Journal of Science and Medicine in Sport 19 (2016) 272–276

Contents lists available at ScienceDirect

Journal of Science and Medicine in Sport

journal homepage: www.elsevier.com/locate/jsams

Original research

Effects of sodium phosphate and caffeine ingestion on repeated-sprint ability in male athletes

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ARTICLE INFO

Article history:
Received 13 August 2014
Received in revised form 6 March 2015
Accepted 8 April 2015
Available online 24 April 2015

Keywords:
Dietary supplements
Aerobic exercise
Sports performance
Team-sports

ABSTRACT

Objectives: To assess the effects of sodium phosphate (SP) and caffeine supplementation on repeated-sprint performance.
Design: Randomized, double-blind, Latin-square design.
Methods: Eleven team-sport males participated in four trials: (1) SP (50 mg kg^{-1} of free fat-mass daily for six days) and caffeine (6 mg kg^{-1} ingested 1 h before exercise); SP + C, (2) SP and placebo (for caffeine), (3) caffeine and placebo (for SP) and (4) placebo (for SP and caffeine). After loading, participants performed a simulated team-game circuit (STGC) consisting of 2 × 30 min halves, with 6 × 20-m repeated-sprint sets performed at the start, half-time and end of the STGC.
Results: There were no interaction effects between trials for first-sprint (FS), best-sprint (BS) or total-sprint (TS) times ($p > 0.05$). However, SP resulted in the fastest times for all sprints, as supported by moderate to large effect sizes (ES; $d = 0.51–0.83$) and 'likely' to 'very likely' chances of benefit, compared with placebo. Compared with caffeine, SP resulted in 'possible' to 'likely' chances of benefit for FS, BS and TS for numerous sets and a 'possible' chance of benefit compared with SP + C for BS (set 2). Compared with placebo, SP + C resulted in moderate ES ($d = 0.50–0.62$) and 'possible' to 'likely' benefit for numerous sprints, while caffeine resulted in a moderate ES ($d = 0.63$; FS: set 3) and 'likely' chances of benefit for a number of sets.
Conclusions: While not significant, ES and qualitative analysis results suggest that SP supplementation may improve repeated-sprint performance when compared with placebo.

1. Introduction

Caffeine and sodium phosphate represent two nutritional aids shown to improve exercise performance. While caffeine can improve endurance performance,[1–3] its effect on repeated-sprint ability (RSA) is inconclusive. For example, sprint times during 5 sets of 6 × 20-m sprints were significantly faster after caffeine (6 mg kg^{-1}),[4,5] while no benefit was found for 2 × 60-s cycling bouts separated by 3 min[6] or 10 × 20-m running sprints departing every 10 s.[7] These results however, may have been due to excessive accumulation of metabolic waste products due to using sustained sprint efforts and/or short recovery periods.[8] To date, the most common mechanism proposed to explain caffeine's ergogenic effect is adenosine receptor antagonism, which may have a stimulatory effect on the central nervous system that reduces feelings of exertion and pain, as well as promoting heightened alertness and increased neural firing rates that directly affect skeletal muscle.[9] Notably, all of these proposed benefits of caffeine have been posited to improve repeated-sprint performance.[4,5]

Similar to caffeine, sodium phosphate (SP) can improve endurance performance[10–12] and maximal oxygen uptake ($\dot{V}O_{2\,max}$) following 3.6–4 g or 50 mg kg^{-1} free fat mass (FFM) doses ingested daily over a 3–6 day period,[10,12,13] but its effect on RSA is unknown. Numerous mechanisms have been proposed to explain the ergogenic effects of SP supplementation. Briefly, these are increases in (a) 2,3-Diphosphoglycerate (DPG) in red blood cells, promoting oxygen unloading from haemoglobin to the tissues;[14] (b) myocardial efficiency, which may increase stroke volume;[12] (c) hydrogen ion buffering ability;[14] (d) adenosine triphosphate (ATP) and phosphocreatine (PCr) resynthesis due to a larger energy (phosphate) pool;[14] and (e) activation of rate-limiting constituents of the glycolytic and Krebs cycles.[15] Of relevance, all these mechanisms may potentially result in improved RSA, but this has not yet been investigated. Nor has the combined effects of SP and caffeine on RSA. As the mechanisms proposed to improve exercise performance after SP or caffeine ingestion are different,

