

The effect of combined preconditioning strategies on isokinetic strength in well trained kickboxers

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract

Purpose: The use of preconditioning strategies (PconSt) alone has a positive impact on performance. However, it is thought that there will be more impact on the performance of the combined preconditioning strategies, and this is the first work to prove it. This study was to examine the effect of combined preconditioning strategies on isokinetic strength in well-trained kickboxers.

Material: The following preconditioning strategies were combined: morning resistance exercise (MRE), ischemic preconditioning (IP), active warm-up (AW-U), hormonal preconditioning (HP) and post-activation potentiation (PAP). Fifteen well-trained male kickboxers (age: 22.38 ± 4.01 years, height: 182.23 ± 1.05 cm, body mass: 77.67 ± 8.01 kg) volunteered for this study. Peak isokinetic knee extension and flexion moment were determined at $60^\circ/s$, $180^\circ/s$ and $240^\circ/s$ bilaterally. All participants performed the pre-test and then were randomly divided into Sham and PconSt groups on separate days. For the PconSt group, MRE, IP, AW-U, HP and PAP were implemented sequentially before test.

Results: The findings indicated significant increase in strength after combined training in the PconSt groups for right leg flexion at $180^\circ/s$ flexion ($p < 0.05$). The average percentage strength difference between sham and PconSt groups was $4.12 \pm 8.95\%$.

Conclusions: This study showed that a combined preconditioning strategy increased isokinetic strength.

Keywords: isokinetic, post-activation, potentiation, ischemic, preconditioning, hormonal.

Introduction

Increasing performance in sports science applications requires implementation of acute training. Exercises known as preconditioning strategies target acute positive effects and are implemented into a basic training routine within the pre-performance period. Examples of preconditioning strategies include morning resistance exercise (MRE), ischemic preconditioning (IP), active warm-up (AW-U), hormonal preconditioning (HP), post-activation potentiation (PAP) [1] and whole-body vibration (WBV) [2]. Recently, studies have reported that preconditioning strategies have been used to increase athletic performance effectively, especially with respect to muscular strength, power output [1] and sprint performance development [2]. However, to date, no study has examined the effect of combining these strategies. Kilduff et al. [1] stated that performance in short-duration, high-intensity sports could be augmented by implementing single or multiple acute exercise strategies.

MRE is a preconditioning strategy in which exercises are performed 4–6 hours before the event. The aims of MRE include decreased reflex inhibition, increased central nervous system activation, reduced anxiety and improved psychological preparedness. An example MRE routine may comprise 3–6 sets of 5–6 repetitions of exercises such as squats, bench press [3], or backward overhead shot throw [4].

IP is a strategy in which blood flow to blood vessels and tissues is restricted for short periods and is accepted as a method of increasing the ischemic tolerance of tissues

[5]. In addition, there are studies that relate IP to improved sports performance. Studies have shown that IP increases the number of muscle channels that are sensitive to intramuscular adenosine triphosphate [6], the number of potassium channels and adenosine levels [7].

Preconditioning strategies are usually implemented using two warm-up techniques. In the first method, the passive warm-up technique, hot packs, saunas, warm water, or heated clothes are used to increase the core or muscle temperature of an individual who is not moving. In the second method, AW-U, exercise leads to a temperature increase. AW-U results in higher cardiovascular and metabolic responses than passive warm-up [8]. In addition, AW-U is used more commonly and results in positive performance increases [9].

In HP, the trainer motivates the athletes using feedback and a video display [5]. The effects of HP are explained by a hormonal shift that develops in connection to an increase in motivation and confidence. This increase in testosterone level in turn provides improvements in strength performance [2].

Another strategy, PAP, is a dynamic method used to increase top power output. Alternatively, PAP may result in additional muscle contraction at the moment of voluntary maximal contraction; this is achieved by repeating contractions at 75–100% of the maximum [11]. While the rationale behind PAP involves deception of the neural system [22], an increase in motor neuron stimulation speed could be theorized based on an increase in the Ca^{2+} sensitivity of actin-myosin filaments [12, 13] and an increase in light chain phosphorylation [10, 14].

