



The Impact of Ice Compression and Massage Techniques on Lactate Removal and Interleukin-6 Concentrations During Halftime Recovery in Intermittent Sports

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Abstract

Background. High-intensity intermittent sports increase blood lactate levels and inflammatory markers such as interleukin-6 (IL-6), which may hinder recovery and performance. Effective recovery strategies are crucial for enhancing lactate clearance and regulating inflammation.

Objectives. This study aimed to evaluate the effects of 15-minute ice compression and sport massage interventions during halftime on athletes' lactate clearance and IL-6 levels.

Materials and Methods. Thirty-six male soccer players, aged 18 to 24 years, were randomly assigned to one of three groups for this experimental study: ice compression (IC, n = 12), sport massage (SM, n = 12), and passive recovery (PR, n = 12). Each participant completed a standardized exercise regimen designed to induce fatigue. The PR group rested passively after the workout, while the intervention groups received a massage or ice compression for 15 minutes. Blood lactate and IL-6 levels were assessed before exercise (T0), immediately after (T1), and fifteen minutes post-exercise (T2). To analyse the differences observed, a mixed-model ANOVA and post-hoc tests (Bonferroni/Games-Howell) were performed.

Results. According to the results obtained, the lactate levels (IC: $\Delta T1-T2 = -2.34 \pm 0.96$ mmol/L, $d = 2.209$; SM: $\Delta T1-T2 = -1.39 \pm 0.79$ mmol/L, $d = 0.829$) and IL-6 levels (IC: $\Delta T1-T2 = -1.44 \pm 0.93$ pg/mL, $d = 1.206$; SM: $\Delta T1-T2 = -1.58 \pm 0.63$ pg/mL, $d = 1.645$) were both significantly lower than PR ($p < 0.05$). Although IC and SM exhibited similar anti-inflammatory effects ($p = 0.898$), IC demonstrated superior lactate clearance compared to SM ($p = 0.023$, $d = -1.081$). PR showed only minimal decreases in both biomarkers.

Conclusions. Massage and ice compression effectively enhance lactate clearance after high-intensity exercise, with massage offering additional benefits in reducing IL-6-mediated inflammation. These findings support massage as an excellent recovery method for athletes requiring immediate physiological repair following exertion.

Keywords: ice compression, sport massage, lactate clearance, interleukin-6, inflammatory response.

Introduction

In fast-paced sports like soccer, basketball, or futsal, the increase in lactic acid and elevated levels of inflammatory substances, particularly Interleukin-6 (IL-6), during the first half can hinder athletes' performance in the second half due to fatigue (Marqués-Jiménez et al., 2017; Reilly et al., 2008). Fatigue encompasses perceptual-motor, cognitive, and physiological aspects and represents a physiological breakdown that leads to exhaustion. The primary causes of this condition include the depletion of energy stores, thermal strain, and muscle failure, which occur due to prolonged overload during intense physical activity. The nervous system is crucial in maintaining muscle function by regulating metabolic activity to prevent catastrophic system failure (Reilly et al., 2008).

The buildup of inflammatory markers, such as IL-6, and metabolic byproducts like lactate can weaken neuromuscular function and endurance (Chen et al., 2025; Wan et al., 2017). Although lactate is produced to assist in removing H⁺ ions, which can lower pH and hinder muscle contraction, it does not directly cause muscle fatigue (Vavříčka et al., 2024). According to the lactic acid hypothesis, the accumulation of lactate or acid in working muscles slows muscle contractions and impairs exercise performance. This concept is analogous to how products of chemical reactions can inhibit enzymes. Furthermore, studies on heart muscle demonstrate that during periods of diminished blood flow, lactate and H⁺ can lead to weaker heart contractions and irregular heartbeats (Cairns, 2006). Meanwhile, skeletal muscle cells produce the pro-inflammatory cytokine interleukin-6 (IL-6), which is released during prolonged or intense muscle contractions (Lin et al., 2023). It can increase significantly during heavy or prolonged exercise due to physiological muscle stress, microstructural damage, and depleted energy stores, particularly muscle glycogen. IL-6 regulates energy metabolism by enhancing the mobilization of glucose and fatty acids, which indicates metabolic stress (Covarrubias & Horng, 2014). Additionally, it indicates local and systemic inflammatory processes that occur with muscle fatigue, especially following heavy exercise or competition. Research has shown that IL-6 levels rise significantly after completing a marathon, correlating with symptoms of fatigue and diminished physical performance (Nash et al., 2023). Therefore, IL-6 can serve as a biological indicator of muscle fatigue.

