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Effectiveness in the Combination of Active Recovery and Sport Massage Towards the Reduction of Lactic Acid and Perception on Fatigue of Women's Futsal Athletes of Malang City

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ABSTRACT: This research aims to analyze the effectiveness of a combination of active recovery and sports massage in accelerating the reduction of lactic acid levels and perception on fatigue of women's futsal athletes after high-intensity physical activity. This research was a true experimental study with a randomized controlled trial (RCT) design using repeated measures at three measurement times. Subjects were randomized into intervention and control groups using block randomization. Lactic acid levels were measured by using The Edge Blood Lactate Analyzer, while perception on fatigue was measured by using the Borg CR-10 scale. The validity and reliability of the lactic acid measurement instrument were at 0.96, while the reliability of the RPE measurement was in the range of 0.89. The data analysis included a two-way repeated measures ANOVA and an independent samples t-test for the lactic acid variable, as well as the Friedman, Wilcoxon, and Mann–Whitney tests for the RPE variable. The research findings reveal a significant change in lactic acid levels between measurement times ($F = 829.715$; $p < 0.001$) and a significant interaction between time and group ($F = 14.052$; $p < 0.001$), indicating that the combination of active recovery and sports massage is more effective than passive recovery.

KEYWORDS: active recovery, lactic acid, women's futsal, recovery, sports massage.

INTRODUCTION

Futsal is a team sport characterized by high-intensity, intermittent activity that simultaneously demands the physiological and psychological capacities of athletes. The playing pattern, which involves repeated sprints, rapid changes of direction, and high game pressure, results in high metabolic and neuromuscular stress in athletes (Barreira et al., 2019; Barbero-Alvarez et al., 2019). This condition has the potential to lead to accumulated fatigue if not balanced with effective recovery strategies.

Fatigue in sports is multidimensional and encompasses physiological, neuromuscular, and psychological aspects. Physiologically, high-intensity physical activity causes an increase in lactic acid levels, a marker of anaerobic metabolic stress. Although lactate is no longer considered a direct cause of fatigue, blood lactate concentration remains relevant as an indicator of muscle workload and the effectiveness of the recovery process (Brooks, 2020; Gladden, 2020). Subjectively, fatigue can be evaluated through the Rating of Perceived Exertion (RPE), which reflects the integration of physiological and psychological signals during physical activity (Impellizzeri et al., 2019). Furthermore, fatigue also has a psychological dimension that influences an athlete's perception of training load, motivation, focus, and mental readiness to maintain performance (Garcia-Calvo & Diaz-Garcia, 2022). If fatigue is not managed with appropriate recovery strategies, it has the potential to reduce performance and increase the risk of injury (Milioni et al., 2016; Foster et al., 2023).

Recovery strategies are a crucial element in futsal training and competition management, particularly for female athletes, who have different physiological and hormonal characteristics than male athletes (Sung et al., 2021). Passive recovery is still frequently used in field practice, although scientific evidence suggests that active recovery methods and manual interventions such as sports massage have greater potential to accelerate physiological and subjective recovery in athletes (Kellmann et al., 2018).

Active recovery plays a role in increasing blood flow and accelerating the clearance of metabolites, including lactic acid, through increased oxidation and lactate transport mechanisms (Brooks, 2020; Valenzuela et al., 2015). On the other hand, sports massage provides mechanical and relaxing effects that contribute to neuromuscular recovery and reduce the perception of fatigue through activation of the parasympathetic nervous system (Patra et al., 2023; Li et al., 2024). The combination of these two methods has the potential to provide synergistic effects, but empirical studies testing the effectiveness of the combination of active recovery

and sports massage, particularly in female futsal athletes, are still limited. Based on this research gap, this study aims to analyze the effectiveness of the combination of active recovery and sports massage on physiological recovery, as indicated by changes in lactic acid levels, and subjective recovery, as measured by the Responsive Pediatric Exercise (RPE).

METHODS

Research Design

This research is a true experimental study with a randomized controlled trial (RCT) design using repeated measurements at three measurement times.

Participants

The study subjects were 18 female futsal athletes from Malang City who met the inclusion criteria. All subjects were randomly divided into an intervention group and a control group.