Precision measurement devices are necessary for

assessing strength performance gains after implementing combined preconditioning strategies. These devices must be designed to measure the speed of movement, which was difficult to determine before isokinetic dynamometers became available [14]. Isokinetic dynamometers are used in evaluating neuromuscular functions and can be used to provide a significant increase in strength performance [15]. Isokinetic movement involves contraction at a constant rate throughout the range of motion; this contraction is at peak moment for each angle of movement. Maximum isokinetic power is the highest moment value (rotation moment) that an individual can perform during a certain speed of contraction [13]. Evaluation of muscle power is accepted as the main function of these isokinetic dynamometers; they also provide data on moment, work and endurance (i.e., the dynamic performance of muscle) [14].

Previous studies have evaluated individual preconditioning strategies using various protocols and varying results were obtained [1-9]. However, studies evaluating a combination of preconditioning strategies have not been published. It is thought that using a combination of preconditioning strategies will amplify the effect of these strategies on performance. In this context, the purpose of this study is to examine the effect of combined preconditioning strategies on isokinetic strength in well-trained kickboxers. There are two main hypotheses in this study. First, the combined preconditioning strategies will affect isokinetic muscle strength. Second, there will be post-performance differences between the PconSt group and the Sham control group.

Material and methods

Participants. Fifteen well-trained male kickboxers (age: 22.38 ± 4.01 years, height: 180.01 ± 1.05 cm, body weight: 77.9 ± 8.01 kg) volunteered to participate in this study. Table 1 shows the participants' mean age, weight, height, body mass, fat percentage, resting systolic and diastolic blood pressure and IP cuff pressure (systolic blood pressure [SBP] + 50 mmHg). The athletes participated in weekly micro cycles consisting of 10–12 training for 20

weeks as training for a national championship. None of the participants reported chronic diseases or regular use of medicines. All participants refrained from alcohol, caffeine and additional nutritional training supplements for 24 hours before all experimental testing. Before the study, participants were informed of the study details and signed consent documents. This study was approved by the Baskent University Institutional Review Board and Ethics Committee (Project No.: KA14/301) and supported by the Baskent University Research Fund.

Design. A single-blind crossover randomized control trial was performed. The study design is shown in Fig1. After pre-test prevention; the fifteen participants were divided into randomly Sham and PconSt groups. Anthropometric measurements of participants and a familiarization session were carried out on the first day. The one repetition maximum (1RM) for each participant was assessed by using the same protocol [13] and used for normalization and pretest strength testing was performed the next day. Participants performed the Sham and PconSt protocols on two different days with at least 72 hours and the most 96 hours between measurements to provide adequate recovery and avoid an extended IP effect.

Height and weight were measured using an electronic scale (Seca 707, Hamburg, Germany). Fat-free mass and body mass index were measured by bioelectrical impedance analysis (BIA) (Tanita SC 330, Tokyo, Japan). IP was implemented using a leg cuff (Erka, Bad Tölz, Germany). Heart rate and arterial oxygen pressure were determined with a pulse oximeter (Beurer PO30, Ulm, Germany). Muscle strength measurements for knee flexor and extensor muscles were assessed using a computed isokinetic dynamometer (Cybex 770 Norm, Lumex Inc., Rankokoma, NY, USA) at angular velocities of $60^\circ/s$, $180^\circ/s$ and $240^\circ/s$. Blood pressure (BP) measurements were also taken at baseline. Preconditioning strategy application for the PconSt group was implemented in the order given below (Fig 2).

Morning resistance exercise (MRE). MRE was implemented in the PconSt trial 6 hours before strength testing, similar to the method used by Cook et al, [3] The

Table 1. Subject characteristics and resting blood pressure.

