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ORIGINAL SCIENTIFIC PAPER

Effects of Percussive Massage on Lactate Removal, Strength and Explosive Power of Leg Muscles after Physical Exercise

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Abstract

The implementation of percussive massage therapy plays an important role in supporting muscle recovery, reducing fatigue, increasing blood flow, and improving flexibility and performance. However, percussive massage after physical exercise remains limited and is not widely practiced. Therefore, this study was conducted to further investigate the recovery effects of percussive massage on reducing blood lactate levels and increasing strength and explosive power in the leg muscles after physical exercise. A total of 16 participants took part in this study, evenly divided into two groups of eight. The percussive massage group (PM) had a mean age of 20.75±1.48 years, a body weight of 59.05±6.46 kg, a height of 164.50±4.37 cm, and a body mass index (BMI) of 21.90±1.96 kg/m^2. This group received percussive massage on their lower extremities. Meanwhile, the passive recovery group (PR) had a mean age of 20.75±1.48 years, a body weight of 63.40±5.49 kg, a height of 167.03±7.14 cm, and a body mass index (BMI) of 21.78±1.43 kg/m^2, and did not receive any massage. Both groups performed countermovement jump plyometric exercises consisting of 5 sets of 20 repetitions, with a 1-minute rest period between sets and repetitions. Measurements of blood lactate levels, as well as strength and explosive power of the leg muscles, were taken before and after the recovery period. The findings indicated that percussive massage therapy significantly reduced blood lactate levels (p=0.000) and enhanced leg muscle explosive power (p=0.034). Furthermore, there were significant differences in the delta (Δ) of blood lactate levels and leg muscle exploiveness between the PM group and the PR group (p=0.012 and p=0.038), while no significant differences were found in the delta (Δ) of leg muscle strength between the two groups (p=0.089). Based on the findings of this study, percussive massage therapy after physical exercise positively impacts the reduction of blood lactate levels and enhances explosive power in the leg muscles. However, it does does not have a significant effect on leg muscle strength.

Keywords: *muscle recovery, sport massage, percussive massage therapy, blood lactate, leg muscles performance, plyometric exercise*

Introduction

Physical exercise performed at high intensity predominantly utilizes the anaerobic metabolic system to meet energy demands (Baker et al., 2010). This anaerobic system produces residual metabolic byproducts, primarily lactic acid. The formation of lactic acid occurs as a result of prolonged high-intensity physical activity. The accumulation of lactic acid can lead to muscle fatigue and soreness, ultimately impacting performance (Wan et al., 2017). Therefore, proper recovery strategies and accelerated lactate clearance are essential for the body to recover and minimize the risk of injury, allowing it to achieve optimal performance in the next training session and compe-

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tition (Barrenetxea-Garcia et al., 2024). In addition, recovery methods applied after exercise are known to quickly reduce or eliminate lactic acid (Nalbandian & Takeda, 2016). One of the commonly used recovery strategies is massage, that involves the mechanical manipulation of body tissues through pressure and rhythmic strokes to enhance physical condition. The application of massage after exercise can reduce pain and improve joint mobility, while also providing physiological benefits that enhance strength, coordination, balance, and muscle function, as well as treating delayed onset muscle soreness (DOMS). This can enhance an athlete's physical performance while reducing the risk of injury (Kommers et al., 2024). One effective massage method for accelerating recovery is percussive massage therapy, also known as a massage gun (Leabeater et al., 2024).

Percussive massage therapy is a vibration therapy that can be performed using hands (manual) or tools (Opara et al., 2010). Percussive massage tool (massage gun) is a small hammer that is powered by electricity or batteries. It delivers localized vibrations with frequencies ranging from 5 to 300 Hz, amplitudes of 0.12 to 12 mm, and durations of 6 seconds to 30 minutes (Germann et al., 2018). This device mimics the therapeutic effects of tapotement massage therapy (Moraska, 2005). In recent years, percussive massage have been used in both clinical and sports contexts for warm-up, recovery, or as part of treatment (Germann et al., 2018). Although there is still limited scientific evidence regarding the use of percussive massage tool use and their effects on metabolite clearance and physical performance, 15% to 25% of elite triathletes incorporate percussive massage tool into their regular training routines. This suggests that percussive massage tool seem to be a popular and well-regarded tool among athletes (Leabeater et al., 2022).