Procedure

The intervention group underwent active recovery consisting of light jogging at approximately 50% of HRmax for 7.5 minutes, followed by a 7.5-minute sports massage using effleurage, petrissage, and lower extremity shaking techniques. The control group underwent passive recovery with a sitting rest period for the same duration.

Research Instruments

Physiological data, including lactic acid levels, were measured using an Edge Blood Lactate Analyzer. Subjective data, including perceived fatigue, were measured using the Borg CR-10 scale. Measurements were taken at three time points (T1, T2, and T3).

Data Analysis Techniques

Data analysis included normality tests, two-way repeated-measures ANOVA, independent t-tests, and Friedman, Wilcoxon, and Mann–Whitney tests with a significance level of 0.05.

RESULT

The study results included changes in lactic acid levels and perceived fatigue in female futsal athletes before training, after high-intensity training, and after a recovery intervention.

Descriptive Statistics

The pattern of changes in lactic acid levels and RPE in both groups is presented in Table 1 to provide an initial overview of the athletes' physiological and subjective responses.

Table 1. Descriptive Statistics of Lactic Acid Levels and RPE

Variables	Group	T1 (Pre-Exercise)	T2 (Post-Exercise)	T3 (Post Recovery)
Lactic acid levels (mmol/L)	Intervention	1.30 ± 0.26	9.75 ± 0.85	2.98 ± 0.56
	Control	1.23 ± 0.35	8.90 ± 1.01	4.26 ± 0.34
RPE	Intervention	1.78 ± 0.83	8.33 ± 0.86	2.78 ± 0.66
	Control	1.89 ± 0.78	8.11 ± 0.92	3.67 ± 0.70

Table 1 shows that lactic acid levels in both groups changed significantly at each measurement time. In the intervention group (a combination of active recovery and sports massage), lactic acid levels increased sharply from 1.30 ± 0.26 mmol/L at T1 (pre-exercise) to 9.75 ± 0.85 mmol/L at T2 (post-exercise), then decreased significantly to 2.98 ± 0.56 mmol/L at T3 (post-recovery).

Meanwhile, in the control group (passive recovery), lactic acid levels also increased from 1.23 ± 0.35 mmol/L at T1 to 8.90 ± 1.01 mmol/L at T2, and decreased to 4.26 ± 0.34 mmol/L at T3. A similar pattern of changes was also seen in the Rating of Perceived Exertion (RPE) variable. In the intervention group, the RPE score increased from 1.78 ± 0.83 before exercise to 8.33 ± 0.86 after exercise, then decreased to 2.78 ± 0.66 after recovery. In the control group, the RPE score increased from 1.89 ± 0.78 at T1 to 8.11 ± 0.92 at T2, then decreased to 3.67 ± 0.70 at T3.

Table 2. Repeated Measures ANOVA Results for Lactic Acid Levels

Effect	Df (GG Correction)	F	Sig. (p)	Partial η^2
Time	1.411	829.715	< 0.001	0.981
Group	1.411	0.430	0.521	0.026
Time × Group	1.411	14.052	< 0.001	0.468

Based on Table 2 above, the results of the Two-Way Repeated Measures ANOVA indicate a significant effect of measurement time on lactic acid levels, with an $F(1,411) = 829.715$ and $p < 0.001$, and a partial $\eta^2 = 0.981$, indicating a very large effect size. This indicates that lactic acid levels changed significantly between measurement times (before exercise, after exercise, and after recovery).

Furthermore, the analysis of the group factor showed an $F(1,411) = 0.430$ with $p = 0.521$ (> 0.05), indicating no significant difference in average lactic acid levels between the groups overall. However, there was a significant interaction between time and group, with an $F(1,411) = 14.052$ and $p < 0.001$, indicating that changes in lactic acid levels differed significantly between the intervention and control groups. Thus, it can be concluded that the combination of active recovery and sports massage has a different effect on the pattern of changes in lactic acid levels compared to passive recovery.

Table 3. Friedman RPE Test Results

Group	N	χ^2 (Chi-Square)	df	Asymp. Sig. (p)
Intervention	9	16.909	2	< 0.001
Control	9	18.000	2	< 0.001

Based on Table 3, it can be seen that the results of the Friedman test show a Chi-Square value of 16,909 ($p < 0.001$) in the intervention group and 18,000 ($p < 0.001$) in the control group. A significance value smaller than 0.05 indicates that there is a significant difference in RPE scores at all three measurement times (T1, T2, and T3), both in the intervention group and the control group. Thus, it can be concluded that the perception of fatigue experienced a significant change during the series of training and recovery activities, both in the group that received a combination of active recovery and sports massage and in the passive recovery group.