Values	Mean	SD	Values	Mean	SD
Age (y)	22.4	± 4.01	Fat percentage (%)	15.65	± 5.77
Weight (kg)	77.67	± 8.01	Systolic blood pressure (mmHg)	118.42	± 11.63
Height (cm)	182.23	± 1.05	Diastolic blood pressure (mmHg)	79.87	± 0.92
BMI	23.8	± 1.55	Heart rate (beats/min)	68.73	± 8.16
O ² sat (%)	97.39	± 0.72	SBP+ Cuff pressure for IP (mmHg)	170.29	± 11.27

Values are mean ± SD; n = 15; O²sat (%) = percentage of oxygen saturation,

SBP = systolic blood pressure, IP = ischemic preconditioning.

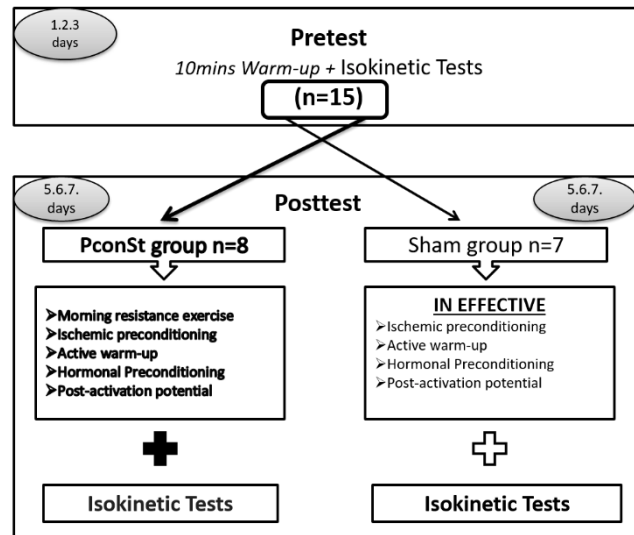


Fig 1. Study design: Pretest and PconSt protocols with test procedures and the intervention phase.

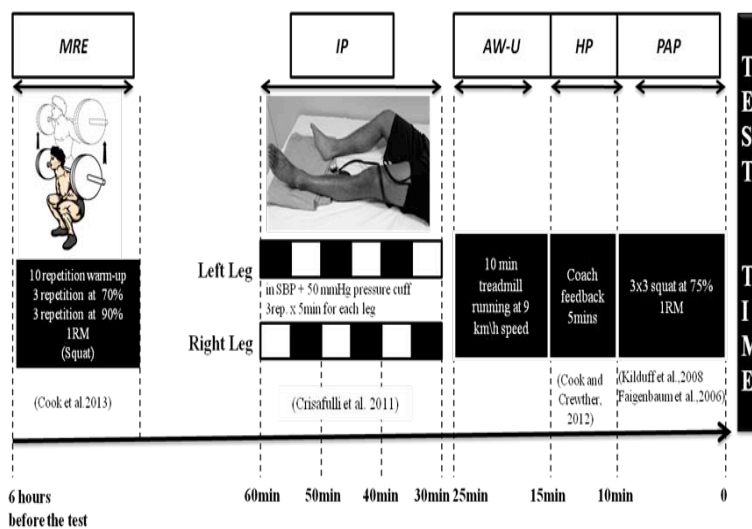


Fig.2 Preconditioning strategies for the PconSt protocol. 1RM = one repetition maximum, SBP = systolic blood pressure, MRE = morning resistance exercise, IP= ischemic preconditioning, AW-U= active warm-up, HP = hormonal preconditioning and PAP = post-activation potentiation. Within the IP section, black boxes represent 5 minutes of metatarsal arterial occlusion and white boxes represent 5 minutes of reperfusion.

