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Effects of Ischemic Preconditioning or Self-Myofascial Release on Muscle Power in Men Trained

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SUMMARY

Objective. The purpose of this study was to compare muscle power gains when trained men were submitted to the ischemia preconditioning (IPC) and Self-myofascial release (SMR).

Methods. This study included 16 men healthy and regular practitioners of resistance training. Prior to training sessions, the Muscle-Bone cross sectional area was estimated (Muscle-Bone CSA estimate). All participants performed 3 sets of 5 repetitions of the deadlift exercise after IPC and SMR at random. Participants underwent to two evaluations (IPC and SMR) with Linear Position Transducer during 1st set, 2nd set, and 3rd set in the deadlift exercise. All evaluations were performed in a two-session separated by 48 hours to assess of the peak muscle power (watts) and velocity (m/s).

Results. The two-way ANOVA no showed interaction effects group × timing for peak power, velocity and repetition for peak power after interventions protocol. However, Pearson's correlation was found to be significant between Peak power and Muscle-Bone CSA estimate-THIGH for left ($p < 0.03$) and right ($p < 0.04$) limbs after IPC protocol. Moreover, significant correlation was also observed between Peak power and Muscle-Bone CSA estimate-LEG for left ($p < 0.01$) and right ($p < 0.03$) limbs after IPC protocol.

Conclusions. Our data contribute to the qualitative and quantitative understanding of the correlation between Peak power and Muscle-Bone CSA estimate using of the IPC protocol which becomes a good option for improving neuromuscular performance in modalities that demand muscle power.

KEY WORDS

Ischemia preconditioning; self-myofascial release; muscle power; resistance training; muscle-bone CSA estimate.

INTRODUCTION

It is evidenced that performance during explosive actions depends on muscle power, which may be determined by a number of neuromuscular variables, such as a combination of morphological and neural factors including muscle cross-sectional area and architecture, musculotendinous stiffness, motor unit recruitment, rate coding, motor unit synchronization, and neuromuscular inhibition (1-3). Such combinations of factors are associated with enhanced external mechanical power, general sports skill performance, decreased injury rates, and training load monitoring (1, 2). However, scientific publications that investigated muscle pre-activation methods to improve muscle power are limited.

Periods of blood flow ischemic/reperfusion of limbs can be used as muscle pre-activation, mainly through mechanical tools such as ischemia preconditioning (IPC) and self-myofascial release (SMR) (4-7). The maneuver of IPC consists of alternating periods of blood flow occlusion/reperfusion of limbs, mainly through a mechanical tool (*e.g.*, specific tourniquet) (4, 5). This maneuver provides a physiological response which an organ exposed to a controlled, short-term, local, sublethal ischemia will be protected from subsequent ischemia (8-10). However, in the sports and fitness, IPC became a target for several sports scientists, assuming that the hyperemia upon reperfusion could improve muscle performance in some way (4, 5, 11, 12).

Based on previous assumptions that IPC may enhance adenosine triphosphate (ATP) production by glycolytic and phosphogenic (13) pathways and that resistance exercise commonly depends on these substrates and metabolic mechanisms (14), it is reasonable to hypothesize that IPC may potentiate performance. In fact, IPC has been associated with potentiated force production (11, 12), and it might be that the reactive hyperemia (during the reperfusion phase after occlusion) in some way generated a beneficial effect.

Self-myofascial release (SMR), via a foam roller or roller massager, is a technique of soft tissue mobilizations to help reduce restrictive barriers or fibrous adhesions observed between layers of the fascial tissue (15-18). Thus, the SMR has been used to alleviate pain, reduce edema and inflammation (15, 16). The mechanism to promote this response may be associated with gradual reactive hyperemia that can promote change in the muscle's viscoelastic properties, increasing mitochondria biogenesis, and increasing blood flow possibly by increasing angiogenesis and vascular endothelial growth factor for which nutritive blood flow is needed for cellular repair and reduce of pain (18-20). In addition, the SMR balance postural distortions, increase range of motion and increase fluid movement patterns (15-17). The simplicity and portability of the SMR tools allow it to be easily implemented in any type of fitness or rehabilitation program. However, the scientific literature still does not directly relate the IPC and SMR protocols with muscle power gains. Consequently, the absence of data supports the need for additional studies in this area. Hence, the purpose of this study was to compare muscle power gains when trained men were submitted to the IPC and SMR protocols.