In some previous studies, it has been shown that percussive massage therapy can increase blood flow, which can support muscle recovery (Needs et al., 2023), enhance flexibility (Alvarado et al., 2022), and reduce fatigue (García-Sillero, Jurado-Castro, et al., 2021), as well as decrease compliance and stiffness muscle (García-Sillero, Benítez-Porres, et al., 2021). Recent research by (Needs et al., 2023) the use of percussive massage for 19 minutes showed an increase in blood flow after the recovery. This supports the research conducted by (García-Sillero, Jurado-Castro, et al., 2021) which proves that percussive massage has been effective in repairing muscle tissue, thus optimizing recovery after high-intensity physical exercise.

Although percussive massage has become a popular tool among athletes for recovery after physical exercise (Leabeater et al., 2022). However, there are still few studies that examine the effects of percussive massage methods after physical exercise. This study contributes to the development of recovery strategies for athletes after high-intensity physical exercise. Furthermore, percussive massage for recovery strategies may be able to improve physical performance while reducing the risk of injury for athletes. Therefore, the purpose of this study was to optimize recovery using percussive massage after physical exercise by examining parameters of blood lactate levels, strength, and explosive power of leg muscles.

Methods

Study participants

A total of 16 male participants, aged 19 to 24 years, who are actively engaged in sports, had no history of chronic diseases, and voluntarily consented to participate in this study were included. Participants were divided into two groups: the percussive massage group (PM) and the passive recovery group (PR). In the PM group, 8 participants had an average age of 20.75±1.48 years, a body weight of 59.05±6.46 kg, a height of 164.50±4.37 cm, and a body mass index (BMI) of 21.90±1.96 kg/m². In the PR group, which also included 8 participants, the average age was 20.75±1.48 years, with a body weight of 63.40±5.49 kg, a height of 167.03±7.14 cm, and a BMI of 21.78±1.43 kg/m². All participants received information both verbally and in writing prior to the study, and they expressed their willingness to participate by signing an informed consent form. This study was approved by the Health Research Ethics Committee of the Faculty of Medicine at Universitas Airlangga, Surabaya, Indonesia, under approval number 49/EC/KEPK/FKUAN/2024.

Protcol study

This study was conducted at the Sports Science Center of Airlangga University. The participants performed a countermovement jump plyometric exercise protocol, which consisted of 5 sets of 20 repetitions, with a 1-minute rest period between sets and repetitions (Mirzaei et al., 2014). The participants were instructed to refrain from any exercise for 24 hours prior to the study and to fast for 8 hours, consuming only mineral water during this time. Percussive massage recovery was performed with the participants in both prone and supine positions. The percussive massage treatment was performed using a Hypervolt device (Hyperice, California, USA) on the lower extremities for 20 minute, employing a frequency of 53 Hz, starting from distal to proximal areas (Konrad et al., 2020; Leabeater et al., 2024). In the prone position, the treatment included five minutes on the gastrocnemius muscle and five minutes on the hamstring muscle. In the supine position, the treatment consisted of five minutes on the tibialis anterior muscle and five minutes on the quadriceps muscle. Meanwhile, passive recovery (PR) was performed with the participants in the prone position for 20 minutes, during which no massage was given.

