Original Article

Effects of post-activation potentiation and carbohydrate mouth rinse on repeated sprint ability

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ABSTRACT

The aim of this study was to investigate the effect of post-activation potentiation (PAP), carbohydrate (CHO) mouth rinse, and the combination of both strategies on repeated sprint ability (RSA). Twenty male soccer players (age = 18.9 ± 0.9 years, body mass = 71.8 ± 5.2 kg, height = 178.2 ± 6.3 cm) randomly performed four experimental conditions before RSA test (six sets of 40 m): (I) placebo (PLA) control, (II) CHO mouth rinse (6% maltodextrin), (III) PAP + PLA, and (IV) PAP + CHO. The PAP protocol involved two sets of five repetitions (80% 1RM) of the back squat exercise. A one-way repeated measures analysis of variance followed by Bonferroni post hoc test was used to compare the experimental conditions. Results indicated that PAP + CHO and PAP + PLA had better results for the variables best sprint time, mean sprint time, and total sprint time compared with CHO and PLA (p<0.001; small effect size). No significant interaction between the experimental conditions was observed for the variable RSA performance decrement, and no significant difference between conditions, i.e., PAP + CHO vs. PAP + PLA and CHO vs. PLA control was found. In conclusion, PAP positively affects RSA performance in soccer players; however, the combination of PAP and

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CHO mouth rinse showed no additional effect. **Keywords:** Ergogenic aid, Soccer, Sprint time, Fatigue, Performance.

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INTRODUCTION

Techniques/practices or substances used prior to physical exercise for the purpose of enhancing work capacity are identified as ergogenic aids (Thein et al., 1995). An ergogenic aid can increase athletic performance in different mechanisms (i.e., mechanical, physiological, and/or psychological); however, the interaction and combination of different ergogenic strategies remain poorly investigated (Naderi et al., 2016).

Repeated sprint ability (RSA), which is defined as the performance of repeated sprints, with each sprint separated by a short recovery interval (Spancer et al., 2005), is recognized as an important component in intermittent sports, such as rugby, handball, and soccer. Thus, strategies for the acute improvement of RSA performance could be of great interest for strength and conditioning coaches. Moreover, studies have shown that resistance exercises with low volume and moderate/high-intensity load can acutely enhance sprint performance, with distances between 5 and 40 m (McBride et al., 2005; Chatzopoulos et al., 2007; Yetter and Moir, 2008; Bevan et al., 2010; Seitz et al., 2014; Evetovich et al., 2015), which has been attributed to post-activation potentiation (PAP). In addition, two mechanisms are proposed: (a) regulatory myosin light chain phosphorylation, with increased sensitivity of actin-myosin myofilaments to calcium during subsequent muscle contractions and (b) increased recruitment of high-threshold motor units (Tillin and Bishop, 2009).

Carbohydrate (CHO) mouth rinsing is another strategy for endurance performance, which is recently investigated (Rollo and Willians, 2011). The mechanisms involved are not fully elucidated; nevertheless, CHO possibly stimulates taste receptors and neurophysiological pathways, which in turn could influence physical performance (Jeukendrup and Chambers, 2010). Additionally, previous studies using functional magnetic resonance imaging indicated that rinsing with CHO solutions stimulates brain regions associated with motivation and neuromotor control (Chambers et al., 2009; Gant et al., 2010; Turner et al., 2015). These data indicate that mouth rinsing with CHO without ingestion possibly has a non-metabolic effect, which may in turn influence high-intensity and short-duration activities. Few studies investigated the effects of CHO mouth rinse on sprint performance (CHONG et al., 2011; BEAVEN et al., 2013; BORTOLLOTI et al., 2013; PHILLIPS et al., 2014; PŘIBYSLAVSKÁ et al., 2015), with some evidence reporting positive results for single sprint performance (PHILLIPS et al., 2014) and repeated sprint performance (BEAVEN et al., 2013) on a cycle ergometer.