On this basis, recovery strategies during match intervals become crucial (Fajar et al., 2025; Romagnoli et al., 2016). Efficient recovery strategies during short match intervals (e.g., halftime) are critical for maintaining athletic performance. Ice compression and massage are two popular methods to accelerate recovery (Fajar et al., 2025; Kafrawi et al., 2024). Ice compression, a cold therapy method, has decreased tissue temperature and inflammation and promoted metabolic waste clearance, facilitating vasoconstriction (White & Wells, 2013; Yao et al., 2024). Cold application reduces blood vessel narrowing, blood flow, and cellular metabolic activity, slowing lactic acid production due to post-exercise tissue damage. It also inhibits the release of pro-inflammatory cytokines like IL-6, modulating the inflammatory response (Peake et al., 2016). This suppression occurs through cryotherapy's anti-inflammatory effects, which reduce capillary permeability and neutrophil activity,

triggering IL-6 release during post-exercise oxidative stress (Peake et al., 2015). This reduces systemic inflammation, facilitating metabolic recovery and buffering of lactic acid by non-muscle organs (Mila-Kierzenkowska et al., 2013).

Likewise, massage treatment neutralises lactic acids and IL-6. Massage is widely employed in sports recovery; it enhances circulation and may modulate inflammatory responses (Crane et al., 2012). Massage techniques like effleurage and petrissage increase blood and lymph flow, promoting the redistribution of lactic acid from muscles to the liver (Ogai et al., 2008). Rhythmic pressure movements stimulate lactate dehydrogenase, reducing local accumulation (Wiltshire et al., 2010a). Massage reduces post-exercise micro-muscle damage, suppressing IL-6 release from muscle and immune cells. Applying pressure helps activate the parasympathetic pathway, which lowers oxidative stress and pro-inflammatory cytokines, leading to a healing environment for recovery after exercise (Waters-Banker et al., 2014; Wiltshire et al., 2010b).

This research aims to address the issue of fatigue in high-intensity intermittent sports like futsal, soccer, and basketball. The accumulation of lactic acid and pro-inflammatory cytokines, such as IL-6, during the first half of a match can reduce athlete performance in the second half. This fatigue affects cognitive and neuromuscular aspects and is caused by metabolic products like lactate and IL-6. The study also focuses on the effectiveness of recovery strategies during match breaks, such as halftime. Interventions like ice and massage have been widely used in post-exercise recovery, but their benefits in intra-competitive contexts are still under-researched. The findings of this study are expected to contribute to improving endurance, optimising performance, and reducing injury risk among athletes involved in high-intensity sports.

Materials and Methods

This research used a randomised, controlled, parallel-group design to evaluate the impacts of ice compression and massage therapies during halftime on lactate clearance and interleukin-6 (IL-6) concentrations in athletes participating in high-intensity intermittent sports. Participants were categorised by football and randomly allocated to one of three groups: (1) ice compression (IC), (2) sports massage (SM), or (3) passive recovery (control/PR). Outcomes were assessed at three intervals: pre-intermittent exercise (T₀), immediately post-intermittent exercise (T₁), and post-intervention (T₂). The study procedure complied with CONSORT's recommendations for randomised trials (Sut et al., 2022).

Study Participants

We recruited 36 male soccer athletes (ages 18–24) from UNESA FC. Inclusion criteria required ≥4 years of competitive experience, regular training (≥4 sessions/week), and no injuries or anti-inflammatory drug use in the preceding month. Exclusion criteria included cardiovascular or metabolic disorders. Sample size was determined via G*Power (v3.1.9.7) with an effect size of 0.4, α = 0.05, and power = 0.8, yielding 12 participants per group.

