IMPACT OF THE ACUPUNCTURE ONPERFORMANCE, AND PHYSIOLOGICAL MARKERS OF ATHLETES: A CROSSOVER CONTROL TRIAL

ABSTRACT

Background: In recent years, interest has grown in complementary therapies to support athletic performance and recovery, with acupuncture showing potential to influence physiological responses during high-intensity exercise. Traditionally applied for pain management and stress reduction, acupuncture's effects on exercise-related factors, such as perceived exertion, lactate levels, and heart rate, remain less examined. This study explores the immediate impact of acupuncture on physical performance and perceived exertion in amateur athletes, aiming to provide initial insights into its possible role as a supportive tool in sports training contexts.

Aims: To determine the acute effects of acupuncture on physical performance and perceived exertion in amateur athletes.

Methodology: A crossover and quantitative study was proposed. The sample was acquired at Estácio de Sá University, Cabo Frio, Rio de Janeiro, between April and May 2020.Fifteen competitive males engaged in HIIT (31.61 ± 7.02 years old; heart rate reserve: 59.71 ± 4.10; lactate: 3.31 ± 0.63 mM/DL) were subjected to two exercise sessions. Both sessions were performed at an intensity of 85-95% of maximum heart rate. Acupuncture points used: ST36, LI4, LI11, LR3. Lactate, heart rate, systolic blood pressure, and perceived exertion were assessed immediately after the exercise challenge, with or without acupuncture pre-conditioning. The Student's t-test and Shapiro-Wilk test were applied for statistical analysis, with Pearson correlation tests conducted. A significance level of 5% was used.

Results: A significant reduction in perceived exertion was observed after acupuncture (PES1: 19.4 ± 1.14; PES2: 16.8 ± 0.84; $p = 0.001$). Acupuncture also led to higher lactate accumulation and heart rate during the session.

Conclusion: Acupuncture improved lactate clearance and reduced perceived exertion, suggesting it may be a useful intervention to enhance athletic performance. Limitations include the small sample size and the absence of direct VO2 max measurement.

Keywords: Acupuncture, Blood Lactate, Heart Frequency, Athletic Performance

INTRODUCTION

Resting serum lactate levels are a potential predictor of muscle exertion during training or competition [1]. In high-intensity activities, such as those involved in most sports competitions, lactate accumulates as a result of cellular energy metabolism when pyruvate cannot be fully utilized by the Krebs cycle. This buildup requires the action of lactate dehydrogenase (LDH) to convert pyruvate into lactate, allowing it to be transported into the bloodstream. Without this process, lactate accumulation inside cells can impair metabolism [2].

Several strategies have been proposed to accelerate blood lactate clearance, including active recovery through low-intensity exercise [3] and cold-water immersion [4]. Additionally, cardiovascular and muscular fitness may play key roles in the efficient removal of lactate [5–7], offering physiological and performance advantages, particularly for athletes who compete in multiple events within a short timeframe [8–10].

Acupuncture, an ancient technique with proven health benefits [11], involves inserting needles into specific body sites to stimulate points and promote the release of endogenous substances that can relieve pain and improve muscle recovery. Studies have demonstrated positive effects of acupuncture on athletic performance, such as post-exercise recovery, improved muscular endurance, and reduced physical discomfort [12, 13]. However, the relationship between acupuncture and energy metabolism, including lactate clearance, has been underexplored in the literature, suggesting a need for further investigation to clarify the connection.

Given the potential benefits of acupuncture in promoting recovery and enhancing performance without the use of medication, it is an important area of interest for the sports community. This study aims to investigate the acute effects of acupuncture on physical performance and perceived exertion in amateur athletes.

METHODS

This crossover study involved 15 male CrossFit athletes aged between 29 and 32 years who regularly engaged in high-intensity interval training (HIIT). Participants were selected based on their training history and met specific inclusion and exclusion criteria. Exclusion criteria included recent bone, muscle, or joint injuries, individuals in recovery, users of analgesics or anti-inflammatories, those using orthoses or prostheses, smokers, alcohol drinkers, and individuals taking antidepressants, beta-blockers, appetite suppressants, or anabolic steroids. Out of 24 volunteers initially interviewed, 15 met the criteria and were selected for participation.

The study was structured as a crossover trial, with each participant serving as their own control to enhance the reliability of the comparisons. Each participant underwent both the intervention and control conditions in randomized order, with a washout period to minimize carryover effects. All evaluation procedures followed the protocols previously published by [17, 18]. The research was conducted in the Exercise Physiology Laboratory at Estácio de Sá University, with measurements taken under consistent conditions to ensure comparability across phases.

