Science & Sports (2019) **34**, e225—e228

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BRIEF NOTE

Effects of ischemic preconditioning on the isometric test variables

Effets du préconditionnement ischémique sur les variables de test isométrique

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Received 4 January 2017; accepted 27 August 2018
Available online 17 December 2018

KEYWORDS
Exercise;
Performance;
Strength;
Power;
Strategy

Summary
Introduction. — Recent studies reported improvements in aerobic performance after ischemic preconditioning (IPC) compared to a control or placebo condition. However, the effects of IPC on both skeletal maximal muscle strength and power have not been investigated.
Summary of facts and results. — Considering the importance of muscle strength/power production and the potential benefits of IPC, the purpose of this study was to investigate the effects of IPC on peak isometric torque and rate of force development (RFD). Ten participants performed on separated days 4 sets of either ischemic preconditioning (5 min of ischemia [250 mmHg] and 5 min of reperfusion) or placebo (5 min of placebo [10 mmHg] and 5 min of reperfusion) alternated in both lower limbs 30 min before maximal voluntary isometric contraction test. RFD was calculated over time intervals of 0—30, 0—50, and 0—200 ms and peak isometric torque was determined from the torque-time curve. Despite no significant difference, there was a moderate effect of ischemic preconditioning on rate of force development in time intervals of 0—30 ms, small effect in 0—50 ms, and trivial effect of ischemic preconditioning on rate of force development in 0—200 ms and on peak isometric torque.
Conclusions. — Considering that RFD is a key factor of performance in tasks with limited time (< 250 ms) for force production, our results suggest that movements such as sprinting, cycling and jumping should not have their performance enhanced.

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https://doi.org/10.1016/j.scispo.2018.08.011
0765-1597/

MOTS CLÉS
Exercice ;
Performance ;
Sport ;
Force

Résumé
Introduction. — Des études récentes ont démontré l'amélioration de la performance aérobie suite à un préconditionnement ischémique (PCI) par rapport à des conditions contrôles et/ou placebo. Cependant, les effets du PCI sur la puissance et sur la force musculaire maximale n'ont pas été étudiés.
Résumé des faits et des résultats. — Étant donné l'importance de la production de force/puissance musculaire et les avantages potentiels du PCI, l'étude avait pour objectif d'analyser les effets du PCI sur le couple isométrique maximal et le taux de développement de la force (TDF). Dix participants ont réalisé, sur différents jours, soit 4 séries de préconditionnement ischémique (5 min d'ischémie [250 mmHg] et 5 min de reperfusion), soit 4 séries placebo (5 min de placebo [10 mmHg] et 5 min de reperfusion), en alternant sur les deux membres inférieurs, 30 minutes avant un test de contraction isométrique volontaire maximal. Le TDF était calculé au cours du temps sur des intervalles 0—30, 0—50, 0—200 ms et le couple isométrique maximal était déterminé à partir de la courbe couple-temps. Malgré l'absence de différence significative, il y avait un effet modéré du préconditionnement ischémique sur le taux de développement de la force sur l'intervalle 0—30 ms, un léger effet sur l'intervalle 0—50 ms, et un effet insignifiant à la fois sur le taux de développement de la force sur l'intervalle 0—200 ms et sur le couple isométrique maximal.
Conclusion. — En considérant que le TDF est un facteur de performance pour des tâches de production de force sur des durées limitées (< 250 ms), nos résultats suggèrent que des mouvements comme le sprint, le cyclisme, le saut ne devraient pas voir leurs performances améliorées.

1. Introduction

Ischemic preconditioning (IPC) consists of brief periods of non-lethal ischemia interspersed with periods of reperfusion, and confers protection against lethal ischemia injury. In addition to this protective role, most of the recent studies reported improvements in aerobic performance after IPC compared to a control or placebo condition [1].

However, the effects of IPC on both skeletal maximal muscle strength and power have not been investigated. Considering the importance of muscle strength/power production and the potential benefits of IPC, the purpose of this study was to investigate the effects of IPC on peak isometric torque and rate of force development (RFD), which are closely associated with muscle strength and power [2].

2. Methods

2.1. Subjects

Sample size was estimated in seven participants based on the results from Libonati et al. [3] (statistical power of 0.8). Ten resistance-trained male participants (22 ± 2 yrs, 77 ± 2 kg, 173 ± 3 cm, 5.6 ± 1.7 yrs of experience) volunteered for this study. All were free from cardiovascular and muscular disorders, and were instructed not to perform strenuous exercise 48 h prior to the tests, and to avoid the consumption of alcohol, tobacco, and caffeine. All participants were informed about the benefits, discomforts and possible risks of the study and signed an informed consent before participation. The University's Research Ethics Committee approved the experimental protocol.

2.2. Ischemic preconditioning

Two customized nylon cuffs (900 × 175 mm) were placed at the top of both thighs and inflated up to the pre-determined pressure (i.e., 250 or 10 mmHg) with individuals laying supine. IPC consisted of four 5-min cycles of ischemia (pressure of 250 mmHg) interspersed with 5 min of reperfusion (without pressure) alternated in each leg. Placebo followed the same procedure except that pressure was 10 mmHg. The entire protocol (IPC or placebo) lasted ~40 min. IPC or placebo was applied to the both legs of participants, but only the dominant leg was tested. To minimize the possible psychological effects, participants were ''deceived'' by being told that the purpose of the study was to compare the effects of two pressures on performance.

2.3. Maximal voluntary isometric contraction test

Participants had their isokinetic dynamometer (Biodex System 4, Biodex Medical Systems, USA) settings determined according to the manufacturer specifications. The estimated center of rotation of the knee joint was aligned with the dynamometer center of rotation at an angle of 60° from the horizontal.