The Institutional Review Board at Semarang State University (068/KEPK/FK/KLE/2024) approved the study

and ensured adherence to the Declaration of Helsinki. Participants received clear instructions and signed an informed consent form. Health insurance was provided throughout the research process. Participants were free to withdraw without penalty and kept their data secure for research purposes.

Study Organization

As mentioned earlier, this study involved three groups: Ice Compression (IC), Sport massage (SM), and Passive recovery as a control group (PR). The night before the pretest, the participants were asked to fast but were allowed to drink water as needed. Participants were asked to undergo a health check at the Surabaya State University soccer field at 06:00 am. After the health check, we gave each group a pretest by collecting data on lactic acid and IL-6 levels. After the pretest, they did intermittent physiological exercise similar to playing soccer. For more details, intermittent exercise will be explained in Table 1.

We developed the intermittent training in this study to replicate the physiological demands typically encountered in soccer. The exercise involved repeated cycles of sprinting, jogging, and walking at prescribed intensities, determined by the percentage of each participant's maximum heart rate (HR max). Each cycle, as shown in Table 1, lasted 4 minutes and comprised 15 seconds of sprinting at 90–95% HR max, 30 seconds jogging at 60–70% HR max, and 15 seconds of walking at 30–40% HR max. Seven cycles were completed, resulting in an aggregate exercise duration of 42 minutes. Organized intervals facilitated the preservation of a work-to-rest ratio of 2:1, hence promoting physiological stress akin to that observed in actual match conditions.

Participants made the simulation more realistic by making three 180° turns during sprinting every two cycles, mimicking the usual speed changes and turns found in competitive situations. The participants' heart rate was monitored using the H10 Polar to ensure the intensity remained on target. We allowed participants to drink water

(3–5 mL/kg BW) every two intervals to prevent dehydration (Li et al., 2024) participants crossed over to the second arm for: NOR+PHS, NOR+CON, HYP+PHS, or HYP+CON. The PHS was prescribed according to the participants' fluid and sweat sodium losses. CON drank ad libitum of commercially-available electrolyte solution. Exercise trials consisted of two phases: (1. This exercise model was designed to induce significant lactate buildup and elevate IL-6 levels, creating a realistic scenario to evaluate the effectiveness of halftime recovery methods.

Immediately after the intermittent exercise, posttest 1 (T1) was conducted by re-measuring lactic acid and IL-6 levels. After the test, participants were immediately given treatment according to their respective groups (IC, SM, and PR). Table 2 explains the details of the intervention.

Participants were given three recovery interventions after completing an intermittent exercise protocol and post-exercise measurements. The interventions were passive recovery (PR), sports massage (SM), and ice compression (IC). Cold gel ice packs were applied to the IC group's quadriceps, hamstrings, and calves because earlier studies indicated they effectively reduce blood flow, lower metabolic activity, and alter inflammation following exercise. To enhance blood and lymphatic circulation, alleviate muscle stiffness, and facilitate the removal of metabolic wastes such as lactate, the SM group underwent a sports massage employing established techniques. For a continuous fifteen minutes, the PR group received no assistance and remained in a comfortable position. The interventions were executed in a standardized, controlled environment to guarantee consistency and comparability. A further post-exercise assessment was performed to evaluate the immediate impact of each intervention on lactate concentration and IL-6 levels (T2).

Measurement

The outcome measure of this research was lactic acid and IL-6 levels. Lactic acid and IL-6 levels were measured

Table 1. Intermittent exercise program

Activity	Intensity (HR max)	Duration	Interval per cycle	Total cycle	Total Duration
Sprint (15 seconds)	90-95%				
Jogging (30 seconds)	60-70%	4 minutes in 1 activity cycle	2 minutes (work rest ratio 2:1)	7 cycle	42 minutes
Walking (15 seconds)	30-40%				

Note: During the sprint, participants perform three 180° direction changes every two cycles (similar to intermittent exercise).

