean ± SD values of the heart rate response.

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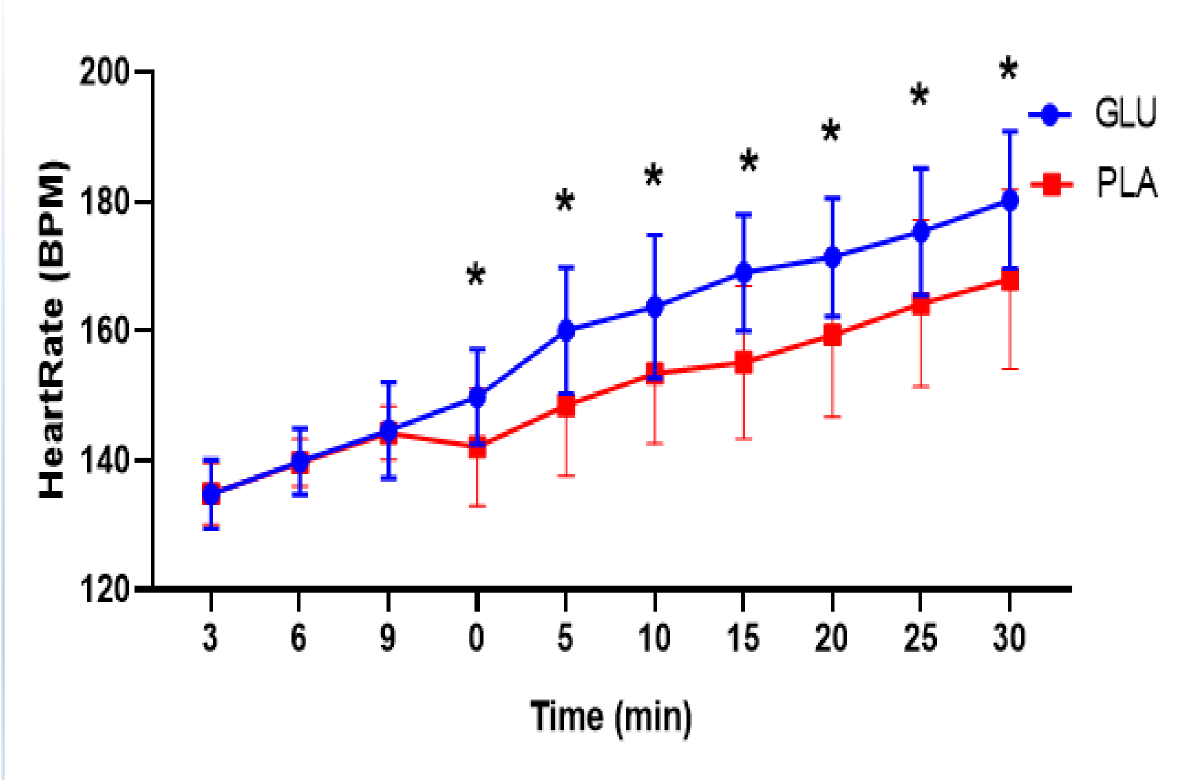

*Significant difference between groups across experimental sessions
Figure 2: Mean ± SD Values of Heart Rate

Psychological Responses.

The psychological response of feeling scale (FS), feeling arousal scale (FAS) and gastrointestinal scale (GS) were presented in Figure 3, 4 and 5. The findings of the Mixed ANOVA showed significant interaction between experimental groups across the experimental sessions for feeling scale (FS) ($F(1,22 = 87.8$, $P<.05$) and feeling arousal scale (FAS) ($F(1,22 = 38.4$, $P<.05$). Pairwise comparisons indicated that glucose mouth rinse group reported better psychological response of feeling scale (FS) and feeling arousal scale (FAS) based on the mean differences. However, no significant interaction ($F(1,22 = .854$, $p>.05$) between experimental group for gastrointestinal scale (GS).