Theoretically, with the acute improvement of physical performance in different ways, our initial hypothesis is that PAP improves RSA and that CHO mouth rinse with PAP has an additional effect on performance. Therefore, this study aims to investigate the effect of PAP and CHO mouth rinse, both alone and combined, on repeated sprint performance in soccer players.

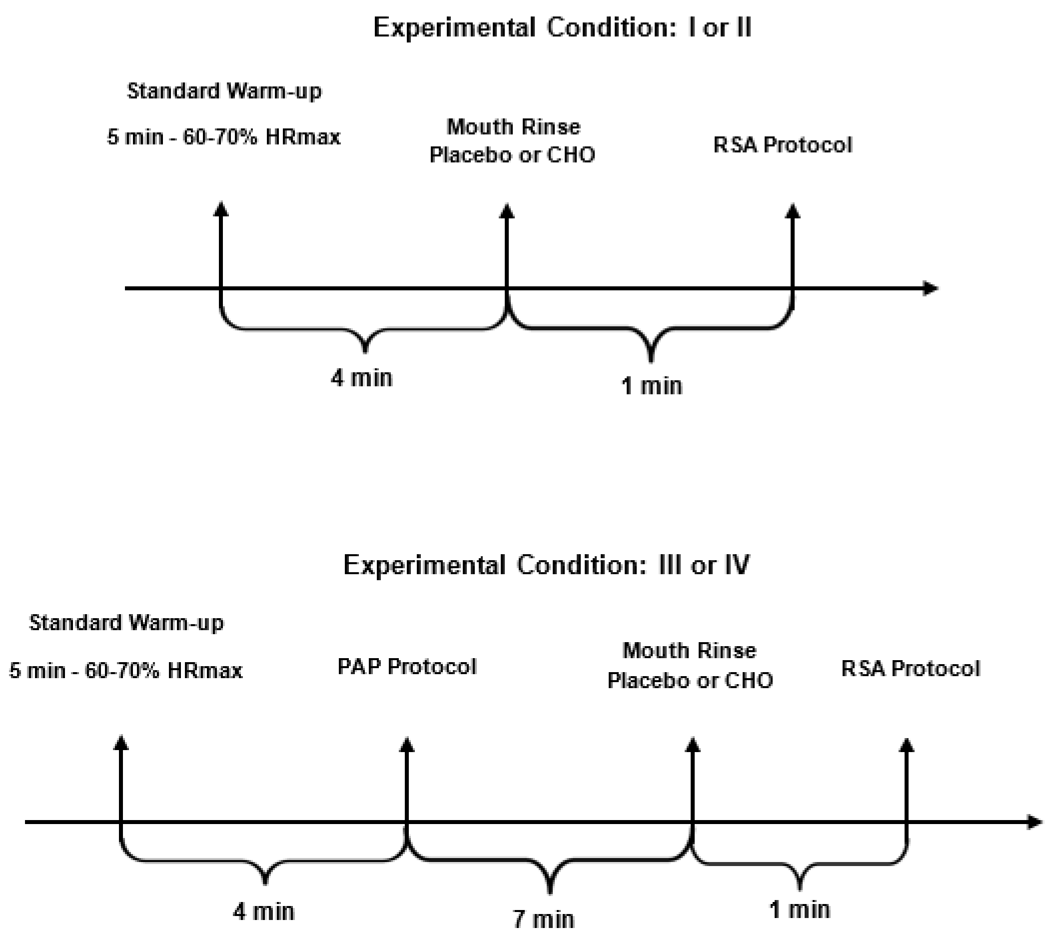
MATERIAL AND METHODS

Experimental Approach to the Problem

This is a randomized, double-blind, placebo-controlled study that investigated the effects of PAP, CHO mouth rinse, and the combination of both strategies on RSA in soccer players. A week before the first experimental bout, the subjects visited the laboratory to determine their maximum muscle strength (1RM test) using the back squat exercise and for familiarization with the RSA test. The experiment involved four test bouts with a 24-h rest interval. Prior to each RSA test, the subjects had one of the following experimental conditions: (I) placebo (PLA) control, (II) CHO mouth rinse, (III) PAP + PLA, and (IV) PAP + CHO mouth rinse.

