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Optimization of Athlete Recovery Strategies: Analysis of Massage Methods To Determine The Best Approach After High-Intensity Interval Training

Optimización de las estrategias de recuperación de los atletas: análisis de métodos de masaje para determinar el mejor enfoque después del entrenamiento en intervalos de alta intensidad

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Abstract. This study aims to optimize recovery after acute exercise using a high-intensity interval method involving the strategy of providing massage to athletes. Exercise heart rate (HR Ex), heart recovery rate (HRR), and blood lactate levels are used as parameters of physiological fatigue due to physical exercise. 24 samples participated in this research; they were divided into 3 groups, namely the during and post-massage group (DPM), the post-massage group (PM), and the control group, namely passive recovery (PR). Each group consists of 8 samples; all samples will carry out high-intensity acute exercise using the Tabata method for 4 sessions. 1 training session is carried out for 4 minutes, and the rest for each session is 4 minutes. Descriptive analysis, paired sample t-tests, and two-way ANOVA were used in data analysis. The results of this study were that all data on fatigue indicators were normally distributed ($p \geq 0.05$) and homogeneous ($p \leq 0.05$), and there were differences in lactate concentrations at each time taking the lactate levels in each group ($p \leq 0.05$). The average blood lactate levels of the three groups were stated to be significantly different after the training program ended for the DPM group (10.30±1.78 mmol/L), PM (12.9±2.05 mmol/L), and PR (13.62±2.87 mmol/L). This research concluded that giving massage has a better effect than passive recovery on recovery in terms of both heart rate and lactate levels. A recovery strategy using massage is the best strategy for managing blood lactate levels, although trainers must understand that giving a massage during training breaks and after the training program ends gives a different response to lactate levels after training ends.
Keywords: Recovery strategy, massage method, blood lactate, heart rate recovery

Resumen. Este estudio tiene como objetivo optimizar la recuperación después del ejercicio agudo utilizando un método de intervalos de alta intensidad que implica la estrategia de proporcionar masajes a los atletas. La frecuencia cardíaca en ejercicio (FC Ex), la tasa de recuperación cardíaca (FCR) y los niveles de lactato en sangre se utilizan como parámetros de fatiga fisiológica debida al ejercicio físico. En esta investigación participaron 24 muestras; se dividieron en 3 grupos, a saber, el grupo durante y después del masaje (DPM), el grupo después del masaje (PM) y el grupo de control, a saber, recuperación pasiva (PR). Cada grupo consta de 8 muestras; todas las muestras realizarán ejercicio agudo de alta intensidad mediante el método Tabata durante 4 sesiones. Se realiza 1 sesión de entrenamiento de 4 minutos y el resto de cada sesión es de 4 minutos. En el análisis de datos se utilizaron análisis descriptivos, pruebas t de muestras pareadas y ANOVA de dos factores. Los resultados de este estudio fueron que todos los datos sobre indicadores de fatiga estaban distribuidos normalmente ($p \geq 0,05$) y homogéneos ($p \leq 0,05$), y hubo diferencias en las concentraciones de lactato en cada momento de la toma de los niveles de lactato en cada grupo ($p \leq 0,05$). . Se indicó que los niveles promedio de lactato en sangre de los tres grupos eran significativamente diferentes después de que finalizó el programa de entrenamiento para el grupo DPM (10,30 ± 1,78 mmol/L), PM (12,9 ± 2,05 mmol/L) y PR (13,62 ± 2,87 mmol). /L). Esta investigación concluyó que dar masajes tiene un mejor efecto que la recuperación pasiva en la recuperación tanto en términos de frecuencia cardíaca como de niveles de lactato. Una estrategia de recuperación mediante masajes es la mejor estrategia para controlar los niveles de lactato en sangre, aunque los entrenadores deben comprender que dar un masaje durante los descansos del entrenamiento y después de finalizar el programa de entrenamiento da una respuesta diferente a los niveles de lactato una vez finalizado el entrenamiento.
Palabras clave: estrategia de recuperación, método de masaje, lactato sanguíneo, recuperación de la frecuencia cardíaca.

