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Full Length Article

Isometric pre-conditioning blunts exercise-induced muscle damage but does not attenuate changes in running economy following downhill running

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ABSTRACT

Running economy (RE) is impaired following unaccustomed eccentric-biased exercises that induce muscle damage. It is also known that muscle damage is reduced when maximal voluntary isometric contractions (MVIC) are performed at a long muscle length 2–4 days prior to maximal eccentric exercise with the same muscle, a phenomenon that can be described as isometric pre-conditioning (IPC). We tested the hypothesis that IPC could attenuate muscle damage and changes in RE following downhill running. Thirty untrained men were randomly assigned into experimental or control groups and ran downhill on a treadmill (−15%) for 30 min. Participants in the experimental group completed 10 MVIC in a leg press machine two days prior to downhill running, while participants in the control group did not perform IPC. The magnitude of changes in muscle soreness determined 48 h after downhill running was greater for the control group (122 ± 28 mm) than for the experimental group (92 ± 38 mm). Isometric peak torque recovered faster in the experimental group compared with the control group (3 days *vs.* no full recovery, respectively). No significant effect of IPC was found for countermovement jump height, serum creatine kinase activity or any parameters associated with RE. These results supported the hypothesis that IPC attenuates changes in markers of muscle damage. The hypothesis that IPC attenuates changes in RE was not supported by our data. It appears that the mechanisms involved in changes in markers of muscle damage and parameters associated with RE following downhill running are not completely shared.

1. Introduction

Running economy (RE) is defined as the energy demand to sustain running at a given submaximal speed (Assumpção, Lima, Oliveira, Greco, & Denadai, 2013). As an important predictor of long-distance running performance, RE can determine which of two athletes with similar maximal oxygen uptake (VO_2max) could win a long-distance race (Hoogkamer, Kipp, Spiering, & Kram, 2016). The association between neuromuscular/biomechanical variables and RE is not yet fully understood and has been the object of many

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studies (Lacour & Bourdin, 2015; Saunders, Pyne, Telford, & Hawley, 2004). For instance, it is well established that maximal strength and power training regimens improve RE in experienced runners (Saunders et al., 2006; Turner, Owings, & Schwane, 2003; Støren, Helgerud, Støa, & Hoff, 2008; Denadai, de Aguiar, Lima, Greco, & Caputo, 2017).

The relationship between RE and muscle function has been further investigated in studies using eccentric exercise-induced muscle damage (EIMD) as a research model (Assumpção et al., 2013). EIMD is a multifactorial phenomenon that occurs when skeletal muscle is exposed to mechanical stress imposed by unaccustomed eccentric contractions (Clarkson & Hubal, 2002). This exposure to muscle strain leads to transient decreases in muscle function, delayed onset muscle soreness (DOMS), and leakage of intracellular proteins such as creatine kinase (CK) to the blood stream (Brentano & Martins Kruel, 2011). It has also been shown that EIMD reduces explosive force production (Peñailillo, Blazevich, Numazawa, & Nosaka, 2015), and range of motion (Chen, Lin, Chen, Lin, & Nosaka, 2011), and impairs RE (Braun & Paulson, 2012; Chen, Nosaka, & Tu, 2007). Indeed, Chen, Nosaka, et al. (2007) found that markers of EIMD and RE were affected following a 30-min downhill run in college-level soccer players, but the magnitude of impairment in RE (6.9% increase in oxygen uptake) was lesser than the decrease in maximal voluntary torque production (−21.3%). Additionally, RE recovered faster than muscle strength (3 *vs* 4 days, respectively).

When a damaging bout is performed for a second time, changes in markers of EIMD are attenuated. This partial protection has been referred to as the repeated bout effect (Hyldahl, Chen, & Nosaka, 2017). Apparently, the repeated bout effect also occurs for RE parameters. Chen, Chen, et al. (2007) showed that changes in EIMD, RE, and running kinematic parameters were considerably smaller following a second bout of downhill running when compared to changes induced by an initial downhill run performed 5 days earlier. Furthermore, Doma et al. (2017) showed that changes in indirect markers of EIMD and submaximal running performance are further blunted following a third bout of damaging exercise (resistance training at 6 repetition maximum). Even though the repeated bout effect might be considered an efficient protective strategy, the damage induced by the first bout might be considered detrimental in many contexts (Lima & Denadai, 2015). Thus, an alternative strategy that does not require initial damage is of great relevance.