Measurements

In this study, blood lactate levels were measured by taking capillary blood samples from the fingertips of the participants and measuring them using the Accutrend Plus Meter (Accutrend lactate meter, Roche Diagnostics, Mannheim, Germany) (Pérez et al., 2008), with concentrations reported in mmol/L. The isometric mid-thigh pull test IMTP) was conducted using a dual force plate device (ForceDecks, VALD Performance, Brisbane, Australia) to measure leg muscle strength (Collings et al., 2024). The IMTP test has been employed for strength assessment in various sports and for research purposes (Comfort et al., 2019). Furthermore, the IMTP test is considered a potentially safer testing method (De Witt et al., 2018). Additionally, the countermovement jump test (CMJ) was conducted using a dual force plate device (ForceDecks, VALD Performance, Brisbane, Australia) to measure leg explosive power (Collings et al., 2024). Two time points were taken: (1) pretest - before recovery, and (2) posttest - immediately after recovery.

Statistical Analysis

The mean and standard deviation of the data in this study are presented. The Shapiro-Wilk test was used to assess whether the data followed a normal distribution. Paired sample t-test was used to analyze the difference between pretest and posttest results. Independent sample t-test was used to analyze the difference between percussive massage group and passive recovery group. All statistical analyses in this study used SPSS software version 26 (Chicago, IL, USA) with a significance level of p<0.05.

Results

The description of participant characteristics data from the results of the study in each group is presented in Table 1. Table 1 shows that both the percussive massage group and the passive recovery group showed similar variations in characteristics. This indicates that there were no significant differences in terms of age, weight, height, and body mass index among the study participants (p>0.05).

The results of the analysis of blood lactate levels, leg muscle strength, and leg muscle explosive power between the pretest and posttest for both the percussive massage (PM) group and the passive recovery (PR) group are presented in Table 2. The analysis of blood lactate levels, conducted using a paired t-test, indicated a significant decrease from pretest to posttest for both the PM group (p<0.05) and the PR group (p<0.05). However, the analysis of leg muscle strength, also using a paired t-test, showed no significant increase between the pretest and posttest in either the PM group (p>0.05) or the PR group (p>0.05). In contrast, the analysis of leg muscle explosive power revealed a significant increase from pretest to posttest in the PM group (p<0.05), while no significant change was observed in the PR group (p>0.05).

Table 1. Research participant characteristics

Variables	PM (n = 8)	PR (n = 8)	p-value
	Mean ± SD	Mean ± SD	
Age (year)	20.75 ± 1.48	20.75 ± 1.48	0.607
Weight (kg)	59.05 ± 6.46	63.40 ± 5.49	0.169
Height (cm)	164.50 ± 4.37	167.03 ± 7.14	0.406
BMI (kg/m2)	21.90 ± 1.96	21.78 ± 1.43	0.898

Note: PM: percussive massage; PR: passive recovery; BMI: body mass index; SD: standar deviation; p-value were obtained using independent t-test.

Table 2. Analysis of blood lactate, strength and explosive power of leg muscles

Variables	Group	Pretest	Posttest	p-value
		Mean ± SD	Mean ± SD	
Blood Lactate (mmol/L)	PM (n=8)	11.27 ± 3.82	5.72 ± 2.24	0.000*
	PR (n=8)	13.07 ± 1.73	4.56 ± 0.67	0.000*
Leg Muscle Strength (N)	PM (n=8)	1471.63 ± 412.49	1497.38 ± 322.74	0.401
	PR (n=8)	1654.63 ± 189.05	1558.75 ± 185.37	0.116
Leg Muscle Explosive Power (N)	PM (n=8)	3086.63 ± 504.33	3249.50 ± 559.53	0.034*
	PR (n=8)	3027.63 ± 328.09	2995.25 ± 365.66	0.599

Note: PM: percussive massage; PR: passive recovery; N: newton; SD: standar deviation; p-value were obtained using paired t-test;
* Significantly different from pretest (p≤0.05)

The results of the analysis of blood lactate levels, leg muscle strength, and leg muscles explosive power between the PM and PR groups are presented in Table 3. According to Table 3, the mean pretest and posttest blood lactate levels for both the PM and PR groups showed no significant difference. However, the delta (Δ) values of blood lac-