An independent researcher prepared the rinse solutions (CHO and PLA), randomly assigned the experimental conditions among the subjects (software) and revealed the solutions and sequence after data collection. Before each experimental condition, the subjects performed a standard warm-up exercise, consisting of 5-min treadmill running with an intensity between 60 and 70% of the maximum heart rate (Tanaka et al., 2001).

The rest interval after the warm-up for the PAP protocol was 4 min. The rest interval after PAP for mouth rinsing (PLA or CHO) was 7 min. The RSA test was performed 1 min after the mouth rinse (PLA or CHO). The subjects were instructed not to consume any food at least 2 h before each experimental condition, to abstain from alcohol and caffeine during the study period, and not to perform intense physical activities. Figure 1 illustrates the experimental design of the study.



HRmax = maximum heart rate; PAP = post-activation potentiation; CHO = carbohydrate; RSA = repeated sprints ability

Figure 1. Experimental design of the study

Subjects

Twenty under-20 male soccer players (age = 18.9 ± 0.9 years; body weight = 71.8 ± 5.2 kg; height = 178.2 ± 6.3 cm) volunteered to participate in this study. All subjects were in the same soccer team competing in national-level competitions. The number of subjects was determined through a G-power analysis using the data of RAS best time from our pilot study; twelve subjects per group were shown to be necessary based on effect size (0.8), alpha level of 0.05 and power (1-β) of 0.90.

The inclusion criteria in this study were as follows: (a) those who have experience with the modality for at least 2 years with their current sports, (b) those who have experienced back squat exercise and 1RM test, and (c) those who have experienced RSA test. The exclusion criteria were the following: (a) any type of injury that could interfere with the study and (b) use of nutritional supplements. All subjects completed a questionnaire for health status assessment and signed a consent form after being informed about the benefits and risks of the experimental procedures. This study was approved by the Local Research Ethics Committee (protocol number: 1.717.565).

Procedures

Repetition Maximum (RM) Test

Maximum muscle strength in the back squat exercise was determined by the 1RM test. Prior to initiating the test protocol, subjects performed a standardized warm-up exercise, which consisted of two sets of ten repetitions with 40-60% of the estimated 1RM external load. After a 5-min rest, they were instructed to perform a single maximum movement (eccentric and concentric) to failure in the back squat exercise. For an unsuccessful attempt, the external load was adjusted by 5-10%, until a 1RM movement with an adequate technique is produced. The squat exercise was performed using a guided bar (Smith equipment – to ensure a greater stability among the participants) at a cadence of 3 s for eccentric and concentric muscle action, with the aid of a metronome (60 beats per minute).

To validate the 1RM test, the subjects were instructed to perform knee flexion up to 90° during the eccentric phase. A researcher visually monitored the range of motion, and two spotters were present next to the exercise bar to ensure the safety of the subjects. The test was performed with a maximum of five attempts and with a 5-min rest in between each attempt.

Post-Activation Potentiation (PAP) Protocol

The PAP protocol involved two sets of five repetitions of the back squat exercise, with an external load at 80% of 1RM and with a 2-min rest in between the sets. The subjects were instructed to perform knee flexion up to 90° during the exercise. The PAP protocol (moderate load, multiple sets and rest interval of 7 minutes after the conditioning activity) was chosen according to meta-analysis study (Wilson et al., 2013).

Carbohydrate (CHO) and Placebo (PLA) Mouth Rinse

The CHO solution contained 6% (w/v) maltodextrin (no flavour and colour) diluted in mineral water. For the placebo solution, non-caloric sweetener (sucralose) diluted in mineral water was used; its appearance is not different from that of the CHO solution. The subjects received 25 mL of the solution (CHO or placebo) and were instructed to rinse the mouth for 10 s and not to ingest the solution and to subsequently expel the solution into a bowl.