PconSt trial performed 10 repetitions at 50% of 1RM squat in warm-up, then three repetitions at 70% of 1RM squat followed by three repetitions at 90% of 1RM squat. Ninety seconds of rest was provided between sets; three sets were performed in total, including the warm-up. The MRE protocol for the sham group was not applied in a weighted environment to avoid performance increases associated with body-weight resistance.

Ischemic preconditioning (IP). IP was carried out 50 minutes before the isokinetic measurements in a similar way to that described by Crisafulli et al. [21] IP was implemented using a leg cuff pressure of 50 mmHg higher than the participant’s systolic blood pressure. After inflating the leg cuff, the circulation of the foot artery (metatarsal artery) was checked to confirm complete interruption. IP implementation was performed separately for each leg during three 5-minute intervals in a supine position. Oxygen saturation, heart rate and blood

pressure were checked continuously. In the sham group, IP implementation was performed for a single 5-minute period at a standard 20-mmHg cuff pressure. After inflating the leg cuff, the circulation of the metatarsal artery was checked for reductions [22, 24].

Active warm up (AW-U). Athletes performed a 10-minute AW-U on a treadmill at 9 km/h following the IP session. Then, three sets of maximal jumping were performed over 10 seconds. In the sham group, athletes performed a classical warm-up consisting of 10 minutes of running and 5 minutes of dynamic stretching [23].

Hormonal preconditioning (HP). In the PconSt trial, verbal warnings and feedback were provided separately for each athlete by their trainers over a 4-minute period and athletes watched 5-minutes of their own kickboxing match videos [16]. In the sham group, trainers discussed tactical factors only and avoided motivational speech.

Post-activation potential (PAP). The PAP protocol was performed 10 minutes before the isokinetic test. The protocol composed of three sets of three repetitions at 75% of 1RM half squat with a 2 minutes rest between each set [20, 25]. In the sham group, participants performed one set of three squat repetitions without any extra load. Ambient temperature was kept at 22°C during the measurements.

Assessment of muscle strength: Muscle strength measurements were carried out using a computed isokinetic dynamometer. The dynamometer was calibrated by a technical service before testing began. Athletes were fixed with dynamometer belts around the upper body, waist and legs. Joint axis locations were aligned with dynamometer axes and fixed close to the expected maximum moment angle for active and passive conditions. All athletes performed 10 minutes of AW-U and 5 minutes dynamic stretching. They performed three repetitions on the same day for familiarization. Five repetitions were carried out at each angular velocity on the test day. Two minutes of rest were provided between sets. Isokinetic strength measurements were implemented bilaterally [14] at angular velocities of 60°/s, 180°/s and 240°/s. All isokinetic measurements were taken by the same researcher. Gravity correction techniques were applied and strong verbal feedback was used during all isokinetic tests. Peak isokinetic strength measurements for both extension and flexion at angular velocities of 60°/s, 180°/s and 240°/s were recorded automatically by the dynamometer [28].

Statistical Analyses. Statistical analyses were performed using SPSS 18.0 software (SPSS Inc., Chicago, IL, USA). All data are represented as mean \pm SD and statistical significance was defined as $p < 0.05$. A two way analysis of variance (ANOVA) (time \times groups) was used to analyze the significance of strength values. Statistical power was calculated using G*Power computer software. With 15 participants and a crossover design, the study power was determined as 83%.

Results

According to isokinetic testing results, a statistically significant difference was determined between pretest and PconSt group flexion strength of the right leg at the 180°/s angular velocity (RL180°F) ($p < 0.05$) (pretest mean \pm SD: 83.7 \pm 28.6 Nm, PconSt mean \pm SD: 111.5 \pm 33.8 Nm). Right leg strength values increases from pretest results ranged from 5.0% to 24.93% and the statistically significant increase in strength for the RL180°F group was calculated as 24.93%. No significant differences of RL180°F changes between sham and PconSt groups were observed. In addition, statistically significant differences were found between the left leg pre- and PconSt values at 240°/s extension angular velocity (LL240°E) (pretest mean \pm SD: 136.7 \pm 39.1 Nm; PconSt mean \pm SD: 162.7 \pm 33.0 Nm), 180°/s flexion angular velocity (LL180°F) (pretest mean \pm SD: 71.6 \pm 31.8 Nm; PconSt mean \pm SD: 98.2 \pm 22.1 Nm) and 240°/s flexion angular velocity (LL240°F) (pretest mean \pm SD: 69.8 \pm 26.5 Nm; PconSt mean \pm SD: 94.6 \pm 19.2 Nm). These results are represented