Table 2. Program interventions in each group (IC, SM, PR group)

Treatment	Procedure
Ice compression (IC group)	Participants received 15-minute localized ice compression using gel packs at 12–15°C (Lateef, 2010) on the major muscle groups of the lower limbs (quadriceps, hamstrings, and calves), facilitated by adjustable compression wraps.
Sports Massage (SM group)	Sports massage is conducted by a certified therapist, concentrating on the primary lower-limb muscle groups (quadriceps, hamstrings, and calves). The massage techniques employed include effleurage, petrissage, shaking, tapotement, and walking, all applying moderate pressure (2–3 kgf/cm ²). We perform each technique six times, using effleurage for both the opening and closing phases, resulting in a total duration of 15 minutes.
Passive recovery (PR group)	Participants rested by sitting passively for 15 minutes.

at three intervals: pre-exercise (T0), immediately post-intermittent exercise (T1), and post-intervention (T2). We assessed lactic acid levels using the Roche Cobas Accutrend Plus GCTL Meter for blood lactate testing. We obtained lactic acid measurements by drawing blood from the participant's fingertip and applying it to the device. To quantify IL-6 levels, we performed an ELISA test using a specific kit (Human IL-6 Immunoassay Quantikine ELISA Kit, catalog No. D6050). We analyzed the data with an ELISA Reader (iMark Microplate Absorbance Reader). The study's ELISA test necessitated the collection of blood samples from participants using a sterile 3 ml syringe, which were subsequently placed into a specialized 5 ml tube (Veroject Plain). We centrifuged the blood sample at 3000 rpm for 15 minutes to isolate the serum from the cellular debris.

Preserve the resultant serum at -20°C if immediate analysis is not conducted.

Statistical analysis.

The research data were analyzed using Microsoft Office Excel 2016 and SPSS Series 23. We conducted descriptive tests by displaying each group's mean ± SD of the variables. We also checked if the data followed a normal distribution using Shapiro-Wilk tests. A mixed-model ANOVA was conducted to compare differences between groups and time points, followed by Bonferroni post-hoc tests. Effect sizes, Cohen's d for ANOVA and Cohen's d for pairwise comparisons, and 95% confidence intervals, were reported. Significance was set at $p < 0.05$.

Table 3. The effect of ice compression, sport massage, and passive recovery intervention on variables

Group	Variable	Mean ± SD	Min	Max	Shapiro-Wilk test	Paired t-test	ES Cohen's d	
IC	IL-6	T0	4.14 ± 0.85	2.69	5.59	0.993		
		T1	7.04 ± 1.28	4.35	8.73	0.322		
		T2	5.60 ± 1.10	3.54	7.88	0.842		
		ΔT0-T1	2.90 ± 1.00	1.41	4.14	0.195	0.00*	2.669
		ΔT0-T2	1.46 ± 0.84	0.44	3.60	0.069	0.00*	1.485
		ΔT1-T2	-1.44 ± 0.93	-3.16	-0.44	0.199	0.00*	1.206
	Lactic acid	T0	5.09 ± 0.87	3.4	6.3	0.237		
		T1	12.29 ± 1.45	10.3	13.9	0.730		
		T2	9.59 ± 0.94	8.5	11.7	0.716		
		ΔT0-T1	6.84 ± 1.70	4.5	9.2	0.237	0.00*	6.021
		ΔT0-T2	4.50 ± 1.49	3.0	7.2	0.073	0.00*	4.961
		ΔT1-T2	-2.34 ± 0.96	-4.5	-0.8	0.716	0.00*	2.209
SM	IL-6	T0	3.93 ± 1.02	2.25	5.79	0.863		
		T1	6.98 ± 0.98	4.62	8.03	0.081		
		T2	5.40 ± 0.94	3.92	6.73	0.653		
		ΔT0-T1	3.05 ± 0.67	2.24	4.35	0.335	0.00*	3.049
		ΔT0-T2	1.47 ± 0.80	0.38	3.64	0.068	0.00*	1.498
		ΔT1-T2	-1.58 ± 0.63	-2.41	-0.39	0.161	0.00*	1.645
	Lactic acid	T0	4.74 ± 0.72	3.6	5.9	0.962		
		T1	11.82 ± 1.86	8.0	15.6	0.999		
		T2	10.40 ± 1.55	7.8	13.3	0.452		
		ΔT0-T1	7.08 ± 2.01	2.9	10.0	0.962	0.00*	5.020
		ΔT0-T2	5.68 ± 1.72	2.7	8.9	0.999	0.00*	4.683
		ΔT1-T2	-1.39 ± 0.79	-2.7	-0.23	0.452	0.00*	0.829
PR	IL-6	T0	4.04 ± 0.99	2.78	5.79	0.193		
		T1	7.15 ± 0.75	5.38	8.12	0.186		
		T2	7.00 ± 0.70	5.4	8.03	0.553		
		ΔT0-T1	3.11 ± 0.58	2.05	4.15	0.990	0.00*	3.541
		ΔT0-T2	2.96 ± 0.69	1.8	3.86	0.357	0.00*	3.452
		ΔT1-T2	-0.15 ± 0.28	-0.65	0.22	0.271	0.08	0.206
	Lactic acid	T0	4.33 ± 1.16	2.8	6.4	0.230		
		T1	11.45 ± 1.40	9.7	14.3	0.066		
		T2	11.36 ± 1.74	8.3	14.8	0.268		
		ΔT0-T1	7.12 ± 0.85	5.7	8.1	0.230	0.00*	5.538
		ΔT0-T2	7.03 ± 1.26	4.2	8.4	0.066	0.00*	4.754
		ΔT1-T2	-0.09 ± 0.66	-1.5	0.7	0.268	0.64	0.056