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http://dx.doi.org/10.1016/j.jsams.2015.04.001
1440-2440/

it is possible that in combination these substances may result in greater improvement in exercise performance than when either supplement is ingested alone. For example, the combined effect of improved buffering, muscle energy (phosphate) pool, tissue unloading of oxygen and myocardial efficiency (from SP loading), plus increased neural firing rates that have positive effects on muscle activation and reduced sensations of effort and pain (from caffeine ingestion) may together result in faster repeated-sprint performance. Therefore, the aim of this study was to assess the effects of SP and caffeine, alone and combined (SP + C), on RSA performed before, midway and after a 60 min simulated team-game circuit (STGC).

2. Methods

Eleven male, team-sport (Australian football, basketball, hockey, soccer) athletes (mean ± SD age 20 ± 2 y, height 181.7 ± 4.4 cm, body-mass 74.5 ± 8.2 kg, training/competition involvement per week of 372 ± 124 min) were recruited from local sporting clubs. All participants consumed <160 mg d^{-1} of caffeine and had not taken any nutritional supplements for at least two months prior to the study. All provided written informed consent and ethical approval was granted by the University of Western Australia Ethics Committee.

Participants completed a familiarization session and four different supplementation trials over a 14-week period (see Fig. 1). During familiarization, participants first undertook a whole body dual-energy, X-ray absorptiometry (Lunar Prodigy, GE Medical Systems, Madison, USA) scan to determine FFM (for SP loading), and then performed one-half (30 min) of a STGC and one set of 6 × 20-m sprints. Four experimental trials were then performed in a randomized, double-blind, Latin-square design, with 17 days between trials to allow body phosphate levels to return to baseline levels.[12] These trials consisted of (1) SP and placebo (for caffeine), (2) caffeine and placebo (for SP), (3) SP + C and (4) placebo (for both SP and caffeine) loading protocols.

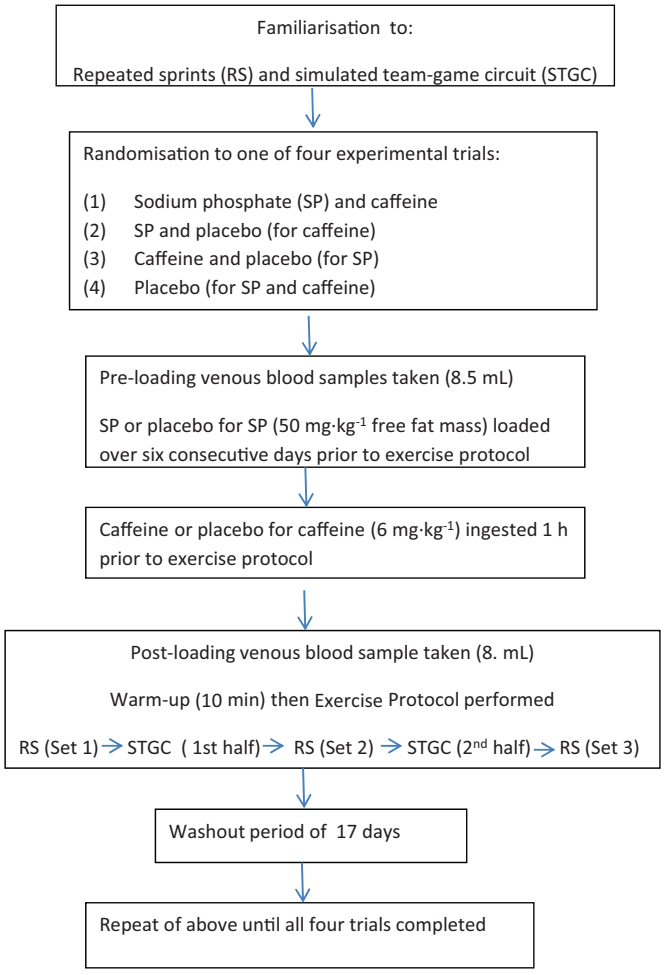

Fig. 1. Overview of experimental design.