Repeated Sprint Ability (RSA) Test

The RSA protocol consisted of six sprints of 40 m (back and forth = 20 + 20 m), with 20 s of passive rest between sprints. The subjects were instructed to start each sprint behind the starting line (0.5 m), run for 20 m until reaching the delimiting tape with any foot, and return to the starting line. The time to completion was recorded by photocells (CEFISE, Nova Odessa, São Paulo, Brazil).

The test was performed in a covered gymnasium to avoid environmental interference (e.g., wind and rain) during the four experimental conditions. Moreover, during the study period, the subjects were instructed to wear the same footwear and sports clothing in performing the test. For analysis, the data on the following were determined: best sprint time (shortest time), mean sprint time (mean time of six sprints), total sprint time (sum of six sprint times), and percentage performance decrement ([mean time/best time × 100] - 100).

Statistical Analyses

Normality of the data was evaluated by the Shapiro-Wilk test. A one-way repeated measures of analysis of variance was used to compare the differences between experimental conditions. When a significant interaction effect was detected, a Bonferroni post hoc test was employed. The level of significance was set at $p<0.05$. Cohen's formula for effect size (ES) was also used for the comparison of the experimental conditions (Cohen, 1988). The thresholds of magnitude adopted were as follows: ≤0.19, trivial; 0.20-0.59, small; 0.60-1.19, moderate; 1.20-1.99, large; and ≥2.00, extremely large (Hopkins et al., 2009). Data are expressed as mean ± standard deviation (95% confidence interval).

RESULTS

Table 1 shows the best sprint time, mean sprint time, and percentage performance decrement in the experimental conditions. Data on the ES between the experimental conditions are shown in Table 2.

Table 1. Repeated sprint ability test variables (n = 20)

	Mean ± SD			
	PLA control	**CHO**	**PAP + PLA**	**PAP + CHO**
Best Sprint Time (s)	7.12 ± 0.26 (95% CI: 7.00; 7.24)	7.14 ± 0.23 (95% CI: 7.03; 7.24)	7.03 ± 0.24 [a.b] (95% CI: 6.91; 7.14)	7.00 ± 0.25 [a.b] (95% CI: 6.89; 7.12)
Mean Sprint Time (s)	7.46 ± 0.29 (95% CI: 7.33; 7.60)	7.47 ± 0.24 (95% CI: 7.36; 7.58)	7.36 ± 0.27 [a.b] (95% CI: 7.23; 7.49	7.35 ± 0.26 [a.b] (95% CI: 7.23; 7.47)
Total Sprint Time (s)	44.76 ± 1.73 (95% CI: 43.95; 45.57)	44.80 ± 1.42 (95% CI: 44.14; 45.47)	44.16 ± 1.63[a.b] (95% CI: 43.40; 44.92)	44.12 ± 1.53[a.b] (95% CI: 43.40; 44.84)
Performance Decrement (%)	4.80 ± 1.23 (95% CI: 4.22; 5.38)	4.62 ± 1.32 (95% CI: 4.00; 5.24)	4.74 ± 1.53 (95% CI: 4.01; 5.44)	5.01 ± 1.53 (95% CI: 4.49; 5.54)

[a] *Significantly different (p < 0.05) from PLA control condition*
[b] *Significantly different (p < 0.05) from CHO condition*