METHODS

Study design

This is an analytical observational study. The sample size was determined by including all participants that complied with the eligibility criteria. All participants were regular practitioners of resistance exercise and performed 3 sets of 5 repetitions of the deadlift exercise after IPC and SMR at random. Participants underwent to two evaluations (IPC and SMR) with Linear Position Transducer during 1st set, 2nd set and 3rd set in the deadlift exercise. All evaluations were performed in a two-session separated by 48 hours to assess of the peak muscle power (watts) and velocity (m/s). All assessment were taken in a temperature-controlled environment (temperature 21 °C, 65% relative humidity) by a Hygro-Thermometer with Humidity Alert (Extech Instruments, Massachusetts, EUA). All assessments occurred between 2:00 and 4:00 P.M.

Participants

This study included 16 healthy men (age: 20.10 ± 3.24 years; height: 172.21 ± 8.66 cm; body mass: 70.27 ± 9.76 kg; body fat: 15.1 ± 3.7%). The participants were eligible if they were non-smokers for the previous 3 months or more; had no cardiovascular or metabolic diseases, systemic hypertension (140/90 mmHg or use of antihypertensive medication), recent musculoskeletal injury and surgery (in the last 6 months), or pain in any region of the body; and had not used anabolic steroids, drugs or any medication with the potential to impact physical performance (self-reported).

The participants' training frequency was 6.2 ± 0.8 days/week^{-1} with a mean duration for each session training of 65 min^{-1} using whole-body training programs. Subjects with at least one year of whole-body training programs experience were included to participate in the current study. All participants performed a routine of whole-body training programs with resistance bands, free-weights, dumbbells, medicine balls and high interval intensity training.

The study was approved by the local institutional Ethics Committee for Human Experiments and was performed in accordance with ethical standards in sport and exercise science research (CAE: 63881716.0.0000.5235 – date of approval: November 10, 2023). The present study was conducted at the A&D training center high performance, Rio de Janeiro, Brazil. All participants were informed of the experimental procedures and gave written informed consent prior to participation. No clinical problems occurred during the study.

Anthropometric measurements

Body composition was measured following an 8-h overnight fast by bioelectrical impedance analysis using a device with built-in hand and foot electrodes (BIO 720, Avanutri, Rio de Janeiro, Brazil). The participants wore their normal indoor clothing and were instructed to stand barefoot in an upright position with both feet on separate electrodes on the device's surface and with their arms abducted and both hands gripping two separate electrodes on each handle of the device. All biometric measurements were carried out in an air-conditioned room (21 °C).

The Muscle-Bone cross sectional area (Muscle-Bone CSA estimate) was estimated by middle muscle circumference (MC) of the thigh, leg and arm. The thigh skinfold (TSF) was measured to represent the thickness of the subcutaneous fat that surrounds the muscle. The following formula was used to estimate the muscle-bone cross sectional area (21):

$$\textit{Muscle-Bone CSA estimate} = MC - [\pi \times (TSF/10)]$$

Velocity-based training assessment

Muscle power assessment occurred from a linear position transducer (encoder) (ERGONAUTA I; Florianópolis, SC – Brazil, 2021). The encoder enabled the acquisition of photoelectric signals from the rotation of its axis. The transducer resolution is 400 pulses/revolution (< 1 mm/pulse) with a maximum pulse frequency of 20 kHz. The photoelectric pulses were sent to a micro-controlled system (Clock of 16MHz) that recorded the pulses from the interruption of digital pins. The acquisition frequency varied according to the axis rotation velocity, being determined by the time-stamping method (1 μs of resolution). Thus, the variables corresponding to velocity (m/s) and peak muscle power (watts) were sent in real time to the computer via the Bluetooth system. All data were stored and analyzed later.