Table 1: Clinical characteristics of the sample.

Participant Characterization	**(*n= 15*)**
Age (Years)	29.86±2.51
Weight (Kg)	73.08±8.54
Height (Cm)	1.76±8.74
%Fat (7 skin)	25.56±2.79
BMI (Kg/m^2)	25.56±2.79
Lactate (mM/DL)	3.17±0.50
HRR (BPM)	59.00±3.33
SBP (mm/Hg)	110.62±2.05
DBP (mm/Hg)	80.41±1.22
Weight (Watts)	182.57±12.05

Legend: Kg= kilograms; Cm= centimetres; BMI= body mass index; Kg/ m2= kilograms per square meter; % Body Fat = seven skin, HRR = heart rate reserve, SBP = systolic blood pressure, DBP = diastolic blood pressure

Data Colection and Procedures

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Data collection occurred at the Exercise Physiology Laboratory of Estácio de Sá University, Cabo Frio Campus. Before the exercise tests, participants were seated for 10 minutes. Blood pressure was measured using an aneroid sphygmomanometer (Premium Grafite, Brazil) and a stethoscope (Littmann Classic III, USA). Serum lactate was measured by collecting one drop of peripheral blood from the earlobe using a metal lancet and a test strip (BM Lactate REF-03012654 370 Accutrend PLUS). Lactate levels were analyzed using a lactate meter (Accutrend Lactate, Roche Mannheim, Germany) [7].

Body composition assessment

Height was measured using a stadiometer (Cardiomed – Brazil) with an accuracy of 5 millimeters, and body mass was measured using a digital scale (Wiso, China). Blood samples were collected again five minutes after the intervention to assess changes in lactate levels. Body fat percentage was estimated using the 7-skinfold method for men.

Lactic and non-lactic anaerobic muscle power determination

Muscle performance and peak muscle power were determined by the Wingate test [30] performed on a mechanical bicycle ergometer (MONARK). To calculate the total revolutions and power of the pedals every five seconds, an optical sensor was coupled to a bicycle ergometer, managed by an acquisition program developed with Labview 6.0 (National Instruments).

Loading was determined by body weight of 0.075 Kp.kg-1, as predicted in the Wingate test protocol. The test was preceded by a two-minute warm-up period, followed by a three-minute active recovery period with a 50-watt load. From individual results, the following parameters were calculated: using absolute (or maximal) peak power (watts) and anaerobic non-lactate power relative to body weight (watts.kg1) and milk production or average (watts). The percent power drop (%) or fatigue rate is determined by the difference between the athlete's highest and lowest power achieved during the 30-second test period. Check the bike load before the test begins.

Intervention protocol

Participants in this crossover study completed two exercise sessions, spaced seven days apart. Each session consisted of a high-intensity interval sequence involving 10 burpees, 12 thrusters at 85% of maximum load, and 14 box jumps (75 cm height), sustained over a 12-minute period. The exercises were performed at an intensity range of 85% to 95% of the participants' maximum heart rate, monitored with a Polar A370 device (Finland). Participants were instructed to complete as many repetitions as possible at their maximum capacity, with 30-second rest intervals provided every three minutes, and verbal encouragement offered to maintain high effort levels throughout the session [19–22].

The crossover design allowed each participant to act as their own control. In the first session, participants followed the exercise protocol without any additional intervention. In the second session, participants underwent 20 minutes of acupuncture before the exercise. The acupuncture points used were ST36, LI4, LI11, and LR3. To assess the effects of the intervention, lactate levels were measured five minutes before and five minutes after each session. Data from the second session, with acupuncture, were compared directly to data from the control session without acupuncture, allowing an intra-individual comparison to determine the influence of acupuncture on performance and physiological response.

Acupuncture application

Acupuncture was applied using a heterodox model, with needles inserted perpendicularly into the skin. The points used were ST36 (located 1 cm lateral to the tibial crest), LR3 (between the first and second metatarsal bones), LI4 (between the first and second metacarpal bones), and LI11 (at the lateral extremity of the elbow flexion crease) [23]. Dong Bang needles (China),

0.20 x 0.30 mm in size, were inserted at a depth of 1.00 to 3.00 cm. Needle application lasted 20 minutes.

