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The effectiveness of sports massage and cupping against heart rate changes and lactic acid after high-intensity interval training in athletes

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ABSTRACT

Sports massage and cupping are ubiquitous in elite sports and increasingly common at the amateur level but evidence of these interventions has been underreported. The study's aim was to examine the effect of sports massage and cupping on changes in heart rate and lactic acid after high-intensity interval training (HIIT). This study utilized a quasi-experimental design with three experimental groups (sports massage group, cupping group, and sports massage plus cupping group) and one control group. A total of 40 athletes from East Java, Indonesia, participated. All groups consisted of ten athletes. The results showed that the sports massage intervention was more effective in reducing lactic acid and heart rate than the cupping group, the sports massage plus cupping group, and the control group. The results also indicated that the sports massage and cupping group had the lowest lactic acid and heart rate compared to the other groups ($p \leq 0.001$). This study proves that sports massage and cupping was effective to reduce lactic acid and heart rate after high-intensity interval training. Our findings may contribute to helping guide coaches and athletes about the benefits of sports massage and cupping and provide information for incorporating sports massage and cupping into training and competition.

KEYWORDS

HIIT; Sport Massage; Cupping; Lactid Acid; Athlete

1. INTRODUCTION

Exercise-induced skeletal muscle damage (EIMD) is a common complication of strenuous physical activity (Mohd Daud et al., 2023). Exercise is a physical activity to improve health and body fitness (Kapoor et al., 2022). On the contrary, exercise also has a negative impact on the body, such as muscle damage (Tanabe et al., 2021). Symptoms of muscle damage that commonly occur due to exercise include soreness, decreased muscle strength, range of motion (ROM), increased inflammatory response, and increased serum creatine phosphokinase levels in the blood (Nugraha, 2017). Athletes are never separated from training, but training methods and their application to elite athletes are largely dependent on a "trial-and-error" approach, with the experience and practice of coaches and successful athletes often providing the basis for "post hoc" scientific inquiry and research (Furrer et al., 2023). Therefore, approaches from other aspects in supporting athlete performance are needed.

During physical exercise, humans use various systems such as the respiratory, cardiovascular, nervous, and excretory (Patel & Zwibel, 2022). The physical exercise that can improve cardiorespiratory performance and fitness is high-intensity interval training (HIIT) (Mendelson et al., 2022). HIIT was a form of exercise that is anaerobic (Ito, 2019). The anaerobic makes blood lactate levels and heart rate increase rapidly (d'Unienville et al., 2022). This method has the advantages of short training time, strong flexibility, and less impact on traumatic injuries to the musculoskeletal system, so it is recommended for adolescence (Jones et al., 2010).

HIIT can be one way to maintain physical fitness (Alonso-Fernández et al., 2022). Physical fitness is a person's functional ability to complete relatively heavy daily tasks for a long time without causing significant fatigue (Gultom et al., 2022). In order not to cause excessive fatigue, athletes can do other activities that can restore athletes energy after doing short physical activities (Doherty et al., 2021). Furthermore, HIIT has an impact on the body, especially blood pressure, hormones, blood sugar, lactate levels, and the autonomic nervous system (Nugraha, 2017).

HIIT consists of several short or moderate sessions of high intensity, and each session is interspersed with rest periods of light intensity exercise (Ito, 2019). Several HIIT exercises include running, walking, cycling, swimming, and climbing stairs. HIIT consists of 3 stages: warm-up, maximum intensity training, and cooling down (Botta et al., 2022). Warm up with a duration of 3 minutes for six cycles. Each cycle includes 2 minutes of full intensity exercise with an intensity of 80% to 90% maximum heart rate, and 1 minute of moderate-intensity exercise with an intensity of

60% to 70% maximum heart rate (Pranoto et al., 2023; Rejeki et al., 2023; Merawati et al., 2023). Then the cooling down is 3 minutes (Heydari et al., 2012).