Table 4. Effectiveness of Intervention (T2–T3)

Variable	Test	p	Effect Size
Δ Lactatate	Independent t-test	<0,001	d = 2,65
Δ RPE	Mann–Whitney	0,013	d = 1,45

The results in Table 4 show that the reduction in lactic acid levels in the intervention group was significantly greater than in the control group ($p < 0.001$) with a very large effect size ($d = 2.65$). This indicates that the intervention was not only statistically significant but also practically meaningful in the context of athlete recovery. For the RPE variable, the reduction in perceived fatigue in the intervention group was also greater than in the control group ($p = 0.013$). These findings suggest that the combination of active recovery and sports massage benefits not only physiological recovery but also subjective recovery in athletes.

DISCUSSIUON

The Effect of a Combination of Active Recovery and Sports Massage on Lactic Acid Reduction

The results showed that the combination of active recovery and sports massage provided significantly greater effectiveness in the recovery phase, particularly in reducing blood lactic acid levels, compared to passive recovery. Both groups, intervention and control, experienced a highly significant increase in lactic acid levels from T1 to T2 in response to high-intensity exercise. This increase in lactate to the 8–10 mmol/L range is consistent with the highly demanding nature of futsal, which involves intermittent high-intensity activity, with the dominance of the anaerobic glycolysis energy system during repeated sprints. The emergence of high lactic acid levels after the training protocol confirms the physiological validity of the physical stimulus in this study and aligns with previous futsal match studies that have reported similar values in elite athletes (Barbero et al., 2019; Bekris et al., 2022).

The most crucial difference occurred in the T2 to T3 recovery phase. The intervention group showed a highly significant decrease in lactic acid levels, from 9.75 ± 0.85 mmol/L to 2.98 ± 0.56 mmol/L. In contrast, the control group undergoing passive recovery

only experienced a decrease from 8.90 ± 1.01 mmol/L to 4.26 ± 0.34 mmol/L. The difference in recovery between groups indicates the effectiveness of the intervention both statistically and physiologically. An independent t-test yielded $t = 5.615$; $p < 0.001$ with an effect size of $d = 2.65$, categorized as a very large effect. Meanwhile, the results of the Repeated Measures ANOVA showed a highly significant time × group interaction ($F = 14.052$; $p < 0.001$; partial $\eta^2 = 0.468$), indicating that the recovery patterns of the two groups differed systemically and that these differences were directly influenced by the type of intervention. From an exercise physiology perspective, the effectiveness of the intervention can be explained through the synergy between metabolic and mechanical mechanisms. Active recovery at low intensity (~50% HRmax) maintains type I muscle activity, increases blood flow, and accelerates the lactate shuttle process, described by Brooks (2020) as the transfer of lactate from type II muscle fibers (which produce a lot of lactate) to aerobic tissues for oxidation as an energy substrate. In other words, active recovery optimizes the body's ability to utilize lactate for energy, thereby accelerating recovery toward metabolic homeostasis. This finding aligns with research by Flury (2017) and Valenzuela et al. (2015), which showed that active recovery is more effective than passive recovery in accelerating lactate clearance.

On the other hand, sports massage contributes through both mechanical and neurophysiological effects. Effleurage and petrissage techniques increase superficial blood flow, improve tissue perfusion, and facilitate the transport of metabolites to the lymphatic system, while shaking promotes neuromuscular relaxation and reduces muscle tension. The combined effects of increased perfusion, relaxation, and fluid mobilization accelerate the return of muscle physiology after intense activity. This mechanism is consistent with the findings of Wiewelhove et al. (2018), Patra et al. (2023), and Avandi et al. (2024), which confirmed that massage enhances metabolic recovery while providing a systemic relaxation effect.