Δ represents the difference; T0 refers to pre-intermittent exercise; T1 indicates immediately post-intermittent exercise; T2 denotes post-intervention (T2). The Shapiro-Wilk test shows a normal distribution with $p > 0.05$; * indicates a significant difference with $p < 0.05$; ES stands for effect size.

Results

This section examines the efficacy of ice compression and sports massage interventions lasting 15 minutes after intermittent exercise to neutralize lactic acid and interleukin-6 (IL-6). This study involved 36 soccer players from UNESA FC, with the following means and standard deviations of their physical attributes: age 20.72 ± 1.49 years, body weight 66.47 ± 2.68 kg, body height 173.31 ± 2.59 cm, training experience 10.83 ± 1.48 years, and competitive experience 5.08 ± 0.73 years. Table 2 presents the outcomes of the descriptive statistics.

The study examined the effects of three different halftime recovery interventions: ice compression (IC), sports massage (SM), and passive recovery (PR) on serum interleukin-6 (IL-6) and blood lactate levels. Table 3 shows that both IL-6 and lactate levels went up a lot after exercise, which means that exercise successfully causes metabolic and inflammatory stress. In the IC group, IL-6 levels rose from 4.14 ± 0.85 pg/mL (T0) to 7.04 ± 1.28 pg/mL (T1), followed by a significant reduction to 5.60 ± 1.10 pg/mL at T2. Similarly, lactate levels increased from 5.09 ± 0.87 mmol/L (T0) to 12.29 ± 1.45 mmol/L (T1), before decreasing significantly to 9.59 ± 0.94 mmol/L post-intervention (T2). These findings suggest ice compression may facilitate both inflammatory and metabolic recovery during halftime. The SM group also demonstrated a significant post-exercise elevation in IL-6 and lactate, with post-intervention measurements showing significant reductions in both IL-6 and lactate. However, the PR group exhibited only marginal decreases in IL-6 and lactate. Overall, both active recovery methods were better than passive recovery at reducing the increases in IL-6 and lactate levels caused by exercise.

Next, a mixed-model ANOVA test was done to see how three different treatments (ice compression, sports massage, and passive recovery) affected lactic acid and IL-6 levels. The results indicated that both variables had a p-value (significance) of 0.000, indicating a significant difference. We also performed a difference test to determine which groups differed. To determine which difference test to employ, we examine the results of the Test of Homogeneity of Variances. If the test results indicate equal variances, the subsequent test used is the Bonferroni test. Conversely, if the test results show unequal variances, the next test applied is the Games-Howell test.