High-intensity exercise and short duration, cause an increase in energy requirements up to a hundred times (Vargas-Mendoza et al., 2021). But, the body cannot produce large amounts of energy in a short time, so the fulfillment of energy needs depends on the phosphagen system and anaerobic glycolysis (Morrison et al., 2017). The phosphagen system can only provide energy for activities with a range of fewer than ten seconds, so anaerobic glycolysis is the main metabolic pathway in high-intensity exercise (Koh et al., 2022). However, this anaerobic glycolysis metabolic pathway produces a by-product, lactic acid. Lactic acid accumulation can cause fatigue (Septiani & Said, 2010). The increase of lactic acid in the muscles will inhibit the work of enzymes and interfere with chemical reactions in the muscles, so inhibiting muscle contraction which will result in increased muscle fatigue (Widiyanto, 2012; Wan et a., 2017; Jacob et al., 2022).

Fatigue after HIIT can affect the athletes' performance (Parwata, 2015). Fatigue is common in intensive training and competition where the match is repeated in less than 24 hours. Active recovery is one method to remove lactic acid levels (Laksana et al., 2019; Tesi et al., 2019). In addition to making an active recovery, athletes can also do sports massage to speed up recovery both anatomically, physiologically, and mentally (Davis et al., 2020).

Sports massage is a technique carried out on soft tissues to provide freshness to people so they can carry out more active physical activities (Davis et al., 2020). Sports massage is a set of manipulations carried out using the hands on an athlete's body in a passive state to improve fitness, avoid potentially harmful things, and minimize pain due to sports injuries (Sulistyorini & Basoeki, 2013; Davis et al., 2020). Sports massage is usually intended for people in good health and fitness, especially for athletes who also usually need a comprehensive sports massage of the body after training or competition (Field, 2016).

The studies revealed that sports massage reduces lactic acid levels by 25% after 10 minutes of recovery (Wiltshire et al., 2010; Ningsih et al., 2016). Welis et al. (2023) stated that giving sports massage after exercise and sports competition (high intensity) is very effective in reducing lactic acid levels in athletes. Muscle fatigue can also be reduced by removing toxins through discharging dirty blood with cupping. Thus, it is hoped that the blood produced from cupping can reduce levels of lactic acid in the athlete's body so that athletes can recover from training with an anaerobic dominant energy system. If the athlete recovers normally, the athlete's heart rate will automatically decrease

(Arditiansyah, 2017).

Besides sports massage, cupping is a manipulation method used to treat and relieve various health problems, muscle relaxation, anxiety, and general physical and mental problems (Lee et al., 2011). Cupping is expected to increase blood circulation to accelerate the decrease in lactic acid (Al-Bedah et al., 2018). Cupping as a recommended method has several properties and empirically benefits human health (Furhad & Bokhari, 2022). There are several theories of cupping, one of which is the Taibah theory (Ridho, 2015).

However, very few studies have tested the effectiveness of cupping and sports massage in reducing lactic acid and heart rate after high-intensity interval training (HIIT), especially in Indonesia. Therefore, the study's purpose is to examine the effect of sports massage and cupping on changes in heart rate and lactic acid after high-intensity interval training (HIIT).

2. METHODS

2.1. Study Design and Participants

This study was a quasi-experimental study using randomly selected 40 athletes from East Java, Indonesia. Participants were divided into four groups. Three groups experimented with different treatments (sports massage, cupping, and sports massage + cupping) and one control group (without treatment).

2.2. Interventions and Procedure

The experimental procedure was carried out as follows. (1) four groups were given high-intensity interval training (HIIT) exercise with eight movements for 1 minute and 40 seconds. (2) measurement of pulse rate and levels of lactic acid in the body. (3) each group is given different treatment for 15 minutes for each treatment. (4) measurement of pulse and lactic acid levels. Measurement of heart rate using a Pulse Oximeter (Beurer PO30 Pulse Oximeter, USA)., meanwhile measuring lactic acid using Accutrend Plus Meter (Accutrend® lactate meter, Roche Diagnostics, Mannheim, Germany) in concentration units of mmol/L. Table 1 presents the HIIT training protocol, showing the exercises used and their 20-second work / 10-second rest structure, while table 2 presents the experimental design, showing group divisions, pre-test/post-test (O1–O2), and the different interventions applied (sports massage, cupping, combined, or none).