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Introduction

Tabata physical exercise is a physical activity that uses high-intensity to burn energy quickly but is not sustainable over a long period of time (Sari et al., 2019). When doing high-intensity physical exercise, it will cause a feeling of fatigue, This fatigue is caused by the buildup of metabolic waste in the body (Budak, 2023). This is caused by insufficient oxygen in the breakdown of glucose during high-intensity exercise, so that lactic acid begins to form and will increase (Powers & Jackson, 2008). This increase in lactic acid can cause interference in performance during training and matches (Cairns, 2006). It is known that the use of recovery techniques after training or competition can quickly reduce lactic acid levels (Nalbandian & Takeda, 2016). So a fast recovery method is needed for athletes to reduce lactic acid levels. Proper post-training recovery is key to maximizing training and subsequent matches (Keck et al., 2015). In terms of frequency and duration between training and matches, it is likely that the body will not be able to recover enough naturally to return to optimal performance quickly (Barnett, 2006; Minett & Duffield, 2014). So additional assistance is needed in the recovery process. However, currently, there are still many athletes who apply recovery strategies based on their personal experience, not on the results of existing research data (Simjanovic et al., 2009). Indirectly, they are not aware of the effects that occur when they use inappropriate recovery strategies (Crowther et al., 2017). When implementing inappropriate muscle care, it can result in decreased performance and cause injury (Kaesaman, 2019).

There are several types of recovery methods that have

been proposed that can speed up recovery, one of which is the massage method(Kargarfard et al., 2016). In several studies, massage has been shown to be a method that can speed up recovery and reduce pain (Barnes et al., 2008; Cherkin et al., 2003). In study by Ogai et al. (2008) the use of more effective massage methods decreased quickly compared to passive rest. However, so far, there is still little research that discusses the use of massage methods in every training session.

This study contributes to the development of recovery strategies for athletes when performing high-intensity physical training as well as during important game breaks. Furthermore, it is possible that a recovery strategy through massage will reduce the risk of injury experienced by athletes. The aim of this research is to optimize recovery after acute high-intensity interval exercise by looking at the parameters of exercise heart rate, recovery heart rate, and blood glucose levels. Furthermore, researchers will also compare strategies for providing massage during rest breaks during high-intensity interval training and continuing after the training program ends, as well as strategies for providing massage after the training program ends.

Material and Methods

Study participants

A total of 24 teenagers participated in this research, with an average age of 19–20 years when this study was conducted. Participants will be divided into 3 groups, namely 8 teenagers in the group giving massage during exercise breaks and post-exercise (during and post-massage) (DPM), 8 teenagers in the group giving massage after all interval training ends (PM), and the final 8 teenagers will be included in the control group or simply given passive recovery (PR).

Protocol study

The physical exercise used in this study was interval training using the tabata method. Massage treatment was given using two methods, namely the while and post-massage (DPM) method. In this method, the sample will be given massage treatment using shacking and apothecary techniques not only at the end of the training program but at rest breaks during the training interval. The second method was to give a massage after the exercise program ends, or PM (post-massage). The control group did not receive any treatment in this study or passive recovery (PR). Massage was given to both groups after the exercise program ended for 5 minutes using shaking and apothecary techniques. Lactate data was collected after the training program ended for 10 minutes, 60 minutes, 120 minutes, and 24 hours.

Data collection

Measurement of blood lactate levels using Accutrend Plus Meter (Accutrend® lactate meter, Roche Diagnostics, Mannheim, Germany) with concentration units mmol/L (Wiriawan et al., 2024)s. Lactate blood sampling was carried out five times: immediately post-exercise program ended (Blood Lactate Exercise/BL Exercise), 10 minutes post-exercise (Blood Lactate 10 Minutes/BL 10 Minutes), 60 minutes post-exercise (Blood Lactate 60 Minutes/BL 60 Minutes), 120 minutes post-exercise (Blood Lactate 120 Minutes/BL 120 Minutes) and 24 hours post-exercise (Blood Lactate 24 Hours/BL 24 Hours). Meanwhile, heart rate (HR) of exercise and recovery measurements were carried out using the Polar H10 heart rate sensor (Pranoto et al., 2023; Pranoto et al., 2024).

The use of massage methods was often preferred by athletes after high-intensity exercise because it can speed up muscle building. Massage was performed for 4 minutes during breaks between sets and after training for 10 minutes in the massage group, while in the post-massage group they performed massage only after training for 10 minutes. Applying massage using shaking movements and tapotement (Sheidaei et al., 2021; Welis et al., 2023; Więcek et al., 2018). The data collection protocol in this study was presented in Figure 1.

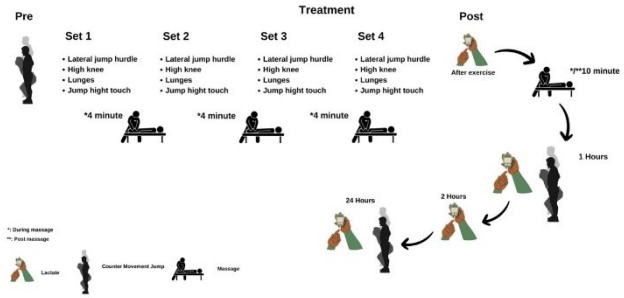

Figure 1. Data collection protocol in this study

Statistic analysis

The results of data analysis in this research used IBM SPSS version 26 software (Chicago, IL, USA). This research uses descriptive statistics to explain the research data and participant data. The data normality test in this study used the Shapirow-Wilk test method. Normality and homogeneity of variance tests were carried out to fulfill the requirements of the one-way ANOVA and two-way ANOVA test. Follow-up test using LSD post hoc test with a significance level of 5%. Data are presented as mean±SD.