Ethics

The study was approved by the Brazilian Ethics Committee under protocol number 79724. All participants provided signed informed consent before the study began. This research followed the Helsinki Declaration and the Brazilian law 466/2012 on research involving humans.

Statistical analysis

Data were analyzed using IBM SPSS 23 software and presented as means and standard deviations. The Shapiro-Wilk test was used to verify the normality and homogeneity of variance. The Student's t-test was used with a significance level of 5%. Pearson's correlation was conducted between lactate levels and heart rate.

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RESULTS

The acupuncture improves the athletic performance

The group showed significant improvements in exercise performance metrics. Acupunture resulted in greater increases in acute maximal oxygen consumption and muscle power leading to higher VO_2 max through early adjustments and achieved a moderate effect ($\int 2 = 0.62$) and after 36 sessions it was significant ($\int 2 = 0.102$), Aboout the muscle performance the acupuncture induced performance improvements in non-lactate and lactate anaerobic muscle strength ($\int 2 = 0.92$ and $\int 2 = 0.94$) as shown in Figure 1.

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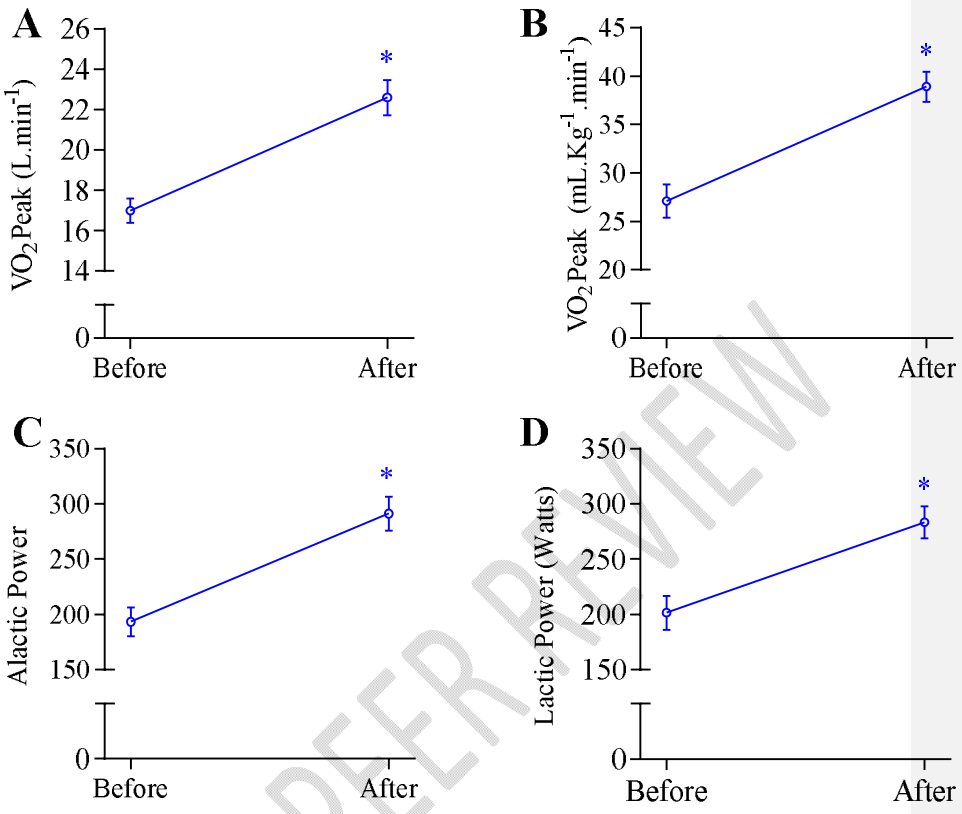

Figure 1:Effects of acupuncture in physical performance . Record cardiorespiratory capacity, muscle strength, heart rate and blood lactate. Blood lactate monitoring procedures were performed before the start of surgery and referred to as baseline, 1 hour after the first day of surgery, on the third day of surgery, 30 days, 60 days, and 90 days after the day of surgery. VO2 measurements, anaerobic and aerobic exercise were performed before and after 30 and 90 days. Differences were determined using two-way ANOVA with Sídak's posterior test, which was set at 5% significance. To determine effect sizes, Cohen's-ʃ2 was used between significance.