Table 1. High-intensity interval training (HIIT)

HIIT Type	Exercise Duration	Rest
Squad Jump	20 Second	10 Second
Push-Up	20 Second	10 Second
Jumping Jack	20 Second	10 Second
Right Split Squad	20 Second	10 Second
High Knee	20 Second	10 Second
Left Split Squad	20 Second	10 Second
Mountain Climber	20 Second	10 Second
Burpees	20 Second	10 Second

Table 2. Experiment procedure

		Pre-test	Treatment	Post-test
Group 1	HIIT	O1	SM	O2
Group 2	HIIT	O1	C	O2
Group 3	HIIT	O1	SMC	O2
Group 4	HIIT	O1	-	O2

Note. *HIIT = High-intensity interval training; O1 = Pre-training; SM = Sport massage; C = Cupping; SMC: Sport massage + cupping; O2 = Post-training*

2.3. Statistical Analyses

This study used Statistical Package for the Social Sciences (SPSS) software to perform a Paired Samples T-Test to examine differences between pre-training and post-training measurements for each treatment group. In addition, a post-hoc One-way ANOVA and Tukey's Honest Significant Difference (HSD) test were conducted to identify the most effective method for reducing athletes' heart rate and lactic acid levels after HIIT, with p-values set at $p < 0.05$ to determine statistical significance.

3. RESULTS

The results of measuring the average heart rate before and after HIIT are shown in Figure 1. Figure 1 shows the reduction in heart rate after treatment in each group. The results of the paired sample t-test analysis showed that there was a significant decrease in the average heart rate after treatment SM, and SMC ($p \leq 0.05$), but CTR and C did not show a significant decrease in the average heart rate after treatment ($p \geq 0.05$).

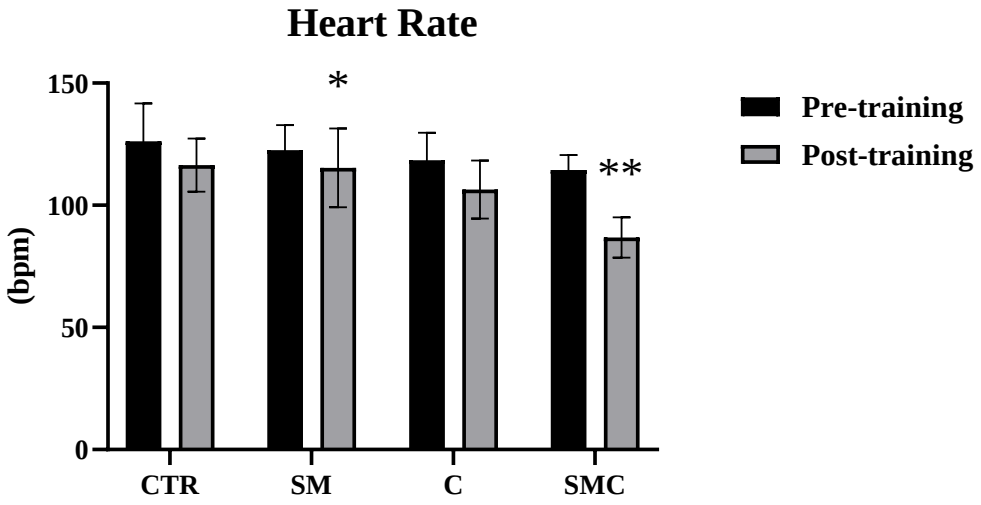

Figure 1. Heart rate before and after treatment in each group
Note. *CTR: Control; SM: Sport massage; C: Cupping; SMC: Sport massage & cupping. (*) Significant vs. pre-training ($p \leq 0.05$). (**) Significant vs. pre-training ($p \leq 0.001$)*

The results of the lactic acid measurements of the four groups above can be summarized in Figure 2.