Table 3. Analysis of blood lactate, strength and explosive power of leg muscles between groups

Time	Group		P-value
	PM (n = 8)	PR (n = 8)	
Blood Lactate (mmol/L)			
Pretest	11.27 ± 3.82	13.07 ± 1.73	0.246
Posttest	5.72 ± 2.24	4.56 ± 0.67	0.182
Delta (Δ)	5.55 ± 2.30	8.51 ± 1.77	0.012*
Leg Muscle Strength (N)			
Pretest	1471.63 ± 412.49	1654.63 ± 189.05	0.273
Posttest	1497.38 ± 322.74	1558.75 ± 185.37	0.648
Delta (Δ)	25.75 ± 112.45	-95,87 ± 151,28	0.089
Leg Muscle Explosive Power (N)			
Pretest	3086.63 ± 504.33	3027.63 ± 328.09	0.786
Posttest	3249.50 ± 559.53	2995.25 ± 365.66	0.300
Delta (Δ)	162.88 ± 174.61	-32,37 ± 166,08	0.038*

Note: PM: percussive massage; PR: passive recovery; N: newton; SD: standar deviation; p-value were obtained using paired t-test; * Significantly different from the PR group pretest (p≤0.05) tate levels in both groups showed a significant difference (p=0.012). In terms of leg muscle strength, the comparison of pretest, posttest, and delta (Δ) values between the PM and PR groups revealed no significant differences. Notably, the mean pretest value for the PM group indicated an increase from the pretest, while the PR group experienced a decrease in mean leg muscle strength. Furthermore, the difference in leg muscle explosive power between the pretest and posttest for both the PM and PR groups showed an increase in the mean for the PM group and a decrease for the PR group, with a significant difference in delta values (p=0.038).

Discussion

The main findings of this study show that percussive massage therapy after physical exercise is effective in reducing blood lactate levels and increasing leg muscle explosive power. However, no differences were observed in leg muscle strength.

In this study, percussive massage was shown to reduce blood lactate levels after a 20-minute recovery period. This is supported by research (Needs et al., 2023), which indicates that percussive massage increases blood flow when applied at a high frequency and for a long duration. During recovery, massage therapy improves blood circulation, reduces lactate levels and alleviate pain (Bakar et al., 2015). The removal of lactate from the bloodstream and muscles is essential for recovery after exercise (Kang et al., 2017). Additionally, percussive massage with different vibration frequencies may provide different results (Konrad et al., 2020). In this study, the percussive massage operated at a frequency of 53 Hz. Applying vibration during rest can effectively reduce blood lactate levels following intense physical exercise (Kang et al., 2017). Although the precise mechanism by which vibration enhances blood flow remains unclear, it is possible that the mechanical stress associated with vibration elevates arterial pressure. When this pressure is released, it may facilitate increased blood flow (Soares et al., 2020). This finding contrasts with a previous study (Alonso-Calvete et al., 2022), which indicated no significant difference in blood lactate reduction when comparing 8 minutes of percussive massage with passive recovery. The discrepancy between these findings and those of the earlier study may be attributed to the differing durations of recovery administered.

This study presents intriguing findings regarding blood lactate after physical exercise. The results indicate that passive recovery is more effective than recovery through percussive massage in reducing lactate levels. This discrepancy is thought to stem from individual variations in metabolism. Basal metabolism is influenced by several factors, including gender, age, body size and composition, and growth factors (Vybornaya et al., 2017). Additionally, there is a difference between trained and untrained individuals, given that this study used participants who were only actively exercising. In trained individuals, the utilization of lactate by muscles increases, resulting in a greater capacity to clear lactate from the bloodstream. Furthermore, the density of capillaries surrounding muscles increases, particularly in slow-twitch muscles. This enhanced capillary density improves blood flow to active skeletal muscles, facilitating lactate clearance and reducing acidosis (Gladden, 2000).