graphically in fig 3a and 3b. Left leg strength increases from pretest results ranged from 8.96% to 27.09% and the statistically significant increase in strength was calculated as 15.98% for the LL240°E group, 27.09% for the LL180°F group and 26.22% for the LL240°F group. Furthermore, significant difference of left leg flexion strength at 240°/s angular velocity (LL240°F) between sham and PconSt group (PconSt mean \pm SD: 110.0 \pm 9.8 Nm; sham mean \pm SD: 94.6 \pm 19.2 Nm) was observed. Statistically significant performance increase of 13.9% was observed in the PconSt group for LL240°F. According to the two way analysis, there were no statistically significant differences at other angular velocities for either the left or the right leg between pre and PconSt values. In addition, statistically significant differences were determined between sham and PconSt groups for left leg extension strength at 60°/s angular velocity (LL60°E) (PconSt mean \pm SD: 201.8 \pm 16.9 Nm; sham mean \pm SD: 186.0 \pm 24.4 Nm), left leg flexion strength at 60°/s angular velocity (LL60°F) (PconSt mean \pm SD: 126.2 \pm 21.9 Nm; sham mean \pm SD: 103.8 \pm 22.6 Nm). Statistically significant performance increases of 7.4% and 17.7% were observed in the PconSt group for the LL60°E, LL60°F, respectively. No statistically significant differences were determined between sham and PconSt group at other angular velocities for either the left or the right leg. A comparison of the results for the PconSt and sham groups is shown in fig 3c and 3d.

Discussion

This study examined the effects of combined preconditioning strategies on isokinetic strength in well-trained kickboxers. The main finding of this study was that acute combined preconditioning strategies may enhance the strength performance of these athletes. To our knowledge, this is the first study in which multiple, sequenced applications were performed before the event at different time intervals. A sham protocol was used to minimize the effect of psychological factors; statistically significant differences between the PconSt group and sham group are shown in Fig 3c and 3d. Differences in strength performance between the PconSt and Sham groups ranged between -11.38% and 17.75% for different angular velocities; the average difference was 4.12 \pm 8.95%. Because there is no comparable study on combined preconditioning strategies, the current results were compared with previous studies of individual preconditioning strategies, including those on MRE, IP, AW-U, HP and PAP [3-11]. Most of the studies on individual preconditioning strategies have not reported an increased or decreased performance percentage. However, in a meta-analysis study, it was reported that 78% of the articles analyzed found that various warm-up applications improved athletic performance [6]. In addition, a study of MRE performed 6 hours before the event showed increased pitching performance; these results match those of the current study. The same study also reported that jumping exercises with an additional 2% body-weight load performed and increased active