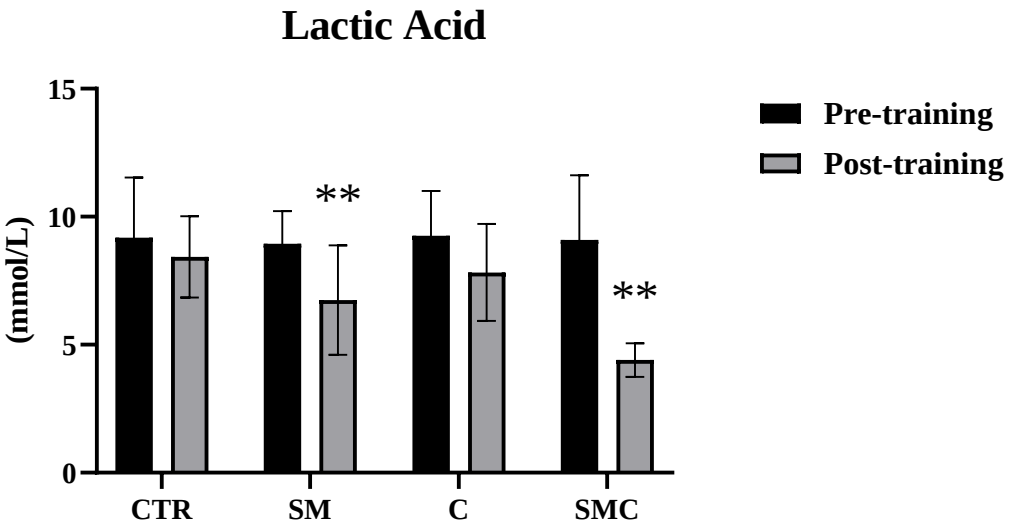

Figure 2. Lactic acid before and after treatment in each group
Note. *(**) Significant vs. pre-training ($p \leq 0.001$)*

Figure 2 showed the reduction in lactic acid after treatment in each group. The results of the paired sample t-test analysis showed that there was a significant decrease in the average lactic acid after treatment SM, and SMC ($p \leq 0.001$), but CTR and C did not show a significant decrease in the

average lactic acid after treatment ($p \geq 0.05$). This study used One way-ANOVA and Tukey's HSD post-hoc test to examine the most effective methods in reducing the heart rate and lactic acid of the athletes after HIIT.

Table 3. Heart rate analysis results with One-way ANOVA

Periods	Groups				*p* value
	CTR	SM	C	SMC	
Pre-training (bpm)	126.20±15.48	122.60±10.24	118.40±11.32	114.40±6.15	0.124
Post-training (bpm)	116.40±10.85	115.30±16.14	106.40±11.85	86.80±8.27*†≠	0.000
Delta (Δ) (bmp)	-9.80±22.13	-7.30±9.46	-12.00±19.07	-27.60±8.97†	0.032

Note. CTR: Control; SM: Sport massage; C: Cupping; SMC: Sport massage & cupping. (*) Significant vs. CTR ($p \leq 0.001$). (†) Significant vs. SM ($p \leq 0.001$). (≠) Significant vs. C ($p \leq 0.001$).

The heart rate results (Table 3) showed no significant differences between the groups on pre-training (p-value = 0.124). Meanwhile, heart rate analysis results post-training showed a significant decrease between groups (p-value = 0.000). Based on the delta (Δ), the SMC group shows the has the highest decrease in heart rate compared to the others group. Therefore we can assume that participants who received SMC had the largest decrease in heart rate compared to other group participants. Table 4 shows the lactic acid analysis results with One-way ANOVA.

Table 4. One-way ANOVA results for lactic acid analysis

Periods	Groups				*p* value
	CTR	SM	C	SMC	
Pre-training (mmol/L)	9.18±2.35	8.95±1.27	9.25±1.75	9.10±2.51	0.989
Post-training (mmol/L)	8.43±1.58	6.74±2.14	7.82±1.89	4.40±0.66*†≠	0.000
Delta (Δ) (mmol/L)	-0.75±2.17	-2.21±1.95	-1.43±2.59	-4.70±2.69*≠	0.004

Note. *CTR: Control; SM: Sport massage; C: Cupping; SMC: Sport massage & cupping. (*) Significant vs. CTR ($p \leq 0.05$). (†) Significant vs. SM ($p \leq 0.05$). (≠) Significant vs. C ($p \leq 0.05$).*

The lactic acid result (Table 4) showed no significant differences between the groups on pre-training (p-value = 0.989). Meanwhile, lactic acid analysis results post-training showed a significant decrease between groups (p-value = 0.000). Based on the delta (Δ), the SMC group shows the has the highest decrease in lactic acid compared to the others group. Therefore we can assume that participants who received SMC had the largest decrease in lactic acid compared to other group participants.