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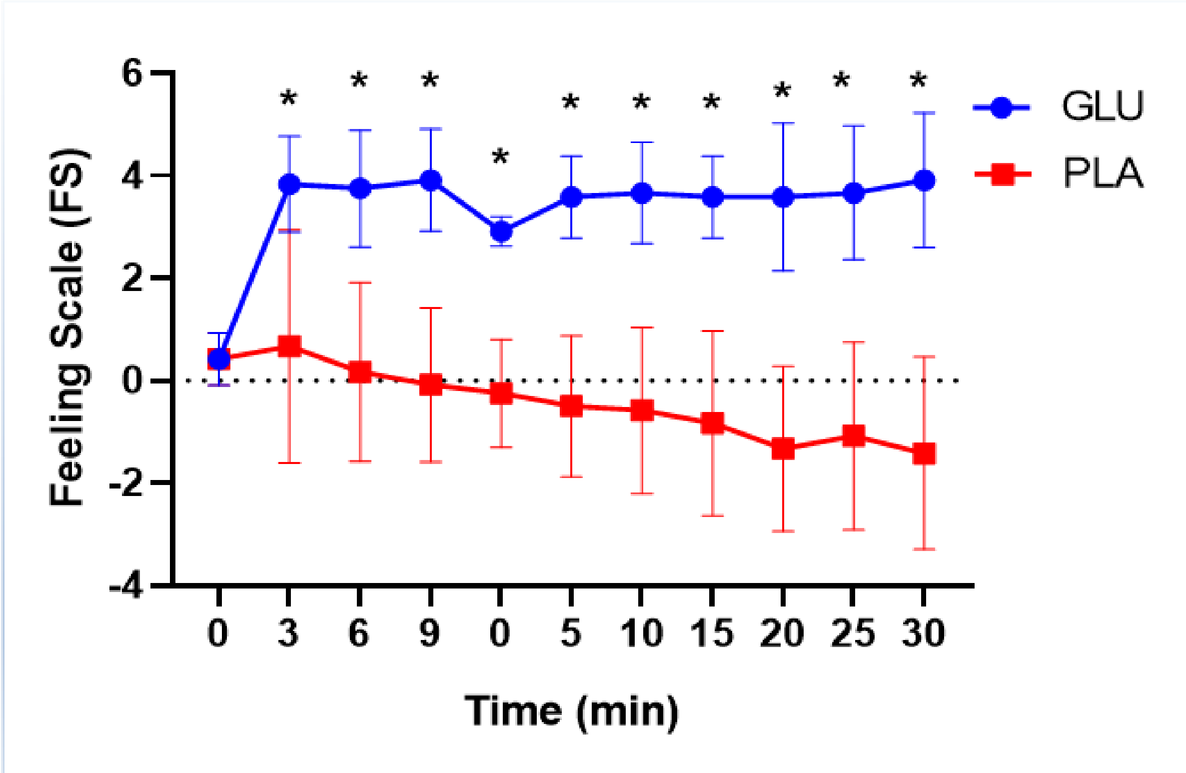

*Significant difference between group across experimental session.

Figure 3: Mean ± SD Values of Feeling Scale (FA)

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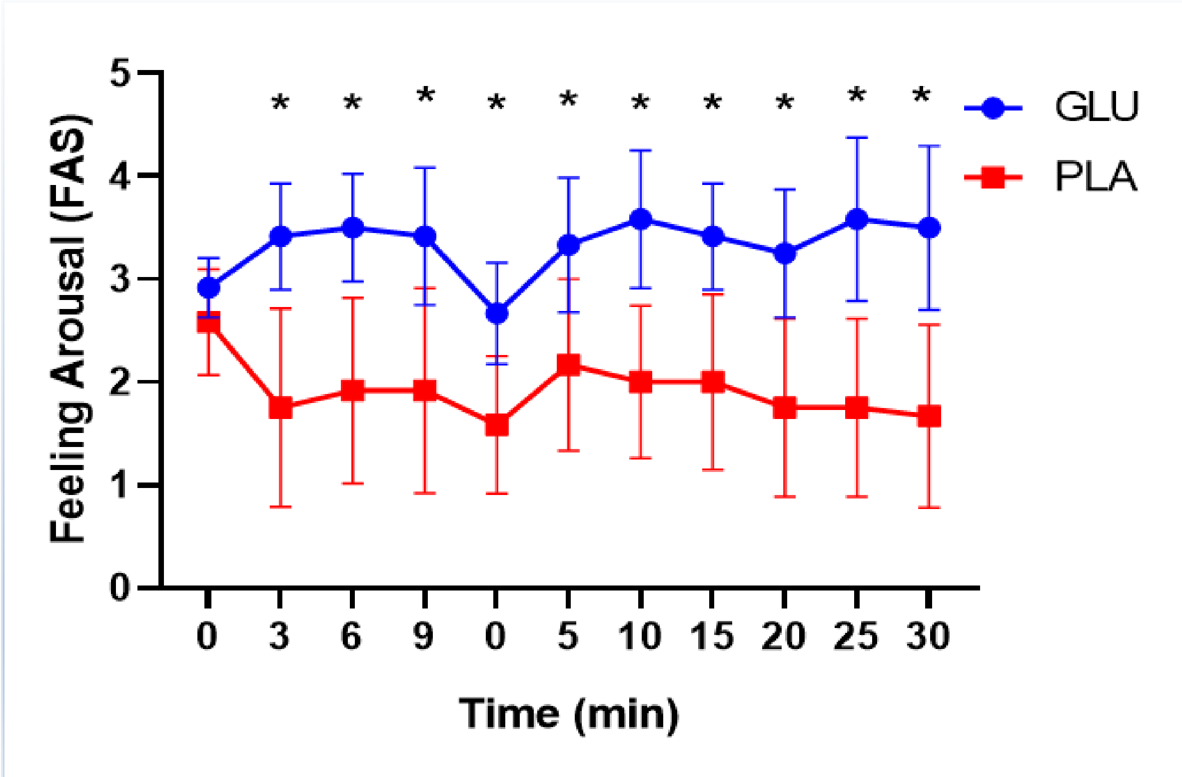