Table 4. Pairwise Comparisons of Intervention Effects on lactic acid and IL-6 levels

Variable	Group	p (sig.)	ES Cohen's d
IL-6	IC SM	0.898	-0.057
	IC PR	0.001*	-1.878
	SM PR	0.000*	-2.933
Lactic acid	IC SM	0.023*	-1.081
	IC PR	0.000*	-2.731
	SM PR	0.001*	-1.786

*Significant difference at $p < 0.05$; IL-6 was analysed using the Games-Howell test; lactic acid was analysed using the Bonferroni test; ES refers to Effect Size

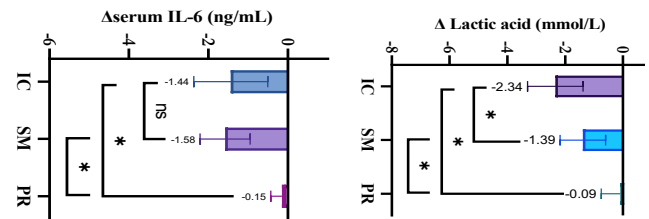


Fig. 1. The changes in serum IL-6 and lactic acid levels were compared among the IC, SM, and PR groups; *significant difference was found at $p < 0.05$, ns indicates no significant difference; Δ is changed after intervention

The results of post-intervention comparisons between groups on lactic acid and IL-6 levels are shown in Table 4. The Bonferroni test was used for lactic acid because the homogeneity assumption was met, and the Games-Howell test was used for IL-6 because of the inhomogeneity of variance. The ice compression (IC) and sports massage (SM) groups did not significantly differ in their IL-6 levels ($p = 0.898$; $d = -0.057$), suggesting that they were equally effective at lowering inflammatory responses following exercise. When comparing the active recovery and passive recovery groups, there were significant differences in lactic acid and IL-6 levels, with ice compression and sports massage showing better results than passive recovery. It's interesting to note that while both significantly accelerated lactate clearance, sports massage was less successful than ice compression ($p = 0.023$, $d = -1.081$). These findings demonstrate that active intervention significantly outperforms passive recovery in lowering fatigue biomarkers during a brief rest interval (halftime), with ice compression providing the benefit of speeding up metabolic recovery.

Discussion

The study investigated the effects of 15-minute ice compression and sports massage on lactate clearance and IL-6 levels in male soccer athletes. The results indicated that both active recovery strategies significantly reduced post-exercise lactate and IL-6 levels, with ice compression demonstrating greater efficacy in accelerating lactate clearance. These findings underscore the differences in their mechanisms and outcomes.

Both IC and SM demonstrated significant reductions in IL-6 levels from T1 to T2 ($p < 0.05$), with effect sizes of $d = 1.206$ and $d = 1.645$, respectively, indicating substantial anti-inflammatory benefits. Interestingly, IC and SM did not significantly differ in their ability to lower IL-6 ($p = 0.898$; $d = -0.057$), suggesting that they are equally effective at regulating the acute inflammatory response. These findings corroborate previous research showing that cryotherapy dampens inflammatory signals by reducing neutrophil activation and capillary leakage, which in turn suppresses IL-6 release (Peake et al., 2015). The downregulation of nuclear factor kappa B (NF- κ B), a transcription factor that regulates pro-inflammatory cytokines under oxidative stress, may be partly responsible for the decrease in IL-6 (VanderVeen et al., 2019). Peake et al., (2017) reported that cryotherapy had anti-inflammatory effects, which they attributed to decreased capillary permeability and

suppressed neutrophil activity. This assertion is supported by the observed decrease in IL-6 levels after IC. The significant decrease in IL-6 ($\Delta T1-T2 = -1.44 \pm 0.93$ pg/mL) in the IC group is corroborated by He et al., (2025), who found that cold therapy reduces overall inflammation by diminishing oxidative stress. The parasympathetic nervous system, which regulates inflammatory responses, is activated by massage, likely explaining why the SM group showed a smaller yet still significant decrease in IL-6 ($\Delta T1-T2 = -1.58 \pm 0.63$ pg/mL) (Waters-Banker et al., 2014).