Table 2. Cohen's d effect size values between experimental conditions

	CHO vs. PLA control	PAP + PLA vs. PLA control	PAP + CHO vs. PLA control	PAP + PLA vs. CHO	PAP + CHO vs. CHO	PAP + CHO vs. PAP + PLA
Best Sprint Time (s)	-0.08 (trivial) (95% CI: -0.96; 0.79)	0.36 (small) (95% CI: -0.52; 1.24)	0.47 (small) (95% CI: -0.42; 1.36)	0.47 (small) (95% CI: -0.42; 1.36)	0.58 (small) (95% CI: -0.31; 1.48)	0.12 (trivial) (95% CI: -0.75; 1.00)
Mean Sprint Time (s)	-0.04 (trivial) (95% CI: -0.91; 0.84)	0.36 (small) (95% CI: -0.53; 1.24)	0.40 (small) (95% CI: -0.49; 1.28)	0.43 (small) (95% CI: -0.46; 1.32)	0.48 (small) (95% CI: -0.41; 1.37)	0.04 (trivial) (95% CI: -0.84; 0.91)
Total sprint Time (s)	-0.02 (trivial) (95% CI: -0.90; 0.85)	0.36 (small) (95% CI: -0.53; 1.24)	0.39 (small) (95% CI: -0.49; 1.28)	0.42 (small) (95% CI: -0.47; 1.30)	0.46 (small) (95% CI: -0.43; 1.35)	0.02 (trivial) (95% CI: -0.85; 0.90)
Performance Decrement (%)	0.14 (trivial) (95% CI: -0.74; 1.02)	0.04 (trivial) (95% CI: -0.83; 0.92)	-0.15 (trivial) (95% CI: -1.03; 0.73)	-0.08 (trivial) (95% CI: -0.96; 0.79)	-0.27 (small) (95% CI: -1.15; 0.61)	-0.18 (trivial) (95% CI: -1.05; 0.70)

Best Sprint Time

A significant interaction between the experimental conditions ($F = 12.22$, $p<0.001$) for the best sprint time values was noted. The post hoc test showed a significant difference between PAP+ CHO vs. PLA control ($p<0.001$, $\Delta = -1.61 \pm 1.79\%$; small effect size) and PAP + CHO vs. CHO ($p<0.001$, $\Delta = -1.89 \pm 1.74\%$; small effect size). A significant difference between PAP+ PLA vs. PLA control ($p = 0.008$, $\Delta = -1.25 \pm 3.60\%$; small effect size) and PAP + PLA vs. CHO ($p<0.001$, $\Delta = -1.54 \pm 1.68\%$; small effect size) was found. No significant differences ($p>0.05$) between PAP+ CHO vs. PAP + PLA ($\Delta = -0.36 \pm 1.22\%$; trivial effect size) and CHO vs. PLA control ($\Delta = 0.30 \pm 1.73$; trivial effect size) were observed.

Mean Sprint Time

A significant interaction between the experimental conditions ($F = 11.94$, $p<0.001$) for the mean sprint time values was observed. The post hoc test revealed a significant difference between PAP+ CHO vs. PLA control ($p<0.001$, $\Delta = -1.41 \pm 1.82\%$; small effect size) and PAP + CHO vs. CHO ($p<0.001$, $\Delta = -1.53 \pm 1.45\%$; small effect size). A significant difference between PAP+ PLA vs. PLA control ($p = 0.001$, $\Delta = -1.32 \pm 1.59\%$; small effect size) and PAP + PLA vs. CHO ($p<0.001$, $\Delta = -1.44 \pm 1.41\%$; small effect size) was also evident. No significant differences ($p>0.05$) between PAP+ CHO vs. PAP + PLA ($\Delta = -0.08 \pm 0.88\%$; trivial effect size) and CHO vs. PLA ($\Delta = 0.13 \pm 1.79\%$; trivial effect size) were observed.

Total Sprint Time

A significant interaction between the experimental conditions ($F = 11.94$, $p<0.001$) for the total sprint time values was observed. The post hoc test showed a significant difference between PAP+ CHO vs. PLA control ($p<0.001$, $\Delta = -1.41 \pm 1.82\%$; small effect size) and PAP + CHO vs. CHO ($p<0.001$, $\Delta = -1.53 \pm 1.45\%$; small effect size). In addition, a significant difference between PAP+ PLA vs. PLA control ($p = 0.001$, $\Delta = -1.32 \pm 1.59\%$; small effect size) and PAP + PLA vs. CHO ($p<0.001$, $\Delta = -1.44 \pm 1.41\%$; small effect size) was found. No significant difference between PAP+ CHO vs. PAP + PLA ($\Delta = -0.08 \pm 0.88\%$; trivial effect size) and CHO vs. PLA ($\Delta = 0.13 \pm 1.79\%$; trivial effect size) was noted.

Percentage Performance Decrement

No significant interaction between the experimental conditions (F = 0.496, p = 0.686) for the variable percentage performance decrement was observed.