*Significant difference between groups across experimental sessions

Figure 4: Mean ± SD Values of Feeling Arousal Scale (FAS)

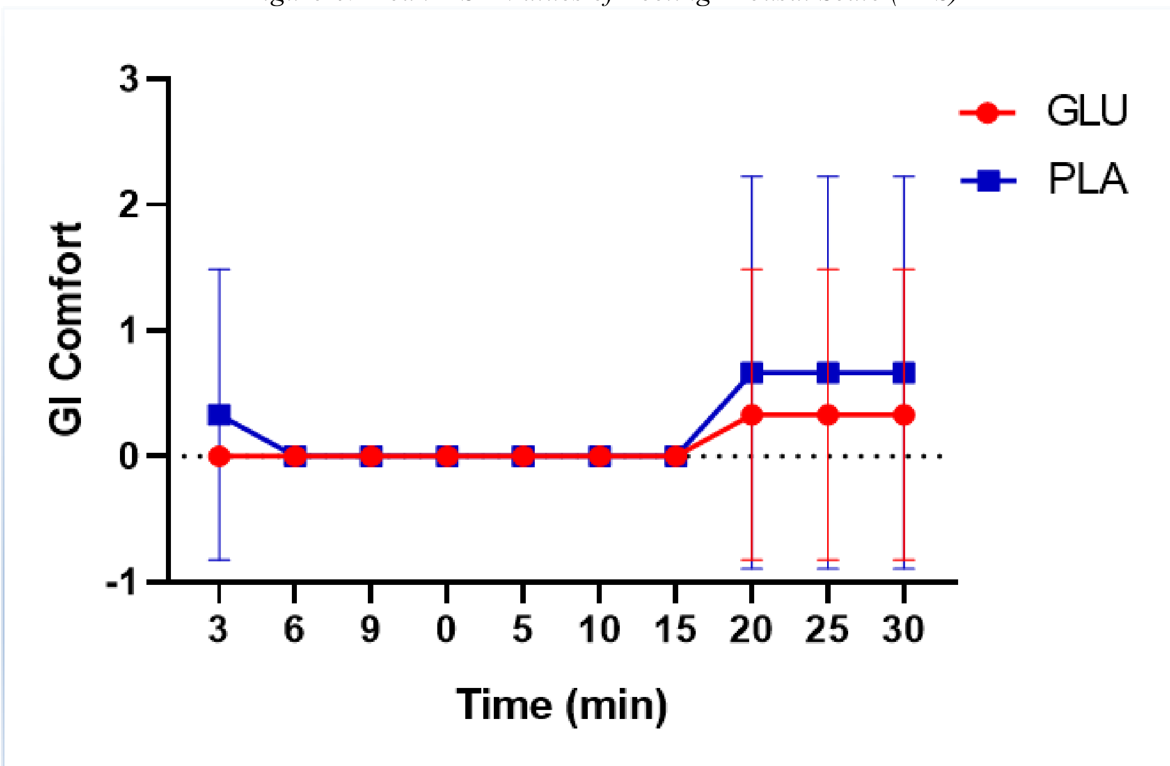

Figure 5: Mean ± SD Values of Gastrointestinal Scale (GI)