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The acupuncture improves the physiologic parameters in athletes

A significant positive correlation between lactate levels and heart rate was found (r = 0.7846; p < 0.05). Lactate levels showed greater accumulation after acupuncture (lac 3.17 ± 0.50; lac1 15.00 ± 1.18; P3 19.59 ± 1.46; p = 0.0004). Heart rate also increased significantly after acupuncture (HR 59.71 ± 4.10; HR1 163.71 ± 7.27; HR2 177.60 ± 6.99; p < 0.0001). Systolic blood pressure was significantly higher following acupuncture (SBP 110.32 ± 3.10; SBP1 174.86 ± 1.57; SBP3 180.86 ± 1.77; p < 0.0001). The perceived exertion scale (PES) scores were lower after acupuncture (PES1 19.4 ± 1.14 vs. PES2 16.8 ± 0.84; p = 0.001). Additionally, the maximum power output achieved during the exercise test increased significantly (WEI1 182.57 ± 12.05 vs. WEI2 206.43 ± 11.39; p = 0.0028). Thes data are summarized in figure 2.

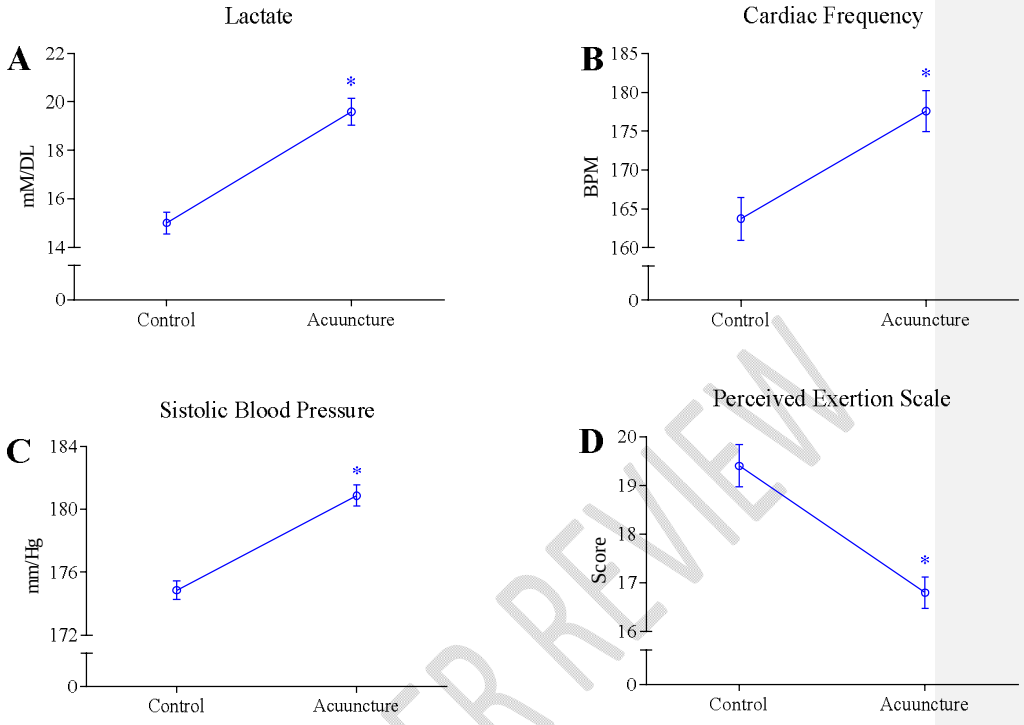

Figure 2: Effects of acupuncture on physiological parameters. Seven volunteers completed a series of exercises at an intensity between 85% and 95% of maximum heart rate, performing the greatest number of repetitions at the highest possible intensity with 30-second recovery intervals every three minutes. Data collection was conducted before, immediately after, and five minutes after exercise. Student's t-test with a significance level of 5% was applied to compare the results. (A: *p = 0.0004; B: *p > 0.0001; C: *p > 0.0001; D: *p = 0.0028).

DISCUSSION

This study aimed to determine the acute effects of acupuncture on physical performance and perceived exertion in amateur athletes. The participants completed a 50-minute CrossFit session with 30-second recovery intervals every three minutes, both without acupuncture and seven days later after receiving acupuncture. The findings suggest that acupuncture has the potential to enhance athletic performance by improving lactate clearance and reducing perceived exertion.

The significant reduction in perceived exertion following acupuncture, despite increases in physiological markers such as lactate and heart rate, indicates that acupuncture may influence pain perception, allowing athletes to perform at higher intensities without feeling increased exertion. These results align with previous studies that found positive correlations between lactate levels and heart rate during high-intensity interval training [24].