4. DISCUSSION

Based on the one-way ANOVA analysis, there were significant differences in heart rate between groups ($p \leq 0.05$). Likewise, delta (Δ) show that received combination of sport massage and cupping (SMC) treatment has the highest decrease in heart rate compared to the others group. Therefore we can conclude that SMC is more effective to reduce the heart rate of athletes after HIIT (Table 3). The finding is in line with previous findings that revealed that sports massage is a massage on certain parts using hands or special tools that aims to improve blood circulation as a treatment or relieve fatigue (Ningsih et al., 2016). In addition, the effect of sports massage leads to the stimulation of nerves and muscles that are tense to make muscle relaxation (Field, 2016). It is assumed to lead to decreased pulse frequency because tense muscles can stretch (relax). In other words, the need for oxygen supply to the muscles will also decrease, which in turn will lead to cardiac activity in supplying oxygen throughout the body marked by reduced heart rate.

It is evident that the treatment of athletes after HIIT is closely related to lactic acid levels. Furthermore, for the lactic acid test, the result shows significant differences in lactic acid levels between the groups ($p \leq 0.05$) (Table 4). Based on the delta score (Δ), the lowest lactic acid is in the sport massage and cupping (SMC) group compared to the others. Therefore we can conclude that SMC has a significant positive impact to decreased the lactic acid levels. This finding aligns with the previous study that revealed that sports massage effectively reduces athletes lactic acid levels (Ningsih et al., 2016).

The increase in lactic acid levels results from glucose metabolism through lactic anaerobic glycolysis reactions and the reduction of pyruvic acid that occurs in parts of muscle tissue under oxygen-deficient conditions (Ferania et al., 2010; Sari et al., 2019). Therefore, sports massage is an effort to restore and activate the mechanism of the venous pump and lymph pump artificially, aiming to improve circulation (Sari et al., 2019). In addition, sports massage is a mechanical manipulation of soft body parts with a rhythmic pressure to produce physiological effects and can be calming and reduce psychological stress (Davis et al., 2020). So it can be concluded that the purpose of sports massage is to make blood circulation (Suardi, 2018). Other studies have also shown that sports massage makes the muscle relax and leads to a decrease in lactic acid and heart rateSports massage also has the effect of relieving stress, increase tissue elasticity, and eliminating lactic acid (Brilian et al., 2021).

These results indicate that sports massage with effleurage manipulation reduces lactic acid

and heart rate. This study is in line with previous research, which showed that sports massage with a combination of techniques such as effleurage, and petrissage friction expedited the clearance of both lactate from the blood (Sriwongtong et al., 2020). Davis et al. (2020) stated that sports massage is widely used as a physical therapy modality for recovery from fatigue and muscle injury in athletes. Physiologically, sports massage has been shown to reduce heart rate, increase blood and lymph circulation, reduce muscle tension, increase joint range of motion and reduce pain (Davis et al., 2020; Bervoets et al., 2015) and reduce levels of the enzyme creatine kinase in the blood (Poppendieck et al., 2016).

As revealed by the previous study, sports achievement depends not only on an athlete's mentality, technique, and tactics but also on recovery methods or post-training or match recovery (Heydari et al., 2012; Putra et al., 2017). The more effective the recovery method is, the faster an athlete's body condition returns to fitness and is ready to do the following exercise and match. Therefore, choosing the right recovery method can improve an athlete's performance (Hottenrott et al., 2022). This study also proves that sports massage treatment can be used as an alternative for athlete recovery after exercising.

5. CONCLUSIONS

This study revealed that sports massage and cupping (SMC) treatment is the most effective in reducing athletes' heart rate and lactic acid after high-intensity interval training (HIIT). Compared to the other groups (control group, sports massage group, cupping group, sports massage, and cupping group), the decrease in heart rate and lactic acid of the participants that received sports massage treatment was the lowest. Our findings may contribute to helping guide coaches and athletes about the benefits of sports massage and cupping and provide information for incorporating sports massage and cupping into training and competition.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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