Intervention protocol

Participants underwent 2 intervention protocols: IPC and SMR.
1) IPC: participants underwent an IPC protocol for 20 minutes before deadlift exercise. This protocol consisted of 3 cycles of 5 minutes of occlusion at 220 mm Hg of pressure using an 85 × 10-cm pneumatic tourniquet applied around the subinguinal region of the upper thighs (Avanutri, Rio de Janeiro, Brazil) alternated with 150 second of reperfusion at 0 mm Hg. The pressure used and cuff width were in accordance with previous studies to certify that subjects had the blood flow occluded during the intervention (4). The occlusion and reperfusion phases were conducted with subjects remaining supine. The effectiveness of occlusion in the IPC session was checked by auscultation of the arteries around the ankle during the phases when the cuff was inflated and was deflated and controlled during the occlusion maneuver (4).
2) SMR: participants underwent an SMR protocol for 20 minutes before deadlift exercise. This protocol used a foam roller (FR) with dimensions of 6.25" × 6.25" × 20.25" (SKLZ, CA, USA) was applied over regions of the thighs, legs, and gluteal region in both lower limbs for 2 sets of 30 seconds in each region of interest with a 30 second rest period between the sets. The participants started at the proximal region of the thighs, legs and gluteal region, and rolled down toward to the distal region. All participants were instructed to utilize their body mass over the thighs, legs and gluteal region with the help of the arms to make the movement and speed was controlled by a metronome (2 seconds/pass).

Exercise protocol

To measure velocity and muscle power, the deadlift exercise was selected for promoting greater safety during the execution of the movement (22). Prior to the deadlift exercise protocol, all participants performed IPC and SMR at random. One minute after the intervention protocols, the subjects performed 3 sets × 5 repetitions in the deadlift exercise at 80% of the body mass, with a 90 second rest between the sets. The interval between exercise sessions (IPC and SMR) was separated by 48 hours.
The deadlift exercise was performed with bar was positioned on the floor over the distal end of the metatarsals, equal load on each side, both hands pronated, and toes pointed forward. During the concentric phase, the participants kept the head neutral, core muscle activated, and the arms fully extended. When lifting the bar off the floor, all participants extended their hips and knees. During the eccentric phase, the participants kept the head neutral, flat back position and performed a hip and knee flexion while returning the bar to the starting position.

Statistical analysis

All data are presented as mean ± SD. Statistical analysis was initially performed using the Shapiro-Wilk normality test and the homocedasticity test (Bartlett criterion). To test the reproducibility between the tests, the intraclass correlation coefficient (ICC) was used. Two-way analysis of variance (ANOVA) was used to test for main and interaction effects of the intervention protocol (IPC *vs* SMR) and timing of measurement for each outcome variable independently and the post hoc Bonferroni was used to possibility a statistically significant. Correlations between variables were assessed using Pearson correlation coefficients and their corresponding 95% confidence intervals. The significance level was set at 0.05 and the software used for statistics was GraphPad® (Prism 6.0, San Diego, CA, USA).

RESULTS

Table I represents the values of Muscle-Bone CSA estimate before interventions protocol. Statistical results showed not a significant difference between right and left limbs at men trained.
Summary statistics for the effects of IPC and SMR groups by timing of measurements are shown in **table II**. The two-way ANOVA showed not interaction effects group × timing for peak power, velocity and repetition for peak power after interventions protocol (**table II**). However, Pearson's correlation was found to be significant between Peak power and Muscle-Bone CSA estimate-THIGH for left ($p < 0.03$) and right ($p < 0.04$) limbs after IPC protocol (**figure 1C**). Moreover, significant correlation was also observed between Peak power and Muscle-Bone CSA estimate - LEG for left ($p < 0.01$) and right ($p < 0.03$) limbs after IPC protocol (**figure 1E**). On the other hand, Pearson's correlation no showed to be significant among Muscle-Bone CSA estimate, peak power and velocity after SMR protocol (**figure 2**).

Table I. Mean ± SD values of Muscle-Bone CSA estimate.

	Right	Left	95%CI	P-value
Muscle-Bone CSA-THIGH (cm)	48.79 ± 1.72	48.40 ± 4.32	0.38 (-0.49-1.27)	< 0.35
Muscle-Bone CSA-LEG (cm)	33.40 ± 2.16	32.98 ± 1.67	0.41 (-0.27-1.1)	< 0.21
Muscle-Bone CSA-ARM (cm)	28.26 ± 3.16	28.05 ± 2.99	1.60 (-0.93-1.35)	< 0.69

Table II. Results (Mean± SD values) for Peak Power, Velocity and Repetition for Peak Power between IPC and SMR in the resistance exercise performance test.