Similar to this, massage reduces oxidative stress and muscle microtrauma by mechanically stimulating the muscles and activating the parasympathetic nervous system (Crane et al., 2012; Waters-Banker et al., 2014). Together, these physiological mechanisms lessen the release of IL-6 from immune and muscle cells. Conversely, the PR group did not exhibit a statistically significant decrease in IL-6 from T1 to T2 ($\Delta = -0.15 \pm 0.28$ pg/mL; $p = 0.08$), confirming earlier findings that passive recovery is insufficiently stimulating to promote inflammatory resolution after intense exercise (Romagnoli et al., 2016).

The IC group showed a greater post-intervention decrease in lactate clearance ($\Delta T1-T2 = -2.34 \pm 0.96$ mmol/L; $p < 0.05$; $d = 2.209$) compared to SM ($\Delta T1-T2 = -1.39 \pm 0.79$ mmol/L) indicating an effective clearance of lactate within a 15-minute halftime intervention. This finding aligns with White & Wells, (2013), who noted that cold application induces vasoconstriction, subsequently reducing metabolic activity and lactic acid production. Conversely, Ogai et al., (2008) propose that enhanced circulation and lactate redistribution through lymphatic drainage may account for SM's moderate effectiveness. Cold therapy can enhance lactate clearance by inducing vasoconstriction, followed by reactive vasodilation. This process improves blood flow and facilitates the removal of metabolic waste during recovery (Khoshnevis et al., 2014). Additionally, cold therapy can reduce muscle activity, helping to conserve energy in the muscles and slowing the lactate production process (Hylldahl & Peake, 2020).

However, to a lesser degree, massage also significantly decreased lactate levels ($\Delta = -1.39 \pm 0.79$ mmol/L; $p < 0.05$; $d = 0.829$). It has been shown that massage helps improve blood flow in small blood vessels and boosts lymphatic flow, which helps move lactate from muscles to the liver, making it easier to remove. While the role of massage in enhancing metabolic recovery is confirmed by this evidence, its mechanisms may require a longer time to reveal their full benefits compared to the more immediate physiological effects of cold application. However, conflicting results exist, Crane et al., (2012) reported no significant decrease in lactate following massage, which may be attributed to variations in the duration or pressure levels of the massage. The discrepancy in results could stem from the study employing a 15-minute moderate-pressure (2–3 kgf/cm²) technique, underscoring the necessity for clear treatment guidelines.

Its two main effects, (1) vasoconstriction, which slows down local metabolism and lactate production, and (2) anti-inflammatory modulation, which lowers IL-6 release by reducing oxidative stress, might explain why IC is more effective for recovery. On the other hand, SM mainly helps remove lactate from the body by increasing blood and lymph flow and reducing muscle stiffness, which helps get rid of waste and provide nutrients. On the other hand, SM mainly helps clear lactate from the body by boosting blood and lymph

flow and reducing muscle stiffness, which aids in removing waste and delivering nutrients. On the other hand, SM mainly improves the mechanical clearance of lactate by increasing blood and lymph flow and reducing muscle stiffness, which improves waste removal and nutrient delivery (Weerapong et al., 2005). Under time-constrained recovery periods, such as halftime, mechanical clearance alone may be less effective than metabolic suppression, as indicated by the smaller effect size of SM on lactate (Cohen's $d = -1.081$ vs IC's $d = -2.731$).

Although this study backs up the effectiveness of IC and SM, other research shows contradictory results. For example, despite shorter intervention durations (10 minutes), Romagnoli et al., (2016) found no significant difference in IL-6 levels between basketball players' active and passive recovery. Furthermore, the fact that only male athletes ($n = 36$) were included restricts its generalisability to female populations, which might have different inflammatory reactions (Aragón-Vela et al., 2021). Despite being statistically powered, the small sample size means that results should not be extrapolated to larger athletic cohorts.