Results

A description of the participant data from the research results in each group is presented in Table 1. Based on Table 1, it shows that there is no significant difference in the average participant data which includes age, weight, height, and body mass index (BMI), so that the three groups are at the same starting point the same one. Meanwhile, the results of heart rate (HR) and blood lactate (BL) data analysis are presented in Figures 1-2 and Table 2.

Table 1.
Description Participant Data

Variable	PR (n = 8)	PM (n = 8)	DPM (n = 8)	p-Value
Age (years)	19.50±1.19	20.12±1.46	20.13±0.99	0.513
Weight (kg)	58.50±7.50	56.25±4.65	56.50±2.98	0.522
Height (cm)	1.66±0.05	1.63±0.04	1.64±0.03	0.662
BMI (kg/m^2)	21.18±1.54	21.06±1.39	20.91±0.77	0.913

Description: Data are presented as mean±SD. p-Value was obtained by one-way ANOVA test.

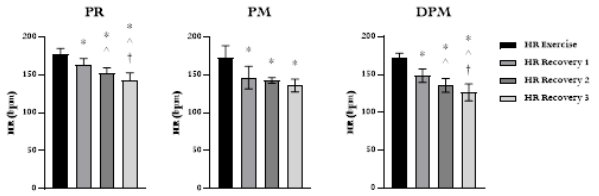

Figure 2. Analysis of exercise and recovery heart rate (bpm). Description: (*)Significant at HR exercise ($p \leq 0.05$). (^)Significant at HR Recovery 1 ($p \leq 0.05$). (†)Significant at HR Recovery 2 ($p \leq 0.05$). Data are presented as mean±SD. p-Value was obtained by two-way ANOVA test.

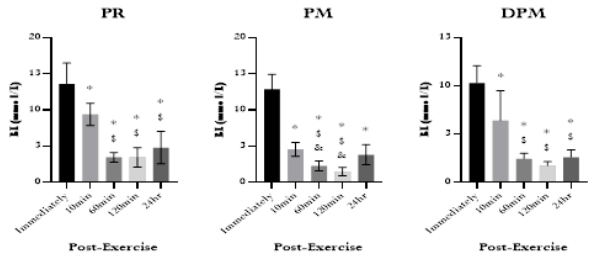

Figure 3. Analysis of blood lactate (mmol/L).
Description: (*)Significant at Immediately post-exercise ($p \leq 0.05$). ($)Significant at 10min post-exercise ($p \leq 0.05$). (&)Significant at 24hr post-exercise ($p \leq 0.05$). Data are presented as mean±SD. p-Value was obtained by two-way ANOVA test.

Table 2.
Analysis of heart rate (bpm) and blood lactate (mmol/L) between groups (PR vs PM vs DPM)

Assessment	PR (n = 8)	PM (n = 8)	DPM (n = 8)	p-Value
Heart rate (bpm)				
Exercise	177.50±7.80	172.00±16.61	172.38±6.16	0.556
Recovery 1	163.50±8.09	146.50±14.88*	148.75±8.84*	0.011
Recovery 2	151.75±7.85	142.50±3.82*	135.88±9.17*	0.001
Recovery 3	143.00±9.97	136.00±8.38	126.50±11.30*	0.012
Blood lactate (mmol/L)				
Immediately post-exercise	13.63±2.87	12.90±2.05	10.30±1.79*	0.021
10min post-exercise	9.40±1.53	4.58±0.97*	6.40±3.12*	0.001
60min post-exercise	3.45±0.68	2.28±0.67*	2.45±0.56*	0.003
120min post-exercise	3.45±1.36	1.50±0.56*	1.75±0.39*	0.000
24hr post-exercise	4.80±2.24	3.83±1.38	2.60±0.75*	0.036

Description: (*)Significant at PR ($p \leq 0.05$). Data are presented as mean±SD. p-Value was obtained by one-way ANOVA test.

Discussion

Heart rate is the easiest but most effective indicator to use in exercise monitoring (Djaoui et al., 2017; Foster et al., 2017). Apart from that, hearing rate is also a valid predictor of someone's fitness (Pramono et al., 2021). The heart rate mechanism is an indicator of fitness based on the performance of the sympathetic and parasympathetic nerves, which work during exercise and rest.