Variables	1st set	2nd set	3rd set	Main and interaction effects
Peak Power (watts)				Interaction: $F_{2,60} = 0.002$, p = .997
IPC	2289 ± 305	2314 ± 391	2384 ± 435	Group: $F_{1,60} = 0.016$, p = .898
SMR	2270 ± 299	2302 ± 249	2381 ± 395	Timing: $F_{2,60} = 0.502$, p= .607
Velocity (m/s)				Interaction: $F_{2,60} = 0.111$, p = .894
IPC	1.8 ± 0.18	1.83 ± 0.24	1.85 ± 0.26	Group: $F_{2,60} = 0.302$, p = .739
SMR	1.8 ± 0.18	1.84 ± 0.18	1.89 ± 0.26	Timing: $F_{1,60} = 0.026$, p= .871
Repetition for peak power				Interaction: $F_{2,60} = 0.279$, p = .757
IPC	2.82 ± 1.72	3.73 ± 1.27	3.55 ± 1.21	Group: $F_{1,60} = 0.000$, p = 1.000
SMR	3.18 ± 1.72	3.64 ± 1.57	3.27 ± 1.10	Timing: $F_{2,60} = 1.225$, p= .301

IPC: ischemic pre-conditioning; SMR: self-myofascial release.

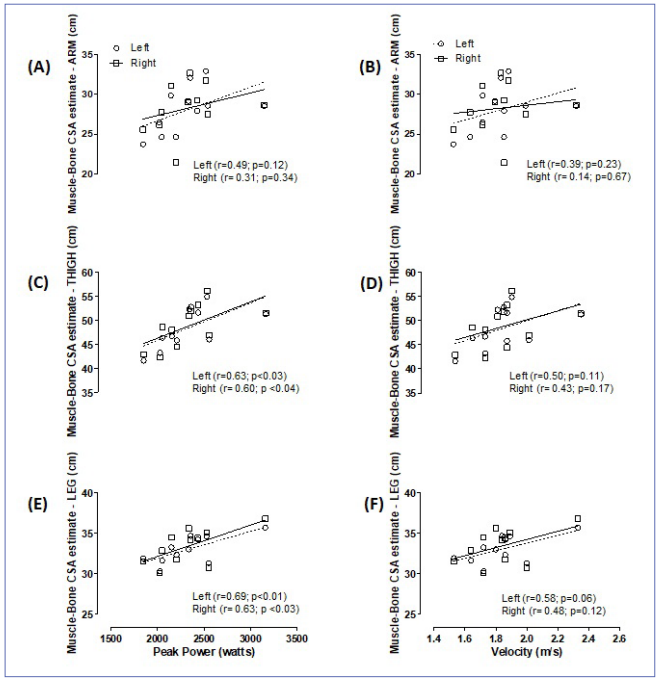

Figure 1. Scatter plot between Muscle-Bone CSA estimate, peak power and velocity after IPC protocol. The continuous line represents the regression curve between variables.