Additionally, in a study involving thirty individuals divided into groups subjected to manual acupuncture, electroacupuncture, or no intervention, the manual and electroacupuncture groups

displayed higher exercise intensities than the controls, supporting the findings of this study [25,26].

However, our findings differ from those of Ma et al. [27], who reported lower lactate concentrations post-acupuncture. This discrepancy may be attributed to differences in study design, acupuncture points used, and exercise protocols. The authors hypothesize that the pain threshold may have been altered by acupuncture, allowing athletes to exert more effort without increased perception of exertion, as observed in a previous study where post-exercise lactate concentrations were lower in the acupuncture group following intense sprinting [27].

Acupuncture is thought to increase local circulation primarily through the production of nitric oxide, which induces vasodilation and stimulates the release of substances that alleviate pain [28]. Reduced perceived pain has been shown to enable athletes to exercise with greater intensity, which may explain our findings. Previous studies also demonstrated that acupuncture applied to points such as PC6 and ST36 reduced heart rate and lactate levels after 60 minutes, suggesting faster recovery [30].

A single session of acupuncture appears to enhance athletic exertion by reducing pain perception, as previously reported [31]. This suggests that manual acupuncture can significantly increase isometric exertion levels compared to controls.

Post-acupuncture VO_2max was improved however. On average, participants exercised 2.75 times per week, and some individuals are known to require four to five times per week to improve cardiorespiratory fitness when exercise is at a lower intensity [38]. This fact proves that acupuncture is efficient to improve the acute cardiorespiratory fitness [39–41]. Although the acupuncture showed cardiorespiratory and muscular adaptations, this is not a performed best over time in terms of adaptations, and all results were attributed at an acute physiologic adaptation, probably, related to a cellular and metabolic use of glucose or in regards a neural adaptation (both unexplored).

What does this article add?

Acupuncture appears to increase athletic effort while reducing perceived exertion. This is evidenced by lactate accumulation, increased heart rate, and elevated blood pressure, suggesting that athletes can achieve higher levels of exertion after acupuncture. The reduction in perceived exertion may be attributed to altered pain perception resulting from high-intensity physical activity during sports. These findings suggest that acupuncture could enhance athletic performance, particularly when applied 30 minutes before a workout or race to allow the effects to take hold during activity.

Limitations

The limitations of this study include the small sample size, which limits the generalizability of the findings. Additionally, there was no direct observation of maximum oxygen consumption (VO2 max), which could have provided more insight into the aerobic capacity of the participants. Other biochemical markers related to physical exercise, such as cortisol or creatine kinase, were not observed, which might have provided a more comprehensive understanding of the effects of acupuncture on recovery and performance.

Furthermore, the study did not control the diet of the participants during the interval week between sessions, which may have influenced the metabolic outcomes. Future studies should include a larger, more diverse sample, control for dietary intake, and examine additional

physical qualities such as strength, flexibility, and body composition. It is also important to investigate the effects of acupuncture on female athletes and elite-level performers.

The physiological mechanisms underlying the observed effects of acupuncture are not yet fully understood. It is speculated that acupuncture may improve local circulation and stimulate the release of endorphins, reducing pain and fatigue. The role of nitric oxide production, as reported by Kimura et al. [28], in enhancing vasodilation and blood flow, may also facilitate faster lactate clearance.

CONCLUSION

This study demonstrated that acupuncture can enhance athletic performance by increasing lactate clearance and reducing perceived exertion in amateur athletes. These findings suggest that acupuncture could be a valuable tool for athletes seeking to improve performance without increasing perceived effort. However, the study's small sample size, lack of a placebo group, and absence of VO2 max measurements limit the generalizability of these results. Future research should include larger, more diverse samples and investigate the long-term effects of acupuncture on athletic performance.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

The authors hereby declare that generative AI technology, CHAT GPT 4.0, was used for editing the English language of the manuscript. The request was solely to correct spelling, punctuation, and grammar, without altering, adding, omitting information or data, or changing the meaning of the text.

CONSENT AND ETHICAL APPROVAL

The study was submitted to, and approved by the Ethics and Human Research Committee of FIMCA College under protocol number 79724. In order to attend the legal exigences of the Ethical Council one parent signed a consent to the children to participate of this investigation, and the children was consulted about his consensual participation during the document assignation of the parent.

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