DISCUSSION

The aim of this tudy is to investigates the effect of CHO mouth rinse on self-selected speed during 30 min treadmill run. Findings of this study showed that, carbohydrate mouth rinse group reported higher heart rate response during trial due to higher self-selected running speed throughout the 30 minutes treadmill running. It is speculated that, CHO mouth rinse able to reduce perceived intensity of the subject which leads to greater effort of running pace and speed. This result supported by (Luden et al., 2016; Sinclain et al., 2014; Rollo & Williams 2011) which stated that simple sugar during mouth rinsing can alters intensity perceived by the athletes that promotes endurance performance enhancement.

The feeling scale (Hardy and Rejeski, 1989) result showed significant improvement for subjective feeling. This finding shows that the intervention group " feels better " with CHO mouth rinsing during exercise. Positive feeling during exercise may promotes greater psychological experience which leads to better performance as supported by Luden et al. (2016) and Fereira et al. (2018). The feeling arousal scale shows significant improvement with CHO mouth rinsing that allows quantification of participants' perceived level of activation. The participants were optimally activated during the 30 min of exercise and this contributes to the faster self-selected running speed and higher heart rate response for the intervention group (Fereira et al., 2018).

Improvement demonstrated in heart rate, subjective feeling and arousal response reported by the intervention group show advantage of CHO mouth rinsing during exercise. The potential mechanism that explained the beneficial effect of CHO mouth rinse is related to receptors involvement in the oral cavity with connections to the reward area in the brain. Information detected by the receptors with CHO mouth rinsing sends afferent signals to the brain areas that control motivation, motor control and pain tolerance (Fereira et al., 2018). The signals and message from the CHO detection at the mouth capable of modifying motor output that leads to performance enhancement.

Despite the significant benefits of CHO mouth rinsing for above parameters, running speed fail to reject the null hypothesis. However, there is a trend of improvement for self-selection speed throughout the experimental session. This shows that, subjects in the intervention group showed greater effort across experimental session. Reduction of perceived exertion during exercise as shown by the significant improvement of subjective feeling finding promotes higher self-selected work rate for a given sense of effort. In line with previous study done by Baur et al. (2019), rinsing a carbohydrate-containing solution in the oral cavity has been shown to improves effort exertion.

There is no significant difference on gastrointestinal (G.I) discomfort between groups during trials among the runners. Therefore, it shows that 6.0g/100ml CHO solution mouth rinse will not cause G.I discomfort. Contrary to the findings of Rehrer et al. (1989) & Rehrer (2001), we did not find such detrimental discomfort that might threaten exercise performance.

CONCLUSION

In conclusion, CHO mouth rinse improves performance during moderate intensity exercise physiologically (heart rate) and psychologically (feeling scale, feeling arousal scale). However, CHO mouth rinse fails to reject null hypothesis on running speed between groups but there is a trend of increasing self-selection speed throughout the experimental session for the intervention group. The whole mechanism that relates to this improvement is at neural stage where CHO mouth rinse activated certain part of brain regions that enhances and promotes positive sensation such as the pleasure that leads to performance advantage.

Practical Aplication

CHO mouth rinse is one of the alternative nutritional strategy that can be used during endurance performance to counter the side effect of gastrointestinal discomfort from carbohydrate consumption.

Authors' contributions:

Nur Ema Hajirah Hamzah carried out this study and drafted the manuscript,

Sharifah Maimunah Syed Mud Puad participated in the design of the study and wrote the manuscript,

Adam Linoby performed the data analysis and participated in the design of the study,

Mohd Faridz Ahmad and Muhammad Zulqarnain Mohd Nasir reviewed manuscript.

All authors read and approved the final manuscript.

Conflict of Interest

Nur Ema Hajirah Hamzah, Sharifah Maimunah Syed Mud Puad, Adam Linoby, Mohd Faridz Ahmad, Muhammad Zulqarnain Mohd Nasir declare that they have no conflict of interest.

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