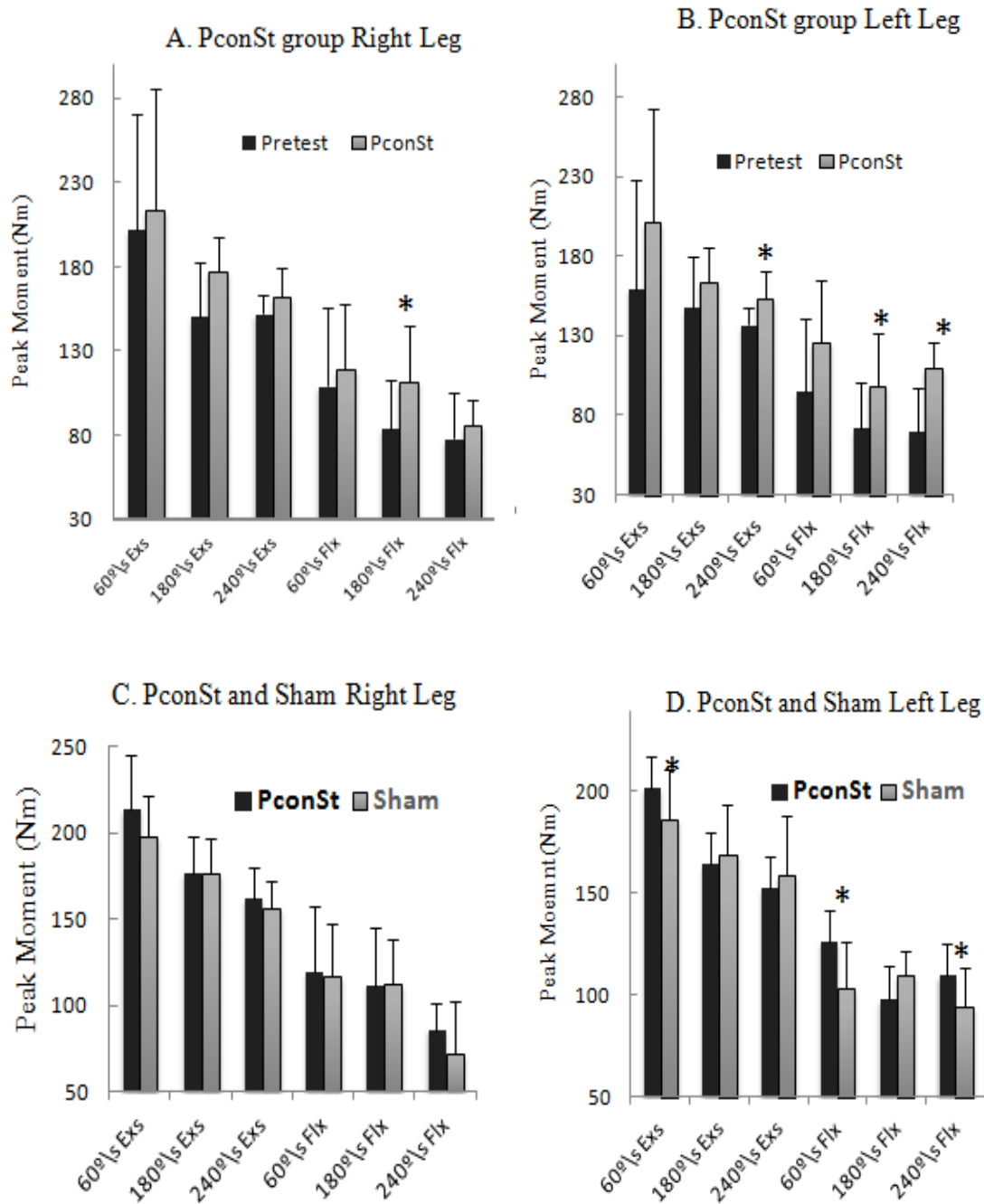


Fig 3. Pretest and PconSt groups analysis results (n = 8).

A. PconSt Group Right Leg, B. PconSt Group Left Leg,

PconSt and sham group analysis results (n = 7).