For SP loading, a 50 mg kg^{-1} FFM dose of trisodium phosphate dodecahydrate (Challenge Chemicals Australia, Western Australia), split into four equal doses a day, was consumed for six consecutive days (mean participant total daily dose = ~3.75 g). Doses were placed into opaque capsules (Melbourne Food Ingredient Depot, Victoria, Australia) by a blinded researcher. Each capsule was consumed with 15 g of Powerade© powder (Powerade Isotonic, Coca-Cola Amatil, NSW, Australia: 133 kJ per 100 mL, 7.6 g of carbohydrate, 28 mg of sodium) that had been dissolved in ~300 mL of water.[10] The ingestion of each capsule was separated by ~4 h. The SP placebo contained 0.55 g of a lactose/sucralose artificial sweetener (Splenda, Johnson & Johnson Pacific Pty Ltd, NSW, Australia) and 0.5 g of table salt and was ingested following the same protocol. Participant compliance with the SP (and placebo) loading protocols was managed by reminder messages being sent each day and was again verbally checked on arrival at the laboratory for a test. All participants expressed full compliance with the requested loading.

In addition, participants ingested either 6 mg kg^{-1} BM dose of anhydrous caffeine (No-Doz, Key Pharmaceuticals Pty Ltd, NSW, Australia: mean participant total dose = ~450 mg) or placebo for caffeine (0.55 g of lactose/sucralose artificial sweetener; Splenda, Johnson & Johnson Pacific Pty Ltd, NSW, Australia) as a single dose 60 min prior to each trial. Each supplement was ground into a powder to make them indistinguishable from each other and placed in an opaque gelatine capsule. These capsules were ingested on arrival at the laboratory.

All exercise testing was performed in an indoor gymnasium on a sprung wooden surface. Before commencing each trial a warm-up consisting of 4 min of light jogging, 3 min of dynamic movements and 3 min of 20-m run throughs at increasing intensities (60, 70, 80, 90, 95 and 100% of max) was performed. Participants then rested for 3 min before commencing the exercise trial. One set of 6 × 20-m sprints was performed immediately before, at half-time and after the STGC. Sprints were timed using two pairs of electronic, single-beamed, infrared timing gates (Fitness Technologies, Adelaide, Australia) positioned 20 m apart. A slow jog return was performed after each sprint and 25 s separated the start of one sprint and the next. A 1 min passive rest period separated the end of a STGC half and starting the second and third sets of 20-m sprints. Typical error and coefficient of variance (CV) for total time for one set of sprints and best 20-m time were 0.060 s, 1.8% and 0.19 s, 1.1%, respectively.[16]

The 60 min STGC was divided into 30 min halves, separated by 10 min of passive rest. The STGC was designed to replicate typical team-sport intermittent movement demands and patterns[17] and was modified to fit into the indoor gymnasium. Each half consisted of 30 × 1 lap repetitions, commencing each minute, while each lap involved three maximal sprints, a 12 m change of direction (agility) section, one striding effort, two jogging periods and three walking periods, taking ~34–47 s to complete, allowing ~13–26 s recovery before the next lap commenced. Total distance covered per lap was ~117 m. Selected lap times were recorded to determine consistency between trials.

Heart-rate (HR; Polar Electro Oy, Kempele, Finland) was recorded before the warm-up, with ratings of perceived exertion (RPE; 6–20 scale[18]) and HR then recorded after each RSA set. Fingertip capillary blood lactate concentrations (Lactate Pro: Cycle Classic