Given its quick metabolic and anti-inflammatory effects, these results support the inclusion of IC in high-intensity intermittent sports halftime recovery regimens. SM is still a useful substitute, especially in situations where cryotherapy is not an option. Future studies should look at: (1) gender-specific responses; (2) combined interventions (e.g., IC followed by SM) to maximise their effects; and (3) long-term results on performance sustainability and injury prevention.

Conclusions

Ice compression and sports massage are more effective than passive recovery in reducing lactate and IL-6 levels after high-intensity intermittent exercise. Ice compression accelerates lactate clearance and diminishes inflammatory responses. These findings indicate that incorporating active recovery strategies during short rest periods, such as halftime in a match, can significantly enhance athlete performance. The study recommends that coaches and sports practitioners integrate these methods into their match rest routines to mitigate muscle fatigue, expedite metabolic recovery, and lower the risk of fatigue-related injuries. Future studies should assess the long-term impact of these methods on performance, investigate their effects on female athletes and various age groups, and explore additional therapies with synergistic effects.

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Conflict of Interest

All researchers declare that there is no conflict of interest in this research

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Вплив льодової компресії та масажних технік на виведення лактату та концентрацій інтерлейкіну-6 під час відновлювальної перерви в інтервальних видах спорту

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Історія питання. Високоінтенсивні інтервальні види спорту підвищують рівні лактату в крові та маркери запалення, як-от інтерлейкін-6 (IL-6), що може перешкоджати відновленню та знижувати результативність. Ефективні стратегії відновлення мають вирішальне значення для покращення кліренсу лактату та регулювання запалення.

Мета дослідження. Метою цього дослідження було оцінити вплив 15-хвилинних інтервенцій із застосування льодової компресії та спортивного масажу під час перерви на кліренс лактату та рівні IL-6 у спортсменів.

Матеріали та методи. Для проведення цього експериментального дослідження тридцять шість футболістів-чоловіків віком від 18 до 24 років було розподілено за методом рандомізації на три групи: льодова компресія (ЛК, n = 12), спортивний масаж (СМ, n = 12) та пасивне відновлення (ПВ, n = 12). Кожен учасник виконав стандартизовану програму вправ, розроблену з метою індукції втоми. Група ПВ після тренування проходила період пасивного відпочинку, тоді як учасники інтервенційних груп протягом 15 хвилин отримували масаж або льодову компресію. Вимірювання рівнів лактату та IL-6 у крові проведено перед тренуванням (T0), безпосередньо після тренування (T1) та через п'ятнадцять хвилин після завершення тренування (T2). Для аналізу виявлених відмінностей проведено дисперсійний аналіз за змішаною моделлю та post-hoc тести (Бонферроні/Геймса-Хауелла).

Результати. Згідно з отриманими результатами, рівні лактату (ЛК: $\Delta T1-T2 = -2.34 \pm 0.96$ ммоль/л, $d = 2.209$; СМ: $\Delta T1-T2 = -1.39 \pm 0.79$ ммоль/л, $d = 0.829$) та рівні IL-6 (ЛК: $\Delta T1-T2 = -1.44 \pm 0.93$ пг/мл, $d = 1.206$; СМ: $\Delta T1-T2 = -1.58 \pm 0.63$ пг/мл, $d = 1.645$) були значно нижчими, ніж у ПВ ($p < 0.05$). Незважаючи на подібні протизапальні ефекти щодо застосування ЛК та СМ ($p = 0.898$), ЛК продемонструвала вищу ефективність кліренсу лактату порівняно із СМ ($p = 0.023$, $d = -1.081$). ПВ показало лише мінімальне зниження обох біомаркерів.

Висновки. Масаж і льодова компресія ефективно сприяють виведенню лактату після високоінтенсивних фізичних вправ, причому масаж має додаткові переваги, зменшуючи запалення, опосередковане інтерлейкіном-6. Представлені результати підтверджують, що масаж є відмінним методом регенерації для спортсменів, які потребують негайного фізіологічного відновлення після фізичних навантажень.

Ключові слова: льодова компресія, спортивний масаж, кліренс лактату, інтерлейкін-6, запальна реакція.

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