DISCUSSION

The aim of this study was to investigate the effect of PAP, mouth rinse with CHO, and the combination of both strategies on RSA. Our main finding was that PAP resulted in RSA improvement among soccer players. Thus, the initial hypothesis of this study was partially confirmed because PAP alone improved the RSA. However, no improvement in RSA with CHO mouth rinse alone was observed, and both strategies (PAP + CHO) showed no additional effect on the performance of repeated sprints.

PAP is a phenomenon where there is an increase in physical performance after a voluntary muscular contraction with moderate/high-intensity, which is termed as previous contractile conditioning (Hodgson et al. 2005). In the current study, the PAP protocol (2 ×5 repetitions 80% 1RM) applied in isolation (PAP + placebo) reduced the sprint time (best time, mean time, and total time) during the RSA test compared with that of the control (placebo).

Previous studies have demonstrated an acute improvement of sprint performance after PAP in athletes of various sports disciplines (Bevan et al., 2010; Seitz et al., 2014; Chatzopouloset al., 2007; McBride et al., 2005; Rahimi, 2007; Yetter and Moir, 2008; Evetovich et al., 2015; Low et al., 2014). Moreover, PAP resulted in improved RSA (best sprint time and mean sprint time) in handball athletes (Okunoet al., 2013). The mechanism responsible for the acute improvement of sprint performance is possibly related to muscle strength/power production capacity. Studies indicated a moderate correlation between muscle strength/power and RSA (WISLOFF et al., 2004; CHELLY et al., 2010). In addition, individuals with greater muscle strength in the squat exercise (1RM test) had greater changes in the performance of sprints after the PAP protocol compared with those with lower muscle strength [29, 30]. These results suggest that the level of muscular strength is associated with the performance of high-intensity and short-duration activities, and strategies that potentiate muscular strength/power results in RSA improvement.

Another possible ergogenic aid investigated in our study was CHO mouth rinse. Evidence showed a positive effect on endurance performance (de Ataide e Silva et al., 2013. Although the mechanisms involved remain not fully elucidated, it is suggested that CHO mouth rinse stimulates taste receptors and neurophysiological pathways, which can potentiate physical performance through a “non-metabolic” manner (Jeukendrup and Chambers, 2010). In this study, the CHO mouth rinse protocol (10 s; 6% maltodextrin) had no influence on the RSA. By contrast, Beaven et al. (2013) and Phillips et al. (2014) found an improvement in peak power with CHO mouth rinse. However, both studies (Beavenet al., 2013; Phillips et al., 2014) evaluated the sprint performance of physically active men on a cycle ergometer.

Moreover, most studies found no significant difference in the performance of sprints after CHO mouth rinse (Bortollotiet al., 2013; Dorling and Earnest, 2013; Přibyslavskáet al., 2015). Consistent with our data, Bortolloti et al. (2013) revealed that CHO mouth rinse (6% maltodextrin) has no significant effect on the performance of repeated sprints (best time, mean time, and performance decrement) in young soccer players. To the best of our knowledge, this is the first study to investigate whether the combination of PAP and CHO mouth rinse has an additional effect on the performance of repeated sprints (PAP + CHO vs. PAP + PLA).

In conclusion, PAP positively affects the RSA in male team-sport athletes; however, the combination of PAP and CHO mouth rinse had no additional effect. Hence, CHO mouth rinse does not exert a significant influence on the performance of short anaerobic tasks. Further studies are necessary to investigate the effect of different concentrations of CHO solution and exposure time within the oral cavity.

PRACTICAL APPLICATIONS

RSA with direction changes is a vital component of intermittent sports modalities, e.g., soccer. In this study, we provided evidence that could support the use of PAP among soccer players prior to performing repeated sprints as a potential method to improve the following variables: best sprint time, mean sprint time, total sprint time. Our data also showed that back squat exercise may be used as a warm-up method to enhance RSA performance during training bouts. However, strength and conditioning coaches should be aware that CHO mouth rinse has no significant effect, particularly on repeated sprints with direction changes.

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