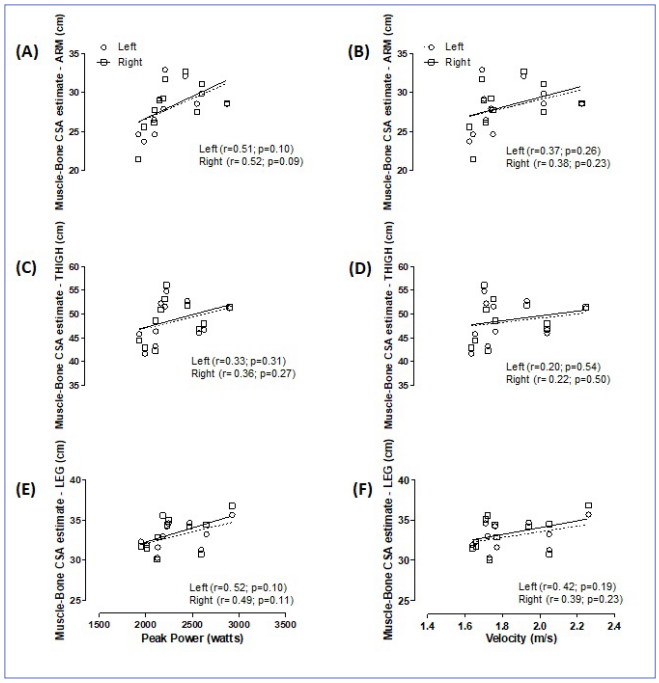

Figure 2. Scatter plot between Muscle-Bone CSA estimate, peak power and velocity after SMR protocol. The continuous line represents the regression curve between variables.

DISCUSSION

This study aimed at investigating the contribution of the IPC and SMR protocols in the peak power and velocity on males trained. The main results obtained with this study showed significant correlation between Peak power and Muscle-Bone CSA estimate-THIGH and LEG for both limbs (left and right) on mates trained after IPC protocol.

Studies previously published by our group showed that the IPC protocol can significantly improve the performance of the upper and lower limbs during resistance training (4, 5). Corroborating previously published results, other studies concluded that performing IPC before resistance exercise can be an important intervention to increase maximum repetition performance and total volume of work performed (11, 23). However, no study has been previously published investigating the correlation between Muscle-Bone CSA estimate, muscle power and IPC protocol. On the other hand, scientific literature has demonstrated that the IPC protocol contributes to improving muscle power in cyclists, endurance athletes, basketball and football players (24-27). These results may be associated with the IPC protocol and the maintenance of high-frequency motor units of the targeted muscles (25, 28, 29).

Our results showed that although the two-way ANOVA did not show a significant difference between groups (IPC *vs* SMR) in relation to performance variables, Pearson's correlation showed significance between Peak power and Muscle-Bone CSA estimate (THIGH and LEG) after IPC protocol. This result may be associated with increased motor evoked potential and activation of nerve pathways, or a combination of these, in response to the IPC protocol (28, 29).

Another hypothesis may be related to the biochemical messengers, such as the heterodimeric protein, hypoxia-inducible factor-1 (HIF-1), that has been proposed to represent a possible mechanism underlying IPC through an oxygen-regulated variant subunit HIF-1α, and a concomitantly expressed variant subunit HIF-1b. Hypoxia-inducible factor-1a is hydroxylated by prolyl hydroxylase 1-3 (PHD1-3) on proline residues immediately after *de novo* synthesis (30, 31). Thus, when the intracellular oxygen level is reduced, the enzymatic activities of PHDs are inhibited. This stimulates nuclear translocation of HIF-1α and induces transcription of several hypoxia-adaptive genes involved in erythropoiesis, angiogenesis, glycolysis, and catecholamine biosynthesis (31, 32). These successive events could improve the energy production and utilization during resistance training. Other authors have proposed that IPC protocol could reduce ATP consumption (18) and increase phosphocreatine production and peak contractile force (2), and it was demonstrated that low-intensity exercise combined with partial vascular occlusion elicits a greater growth hormone response than moderate-intensity exercise without occlusion (33-35). Therefore, we believe that these mechanisms might be useful to explain correlation between Muscle-Bone CSA estimate and muscle power after IPC protocol.

The limitations of the study include the absence of measures of neurophysiological parameters and electromyographic evaluation, which would be interesting. However, this does not limit the answer to the study question. In addition, longitudinal studies are needed to define a cause/effect relationship's differences between IPC and SMR protocols

CONCLUSIONS

Our data contribute to the qualitative and quantitative understanding of the correlation between Peak power and Muscle-Bone CSA using of the IPC protocol which becomes a good option for improving neuromuscular performance in modalities that demand muscle power. Thus, these results may be a helpful for coaches in order to correctly periodize training sessions.

FUNIDINGS

None.

DATA AVAILABILITY

Data are available under reasonable request to the corresponding author.

CONTRIBUTIONS

ASM: design, data analysis and interpretation, writing – original draft, writing – review & editing. AN: design, data analysis and interpretation, writing – review & editing.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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