The higher effectiveness in the intervention group indicates a synergy between the two recovery methods. Previous research by Monedero & Donne (2000) and Chaanchumrat & Srihirun (2024) confirmed that the combination of active recovery and massage resulted in the fastest lactate recovery compared to either method alone. The results of this study reinforce these conclusions and provide a novel contribution because they were conducted in a population of female futsal athletes, who physiologically have more complex metabolic variability than male athletes. Hormonal factors, particularly variations in estrogen and progesterone, can influence the rate of metabolic recovery, body temperature, and lactate oxidation efficiency (Sung et al., 2021).

In the context of this study, menstrual variables were controlled, and only two athletes were menstruating at the time of data collection. These two athletes were evenly distributed in each group, thus preventing systemic bias in the analysis results. While menstrual phase could theoretically influence fluid balance, thermoregulation, and energy metabolism, the balanced distribution ensured that this physiological variability did not affect comparisons between groups. The fact that the intervention group still demonstrated a significantly faster lactate reduction strongly indicates that the intervention's effectiveness depended not on these hormonal variations but rather on physiologically superior recovery mechanisms.

These findings

The Effect of a Combination of Active Recovery and Sports Massage on Perceived Fatigue (RPE)

The results of this study indicate that the combination of active recovery and sports massage is more effective in accelerating the reduction of perceived fatigue (Rating of Perceived Exertion) in female futsal athletes compared to passive recovery, particularly in the acute recovery phase after high-intensity physical activity. In both groups, RPE scores increased significantly from pre-exercise (T1) to post-exercise (T2), with RPE values reaching a range of 8–9. This increase indicates that the training protocol successfully induced high levels of subjective fatigue, consistent with the characteristics of futsal as a high-intensity intermittent sport that demands simultaneous physical and mental effort (Impellizzeri et al., 2019; Foster et al., 2021).

The most striking difference between the two groups occurred in the recovery phase (T2 to T3). The intervention group showed a greater decrease in RPE scores, from 8.33 ± 0.86 to 2.78 ± 0.66, while the control group only decreased from 8.11 ± 0.92 to 3.67 ± 0.70. The Mann–Whitney U test showed that the difference in RPE reduction between groups during the recovery phase was statistically significant ($U = 14.000$; $p = 0.013$) with a Cohen's d value of 1.45, indicating a large effect size. This finding confirms that the combination of active recovery and sports massage is more effective in accelerating recovery from acute fatigue perception compared to passive recovery.

Conversely, the change in total RPE scores from pre-exercise to post-recovery (ΔT1–T3) did not show a significant difference between groups ($p = 0.107$), although the effect size remained relatively large. This suggests that the intervention's effectiveness is most pronounced in the immediate recovery phase after exercise, while returning fatigue perception to baseline requires a longer recovery period. Thus, combined interventions play a greater role in accelerating recovery from acute fatigue than complete recovery in the very short term.

Physiologically and psychologically, the faster decrease in RPE in the intervention group can be explained by the interaction between metabolic, neuromuscular, and autonomic nervous system regulatory mechanisms. Active recovery at low intensity helps reduce increased sympathetic nervous system activity during high-intensity exercise, thereby reducing sensations of shortness of breath, muscle tension, and internal discomfort that contribute to RPE assessment. This finding aligns with research by Flury (2017) and Valenzuela et al. (2015), which states that active recovery accelerates the return of subjective comfort after strenuous activity.

Furthermore, sports massage provides an important contribution through neuromuscular and psychological relaxation mechanisms. Effleurage, petrissage, and shaking techniques are known to activate the parasympathetic nervous system, reducing muscle tension and increasing feelings of relaxation and bodily comfort. This parasympathetic activation plays a role in reducing perceptions of stress and fatigue, although it is not always accompanied by significant physiological changes. Research by Patra et al. (2023) and Avandi et al. (2024) demonstrated that sports massage consistently effectively reduces subjective fatigue perception through neuropsychological mechanisms.

The combination of active recovery and sports massage produces a synergistic effect on RPE recovery. Active recovery plays a role in improving physical condition and metabolic well-being, while sports massage accelerates recovery from fatigue perception through relaxation and neuroregulation. The interaction of these two mechanisms creates a more comprehensive recovery process, resulting in a faster decline in athletes' fatigue perception compared to passive recovery.