This study also revealed intriguing findings regarding leg muscle strength and explosiveness. While no statistically significant difference in leg muscle strength was found, percussive massage resulted in a 1.75% increase. In terms of leg muscle explosive power, the study indicated that percussive massage increased explosive power by 5.28% more effectively than passive recovery. These findings are consistent with a systematic review conducted by (Sams et al., 2023), which reported that percussive massage tools can enhance acute responses in muscle strength, explosiveness, and flexibility, while also reducing pain compared to alternative treatments, placebo, or no treatment. This evidence demonstrates that percussive massage has an immediate effect on improving musculoskeletal performance. As it is known that percussive massage is proven to have benefits in terms of leg muscle strength and explosiveness compared to passive recovery, the mechanism behind this involves the application of pressure or vibration, which can increase blood flow, reduce myofascial tension, increase range of motion, and reduce pain (Cheatham et al., 2021).

Percussive massage used after exercise are designed to restore muscle performance capabilities more quickly than passive recovery alone (Lakhwani & Phansopkar, 2021). A study conducted by (Leabeater et al., 2024) demonstrated that percussive massage had minimal impact on isometric strength in the lower leg following a five minute recovery period. Although previous studies were of little benefit on isometric strength in the lower limbs. This supports a systematic review showing that the application of localized vibration to targeted muscles can increase muscle strength in healthy adults (Alghadir et al., 2018). Additionally, the vibrations produced by the percussive massage increase muscle temperature, leading to vasodilation and enhanced skeletal muscle blood flow (Racinais et al., 2017). Elevated muscle temperature can contribute to improvements in power and jump height (Lee et al., 2018). Localized vibration significantly enhances blood flow, thereby facilitating muscle recovery (Needs et al., 2023).

Similar research has suggested that incorporating higher frequencies alongside pressure and motion may overstimulate mechanoreceptors, leading to responses without any corresponding changes in the affected tissues (Wilke et al., 2020). In this regard, there is still limited understanding of the mechanoreceptors, which play an important role in the initial response to this recovery method, and stronger stimulation results in a more significant response (Weerapong et al., 2005). In this study, percussive massage increased metabolic activity within the muscle, including increased blood flow and lactate removal. These acute physiological responses may have contributed to the positive results observed in leg muscle strength and explosiveness.

This study presents new findings on percussive massage as a recovery method for recovery after physical exercise. Specifically, percussive massage reduces blood lactate levels and enhances explosive power of the leg muscle. This study provides valuable insights into the optimal selection of percussive massage therapy for athlete recovery after physical exercise, aiming to achieve peak performance.

Although this study presents promising findings, it has severa limitations. We acknowledge that the sample size in this study was too small; therefore, future research should aim to increase the sample size to minimize potential bias in the final results. Additionally, future studies may be necessary include both trained and untrained participants, as metabolic differences among individuals may lead to varying responses to percussive massagers. Furthermore, the researchers only conducted acute high-intensity physical exercise to induce fatigue effects in athletes. Future research should focus on chronic research to achieve optimal results in physical recovery management, including the addition of creatine kinase (CK) indicators to look at muscle damage.

Conclusions

This study highlights the effectiveness of percussive massage therapy as a recovery method after physical exercise. The findings demonstrate that percussive massage significantly reduces blood lactate levels and enhances leg muscle explosive power compared to passive recovery. However, percussive massage therapy did not significantly impact leg muscle strength. Given its positive effects on muscle recovery and performance, incorporating percussive massage into post-exercise recovery routines may benefit athletes seeking to optimize performance and reduce fatigue. It is crucial for coaches and athletes to prioritize recovery methods, as effective recovery can enhance athletic performance in both training and competition.

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Conflict of interest

The authors declare no conflicts of interest related to this manuscript.

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