C. PconSt and Sham Right Leg, D. PconSt and Sham Left Leg.

Values are means \pm SD (*p < 0.05). Exs = Extension, Flx = Flexion, 60, 180 and 240 represent angular velocity in degrees per second ($^{\circ}$ /s).

and squat jumping performance [16]. In another study on MRE, hormone levels and the performance effect of power exercise performed in the morning or in the afternoon were investigated; the study concluded that strength exercise performed in the morning increased afternoon performance [6]. Tillin and Bishop reported that 87%

of 1RM chest press (3 sets of 3 repetitions) provided an increase in upper-body power output [18]. IP with a 220-mmHg cuff pressure applied to 13 participants exercising at a medium level (4 \times 5 minutes ischemia application) increased 5-km running times by 5% [26]. Similarly, 3 \times 5 minutes double-leg IP (220-mmHg cuff pressure)

increased the maximum oxygen capacity and power output of 15 elite cyclists by 3% and 2.6%, respectively [27]. In another study performed on 12 amateur male cyclists, 5 minutes of ischemia was implemented on both legs with a 220-mmHg cuff pressure. Although the power output value for the IP group was 290 W compared with 278 W for the sham group, a statistically significant difference was not determined ($p>0.05$); the study concluded that IP did not provide performance increases in sub maximal exercise volume or level of fatigue [19].

Applications that aim to increase performance in connection with cortisol and testosterone level are called HP or hormonal preconditioning [16]. Increases in hormone levels result from positive feedback provided by trainers and from watching motivational videos. In a previous study, the effects of motivational videos and coach feedback on cortisol and testosterone hormone levels were evaluated; the application of these preconditioning activities resulted in maximal free testosterone levels and performance increases [3].

In another study performed on eight recreationally trained male participants, the effects of isokinetic short muscle contraction on jump performance were analyzed. The study reported that different preconditioning protocols did not result in statistically significant differences in jump performance. PAP depends upon maximal voluntary contraction and increase of muscle power principles. The effect of PAP is affected by factors such as size of applied muscle, fibril type in muscle, fast and slow twitch fibril percentage, maximal contraction volume and sub maximal contraction volume [16].

This study has several limitations. Because there are no previous studies of multiple preconditioning strategies, the completion of the sequential preconditioning strategy protocols took longer than expected, especially with challenges that occurred during the measurements. Another limitation was the difficulty of taking blood samples to detect metabolic changes. Overcrowding at the hospital where testing took place, the athletes training to compete in the national championship and the time-intensive application of sequential preconditioning strategies made it difficult to assess testosterone and cortisol levels. A third limitation of this study was the lack of blinding; the sham group realized which testing protocol they were performing.

In the current study, left leg isokinetic strength parameters (at pre-and PconSt and between tests) showed statistically significant differences. It is thought that the reason for these differences was that the left leg was non dominant in all except one of the participants.

The current study showed that preconditioning strategies have a placebo effect, as demonstrated by the statistically significant difference between pre-test and PconSt results for the sham group. However, the statistically significant difference between the PconSt and sham groups after the experiment demonstrates the necessity for sham groups in similar studies on preconditioning strategies. It also shows that the PconSt group benefited from the actual application of combined preconditioning strategies. Consequently, the findings of this study show that combined preconditioning strategies can increase strength performance.

Conclusion

This study showed that a combined preconditioning strategy increased isokinetic strength. Therefore, the systematic combination of preconditioning strategies may provide performance improvements, specifically in strength.

Highlights

The application of preconditioning strategies in a systematic manner provides performance increases, specifically in strength. The results, therefore, show that if coaches and trainers implement this combined protocol prior to an event, they may be able to increase athletic performance in the athletes. This combined preconditioning technique could be used in kickboxing, boxing, some branches of track and field, swimming and many other sports in which anaerobic performance plays a large role.

Acknowledgments

The authors would like to thank the athletes who took part in this investigation and their coaches for their enthusiastic participation.

Conflict of interest

The authors declare that they have no Conflicts of interest concerning this article.

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Cite this article as: Yilmaz A, Gurses VV, Gulsen M. The effect of combined preconditioning strategies on isokinetic strength in well trained kickboxers. *Physical education of students*, 2018;22(5):278–284. doi:10.15561/20755279.2018.0508

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Received: 31.07.2018

Accepted: 20.08.2018; Published: 30.09.2018