Practically, accelerating the decline in RPE has important implications in the context of futsal, which often involves a busy training schedule and consecutive matches. A rapid decrease in fatigue perception reflects the athlete's psychological and neuromuscular readiness to return to training or competition and has the potential to reduce the risk of injury due to residual fatigue. Therefore, the combination of active recovery and sports massage can be recommended as an effective recovery strategy to accelerate fatigue perception in female futsal athletes after high-intensity activity.

Comparison of Intervention Effectiveness on Lactic Acid Reduction and Perceived Fatigue

The results showed that the combination of active recovery and sports massage consistently demonstrated effectiveness on two key dimensions of recovery: lactic acid reduction, as measured by lactate levels, and fatigue perception, as measured by the Rating of Perceived Exertion (RPE). Both indicators demonstrated a faster recovery pattern in the intervention group compared to the control group, although the characteristics and dynamics of the responses in each dimension were not completely identical.

In the physiological dimension, the intervention group demonstrated a significantly greater reduction in lactic acid levels during the recovery phase than the control group. Lactic acid levels in the intervention group decreased from 9.75 ± 0.85 mmol/L to 2.98 ± 0.56 mmol/L, while in the control group, they only decreased from 8.90 ± 1.01 mmol/L to 4.26 ± 0.34 mmol/L. This difference in reduction was statistically significant in the recovery phase (ΔT2–T3), as demonstrated by an Independent Samples t-test with Cohen's d = 2.65, indicating a very large effect. Furthermore, a Two-Way Repeated Measures ANOVA revealed a significant interaction between time and group ($p < 0.001$; partial $\eta^2 = 0.468$), indicating that the pattern of changes in lactic acid levels over time differed significantly between the two groups as a direct effect of the type of intervention administered.

Meanwhile, regarding perceived fatigue, the intervention group also demonstrated a more rapid decrease in perceived fatigue than the control group, particularly in the acute recovery phase. The RPE score in the intervention group decreased from 8.33 ± 0.86 to 2.78 ± 0.66, while the control group decreased from 8.11 ± 0.92 to 3.67 ± 0.70. The difference in RPE reduction between groups in the T2–T3 phase was statistically significant ($p = 0.013$) with a relatively large effect size (Cohen's d = 1.45). However, the total change in RPE from pre-exercise to post-recovery (ΔT1–T3) did not show a significant difference between groups ($p = 0.107$), indicating that recovery from perceived fatigue requires a longer time to fully return to baseline.

Comparing these two dimensions of recovery indicates that the intervention's effectiveness is stronger and more consistent in the physiological aspect than in the subjective aspect. Lactic acid reduction occurs through a relatively rapid biochemical mechanism that is responsive to increased blood flow and low-intensity muscle activity, allowing for a significant reduction in lactic acid levels in a short period of time. In contrast, fatigue perception involves an integrative process influenced by the central nervous system, neuromuscular comfort, and psychological and emotional factors. Therefore, the rate of recovery tends to be more variable and does not always align completely with lactic acid reduction.

Nevertheless, these two dimensions of recovery are functionally interrelated. A rapid decrease in lactic acid levels contributes to reduced sensations of muscle discomfort and peripheral fatigue, which indirectly reduces the perception of fatigue. Conversely, a more rapid decrease in RPE, particularly through the relaxing effects of sports massage, can accelerate the activation of the parasympathetic nervous system, which supports the process of reducing lactic acid. This two-way interaction demonstrates that athlete recovery is a multidimensional psychophysiological process that cannot be explained by a single indicator.

In the context of female futsal athletes, the dynamics of recovery are further complicated by physiological variations influenced by hormonal factors. Although this study included only two athletes who were menstruating and were evenly distributed across both groups, the results showed that the combined intervention still produced consistent recovery patterns across both dimensions of recovery. This indicates that the effectiveness of the combination of active recovery and sports massage is relatively stable across the female athletes' internal physiological variations.

CONCLUSIONS

Based on the analysis and discussion, this study yielded the following conclusions:

1. The combination of active recovery and sports massage significantly accelerated the reduction of lactic acid levels in female futsal athletes after high-intensity physical activity.
2. The combination of active recovery and sports massage also significantly reduced the perception of fatigue (Rating of Perceived Exertion) in female futsal athletes after high-intensity physical activity.
3. Overall, the combination of active recovery and sports massage proved more effective than passive recovery methods in accelerating the reduction of lactic acid levels and the perception of fatigue.

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