Prior to the tests, participants performed two sets of 6 concentric sub-maximal knee-extension contractions at 120° s^{-1}, with 1-min rest interval between warm-up sets. Participants were instructed to perform isokinetic contractions at an intensity they felt to be around 50% and 70% of their

Table 1 Peak isometric torque and RFD over the three intervals for each condition, the percentage difference between conditions and the effect size.

	Placebo	IPC	P	Δ%	Effect size
Peak Torque (Nm)	282 (258–305)	288 252–321)	0.64	1.5% (−7.5–10.5)	0.11 (trivial)
RFD (0–30 ms) ($Nm.s^{-1}$)	2163 (1735–2590)	2535 (2262–2808)	0.07	27.8% (−4.0–59.6)	0.66 (moderate)
RFD (0–50 ms) ($Nm.s^{-1}$)	1716 (1380–2050)	1844 (1568–2120)	0.23	12.8% (−5.9–31.4)	0.26 (small)
RFD (0–200 ms) ($Nm.s^{-1}$)	828 (667–990)	862 (726–999)	0.70	11.0% (−10.9–32.9)	0.14 (trivial)

Mean (95% confidence interval) of peak isometric torque (Nm) and rate of force development (RFD $Nm.s^{-1}$) over 30 (0–30), 50 (0–50), and 200 (0–200) ms, P-value, absolute change (Δ), and effect size.

maximal during the first and second sets, respectively. Five minutes after the completion of the warm-up, participants performed three 3-s knee extension maximal isometric contractions, separated by 2-min interval. They were instructed to produce torque as fast and as hard as possible, and then relax. During maximal voluntary isometric contraction test (MVIC), knee joint was positioned at 60° flexion (0° = full extension). Strong verbal encouragement and visual feedback were provided during the tests.

Knee extension peak isometric torque was determined as the highest value found in the stable part of torque curve. Rate of force development was calculated in time intervals of 0–30, 0–50, and 0–200 ms relative to the beginning of contraction. Contraction onset was determined when torque values reached 15 N above mean resting value.

2.4. Statistical analysis

Data are presented as mean and 95% confidence intervals. After a visual inspection (i.e., box plot), Shapiro-Wilk test was used to confirm data normality. All data of peak isometric torque and rate of force development over the three calculated intervals for the two experimental conditions (IPC and placebo) were analyzed with paired t-test. The level of significance was set at $P < 0.05$. Also, Cohen's d effect size (ES) was calculated.

3. Results

There was no significant effect of the IPC on peak isometric torque and RFD ($P > 0.05$). Table 1 presents the peak isometric torque and RFD over the three intervals for each condition, the percentage difference between conditions and the effect size. There is a moderate effect of IPC on RFD in time intervals of 0–30 ms, small effect in 0–50 ms, and trivial effect of IPC on RFD in 0–200 ms and peak isometric torque.

4. Discussion

We investigated the influence of IPC on peak isometric torque and RFD, indices of maximal strength and power, respectively. In our study, IPC did not influence peak isometric torque and RFD over different intervals, which is in accordance with the conclusions of Incognito et al. [1] that IPC does not affect short-duration (< 10 s) tasks.

We are aware of only one study that investigated the influence of IPC on maximal strength production. Libonati et al. [3] reported an approximately 20% increase in MVIC after IPC. Muscle group, number of IPC cycles, pressure applied, and time interval between IPC and test may explain the differences between the results from Libonati et al. [3] and ours. Although this needs further investigation.

In addition, RFD assessed over different intervals was not augmented by the IPC. Considering that RFD is a key factor of performance in tasks with limited time (< 250 ms) for force production [2], our results suggest that movements such as sprinting, cycling and jumping should not have their performance enhanced.

Peak isometric torque and RFD are influenced by both muscle (fiber type composition, temperature, and potentiation) and neural (motor unit recruitment, firing rate and synchronization of motor unit discharges) factors [2]. Even though it is unlikely that IPC impacts muscle factors, it was suggested that IPC could affect neural factor by enhancing the efficiency of excitation-contraction coupling [4]. Nitric oxide (NO) modulates the activity of several key calcium channels involved in EC coupling, augmenting the concentration of calcium in the cytosol, influencing actomyosin ATPase activity and cross-bridge kinetics. Thus, an increase in NO production by IPC may trigger an improvement in performance. Despite the non-significant effect of IPC on RFD, it is noteworthy that ES and percentage changes decreased as time interval increases (0.66 and 27.8% in 0–30 ms to 0.14 and 11.0% in 0–200 ms). Aagaard et al. [2] proposed that improvements in RFD over short time intervals seem to rely predominantly on changes in neural factors and not on changes in contractile properties (muscle factors). Our results together with Aagaard et al. [2] suggestion may lend some support for the effect of IPC on neural aspects. IPC does not significantly influence maximal strength production and power, but may have had a small influence on EC coupling, which could be detected only with very sensitive techniques.

This study is not without limitations. Even though, sample size was estimated based on previous study investigating a similar outcome (i.e. MVIC), differences in our study were not of the same magnitude and power achieved was very low [0.06 for MVIC, and 0.46 for RFD (0—30 ms)]. It is possible, then, that by increasing sample size, results could be different. Our experimental designed was created to investigate the effects of IPC in a controlled environment, in an attempt to increase internal validity. However, caution should be exercised when results from this study are transferred to the field situation, such as sprinting and jumping, which should be investigated.

Disclosure of interest

The authors declare that they have no competing interest.

Acknowledgements

The authors would like to thank the participants who took part in this investigation for their time, effort, and support.

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