In this study, the three groups carried out physical exercise to reach 85% of their maximum heart rate. The difference occurred 2 minutes after the exercise ended, where the massage group had a better reduction effect than the passive recovery group. Providing massage has the potential to increase recovery from autonomic modulation of heart rate (Mantovani Junior et al., 2018), besides that, the vibration effect can be an effective method for speeding up recovery and regaining lost motor abilities in muscle groups tired due to exercise (Chwała et al., 2021; Kargarfard et al., 2016).

Interestingly, the massage strategy in this study gave different results when compared to giving PR 3 minutes of exercise for heart rate recovery. Providing vibration massage (friction and apotement) further accelerates the reduction in the recovery pulse rate. Giving a massage after 5 minutes of physical exercise will speed up the athlete's recovery(Atan, 2022).

This study provides interesting results on blood lactate accumulation after physical exercise. The massage group provided lower scores than the passive recovery group. This is the same as research studies(Budak, 2023; Rasooli et al., 2012) which provide better results from giving massage compared to passive recovery after physical exercise on blood lactate concentrations. Lactate accumulation is an illustration of muscle damage due to physical exercise(Koch et al., 2014).

It is interesting that in this study all athletes carried out maximum physical activity (intensity 85% of DNM), but blood lactate concentrations were different in the third group. The group provided massage during exercise breaks and post-exercise ended, providing the best control on blood lactate production after maximum physical exercise. In fact, the accumulation of blood lactate is a reflection of the level of fatigue that occurs after physical exercise (Huang et al., 2014). Apart from that, giving massages during the recovery period will increase blood circulation, break down lactate, and reduce pain(Bakar et al., 2015).

Consistent scientific studies consistently show that the removal of lactate from the bloodstream and muscles is critical for recovery post-exercise and performing more physical activity(Kang et al., 2017; McLoughlin et al., 1991; Y et al., 1992). Even giving massage using a vibration method at rest can restore lactate concentration and heart rate recovery after intensive physical exercise(Kang et al., 2017).

This research provides new findings on massage treatment as a method to control lactate concentration in the blood. Giving massage during the recovery break during exercise has a better effect than the method of giving massage post-exercise ends because it can reduce the concentration of lactate in the blood post-exercise ends. Providing this treatment will certainly help athletes achieve optimal performance when training because of the effect of low lactate accumulation in the blood. High-intensity

training intervals must be prepared with the athlete's optimal physiological condition for each session or interval so that the athlete can gain optimal performance and avoid injury. This is possible due to research(Forman et al., 2014) which explains that massage treatment can encourage an increase in permanence and range of motion.

Furthermore, giving massage is still better than giving passive recovery 10 minutes post-exercise ends. This finding is very useful for several competitions, which provide recovery time for each athlete before continuing in the next competition. The reduction due to massage was 38%–65% of lactate accumulation post-exercise. Every football match always has a rest break of 10–15 minutes, which must be used properly by athletes to restore their physiological condition. The findings in this study provide an effective method for reducing blood lactate. Complete recovery is not always possible due to the repetitive nature of many athletes' competitions, so utilizing the available time as effectively as possible can provide a major competitive advantage(Bielik, 2010; Stanula et al., 2014).

What was surprising in this study was the increase in blood lactate concentrations after 24 hours of exercise. This is different from research (Gholami, 2023) that states that giving massage will control the increase in lactate concentration in the blood 24 to 48 hours after physical exercise. Although different, researchers agree that giving massage will control the increase in blood lactate concentrations compared to the passive recovery group. This is believed to be due to the fact that massage applications rapidly remove blood lactate by increasing passive blood circulation (Sarı et al., 2016). (Sharma et al., 2017) show the benefits of massage in recovery, including accelerating blood flow and venous return, helping the excretion of lactic acid, and improving well-being while reducing pain.

This research provides the best picture of recovery strategy patterns for athletes when undertaking physical training and competition. Recovery strategies are part of an athlete's needs so that they can show optimal training progress and prevent injury. The provision of massage in this study resulted in a new strategy that can be applied in the sports training process to support athlete performance. This research has limitations in that the researchers only carried out acute exercise and high-intensity training as a procedure to provide a high fatigue impact on athletes. It needs to be developed in chronic research to get the best results in physical recovery management and with the addition of creatine kinase (CK) indicators to see the muscle damage that occurs.

Conclusion

New information about recovery techniques that coaches and athletes can use during practice and competition is the result of this research. Giving massage in this study was proven to reduce pulse rate and blood lactate levels. In addition, this study found that the strategy of giving massage during rest breaks during high interval training had an effect on blood lactate concentrations after the physical exercise program ended compared to the group giving massage after the exercise program ended. The massage in this study was given for a duration of 5 minutes. The massage technique used was shaking and also apotemen. Current recovery strategies are important for coaches and athletes to pay attention to because fast recovery will provide athletes with the opportunity to improve their performance during training and competitions.

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