There is evidence that performing low-volumes (2–10) of maximal voluntary isometric contractions (MVIC) 2–4 days prior to damaging bouts promotes significant attenuation of markers of EIMD in the ipsilateral (Chen, Nosaka, Peake, & Chen, 2012; Chen et al., 2013) and contralateral arm (Chen et al., 2018). Thus, isometric pre-conditioning (IPC) could be an efficient non-damaging alternative to promote acute protection against EIMD. However, it is important to note that the prophylactic effect of IPC was investigated mostly in upper limb muscles, which are not frequently exposed to EIMD. In this context, Lima and Denadai (2015) proposed that lower limb muscles, which are highly exposed to EIMD, would present a reduced protective effect during eccentric exercise. To date, the only study that has investigated the effects of IPC on signs and symptoms of EIMD in lower-limb muscles was performed by Tseng et al. (2016). A potent protective effect was identified when subjects performed 60 MVIC two weeks prior to maximal eccentric contractions in an isokinetic dynamometer. However, the authors found small, yet significant, changes in markers of EIMD following the 60 MVIC, which seems to be contradictory to the principle of IPC as a non-damaging alternative.

To the best of our knowledge, no previous studies have investigated the effects of low-volume IPC on changes in markers of EIMD following downhill running. Nor have we found evidence showing that this type of pre-conditioning exercise attenuates the magnitude of changes in RE following damaging bouts of any sort. Thus, the aim of the present study was to investigate the effects of performing an IPC bout consisting of 10 closed kinetic chain MVIC two days prior to a downhill running bout on: 1) muscle function; 2) indirect markers of EIMD; 3) metabolic and kinematic parameters of RE. It was hypothesized that the IPC protocol would attenuate changes in markers of EIMD and parameters of RE in the following days.

2. Methods

2.1. Participants

Thirty young men (22.8 ± 2.3 years, 1.77 ± 0.04 m, 78.6 ± 8.9 kg) with no recent (6 months) experience with strength and/or endurance training volunteered to participate in the present study. They had no history of muscular, joint or bone injuries in the lower limbs. Sample size was calculated based on an effect size of 0.5, and α level of 0.05, and β level of 0.8. Inclusion criteria for this study were healthy men aged 18–30 years old. None of the participants reported regular use of any type of medicine or nutritional supplement before and during the study upon questioning from the examiners. Participants provided written consent for their participation on the study and were instructed to maintain their daily routines, not engaging in novel exercise programs and maintaining their regular eating habits. All procedures were conducted in accordance with the Helsinki Declaration on the use of humans as research subjects, and the protocol was approved by the University's Ethics Committee.

2.2. Experimental design

Incremental tests were performed on a treadmill (Pulsar, h/p/cosmos, Germany) prior to any experimental procedure to determine the maximal oxygen uptake (VO_2max) and velocity associated with VO_2max (vVO_2max) using a gas analyzer (Quark, PFT Ergo, Cosmed, Italy). The incremental test protocol has been described elsewhere (Lima, Assumpção, Prestes, & Denadai, 2015). Following the determination of VO_2max, participants were randomly assigned to either a control (n = 15) or experimental (n = 15) group. Participants in both groups performed a 30-min downhill (−15%) running bout at a speed of 70% of their VO_2max. Muscle function (isometric peak torque and countermovement jump height) was assessed before, immediately after, and 1–4 days following downhill running. Muscle soreness was assessed immediately before and 1–4 days following downhill running. Serum CK activity was assessed only before, and 2 and 4 days after the run due to the invasiveness of the procedures adopted for blood extraction (i.e., from