

Effectiveness of two different recovery process on blood lactate removal pattern of soccer players

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim

Soccer is a high-intensity intermittent sport that requires players to alternate between explosive activity and recovery. This often leads to significant blood lactate accumulation, a by-product of anaerobic metabolism, which can impair performance by inducing muscular fatigue and reducing the ability to sustain optimal effort. This study aimed to examine the effect of two different recovery processes on the blood lactate removal pattern of soccer players in Tripura.

Material and Methods

Ten male junior national soccer players from Tripura were purposively selected for the study. Participants performed graded exercise on a treadmill, followed by either active or passive recovery on two separate days. Blood samples were collected before exercise, after 10 minutes of graded exercise, and after five minutes of treadmill running at 90% intensity. Additional samples were taken immediately after five minutes of active or passive recovery and at 10, 20, 30, 40, 50, and 60 minutes of rest. Data were analyzed using a paired t-test, with the level of significance set at 0.05.

Results

Statistical analysis showed a significant difference in blood lactate removal between active and passive recovery ($P < 0.05$). Active recovery led to peak removal at the 5th and 20th minutes, while passive recovery showed maxima at the 10th and 40th minutes. Neither method restored blood lactate to baseline within one hour. Active recovery facilitated the highest lactate removal between phases III-IV (28.44%) and V-VI (28.04%), while passive recovery peaked at 23% between phases IV-V. After 60 minutes, lactate clearance reached 96% with active recovery and 91% with passive recovery. Logistic model analysis ($p = 0.06$) suggested that active recovery was more effective, though significance was observed at the 0.10 level.

Conclusions

The findings of this study indicate that low-intensity active recovery is a more effective strategy for accelerating blood lactate removal in soccer players compared to passive recovery. Incorporating active recovery into training and competition protocols can enhance post-exercise physiological recovery and support sustained performance.

Keywords: blood lactate, graded exercise, active, soccer, passive recovery

Introduction

The study of recovery methods in sports science is essential for understanding and enhancing athletic performance. Among the key factors influencing recovery is the removal of blood lactate, a by-product of anaerobic metabolism that accumulates during high-intensity exercise. Soccer, a sport characterized by its dynamic, intermittent nature, requires effective recovery strategies to mitigate the physiological challenges of accumulated fatigue and maintain optimal performance.

Soccer is classified as an intermittent sport, with activity changes occurring every 4–6 seconds [1]. Soccer players experience temporary fatigue during different phases of the game [2]. The onset of fatigue has been linked to high muscle lactate concentration, low muscle creatine phosphate levels, extracellular potassium accumulation, muscle glycogen depletion, thermal stress, and dehydration [1]. Jimenez et al. [2]

reported that impaired sarcolemma excitation and disturbances in ion homeostasis within muscle cells may contribute to fatigue.

According to scientists and sports trainers, the two most important physiological parameters for analyzing aerobic capacity are heart rate and blood lactate responses [3]. Several studies have indicated that lactic acid, which accumulates during intense exercise, can be removed from the blood by various organs, including the liver, myocardium, renal medulla, and brain. However, the majority of lactate is cleared by skeletal muscle [4, 5].

Blood lactate removal is influenced by the type of exercise, training status, muscle fiber composition, and intensity of recovery exercise [4]. Gur reported that the recovery process enhances blood flow to working muscles, accelerates the resynthesis of high-energy phosphates, replenishes oxygen in the blood, and facilitates lactate clearance. Furthermore, post-exercise basal blood lactate levels are typically restored within an hour, and light exercise during recovery can enhance lactate removal.

One of the most important aspects of the recovery process is the removal of lactic acid from the blood and muscles. Additionally, active recovery has been found to be more effective for lactic acid clearance compared to passive recovery. However, the optimal intensity of active recovery remains unclear [6].

Davis and Gass [7] reported that after high-intensity exercise, the rate of blood lactate removal increased with low-intensity active recovery. Another study demonstrated that blood lactate removal was higher at 40% of maximum speed compared to passive recovery and 60% of maximum speed [8]. Eliakim et al. found that motivational music during non-structured recovery enhanced lactate clearance. Fox et al. [9] stated that maximal lactic acid removal occurs within 1 hour and 15 minutes of passive recovery following maximal exercise.

Recovery processes, both active and passive, play a crucial role in facilitating blood lactate clearance. Active recovery, involving low-intensity physical activity, is widely recognized for promoting faster lactate removal through enhanced blood circulation and metabolic activity. In contrast, passive recovery, characterized by rest or minimal physical activity, allows the body to restore energy stores but is less effective in lactate clearance. Understanding the comparative effectiveness of these two recovery modalities is essential for optimizing recovery strategies tailored to soccer players.

Previous research has emphasized the importance of recovery in various sports contexts, but few studies have specifically examined soccer players, particularly in relation to positional roles and physical demands. Furthermore, the influence of different recovery methods on lactate removal patterns in soccer-specific scenarios remains underexplored. The present study aimed to assess the effect of low-intensity (25%) active recovery and passive recovery on blood lactate clearance in junior-level soccer players from Tripura.

Materials and Methods

Participants

The selected subjects of the study were 10 male U-17 National-level soccer players, age 15.6 ± 0.52 years, height 167.25 ± 6.09 cm, weight 53.45 ± 4.07 kg, from Tripura Sports School (TSS). They were also members of the State Junior Football team. The subjects were informed in detail about the experimental procedure and agreed to volunteer for the study. They also provided written consent, including parental consent for participation. Prior to the test, ethical approval was obtained from the ethical committee of Tripura University.

Research Design

Exercise protocol

The maximum speed ability of the subjects was assessed using a repeated 50-meter flying start test. The laboratory tests were conducted in the morning under controlled conditions. Subjects were instructed to refrain from training for 24 hours before each test day. Each participant completed a submaximal exercise test followed by two recovery sessions (active or passive) on separate days.

The test began at 40% intensity, with increments of 10% every 2 minutes until reaching 80% intensity. Participants then ran at 90% intensity for 5 minutes. Exercise intensity was determined using a standard maximum speed ability test for each individual. The exercise sessions were conducted one week apart, with the same protocol applied on both days.

Recovery Protocol

Active Recovery – After submaximal exercise, participants ran for 5 minutes at 25% intensity on a treadmill, followed by 1 hour of seated rest. **Passive Recovery** – After submaximal exercise, participants rested in a supine position (Shavasana) on a yoga mat for 5 minutes, followed by 1 hour of seated rest.

Blood Sampling

Blood samples were collected before exercise, after submaximal exercise, immediately after 5 minutes of active or passive recovery, and at 10, 20, 30, 40, 50, and 60 minutes during rest. Samples were obtained from the fingertips and analyzed using the Lactate Pro 2 Blood Lactate Test Meter (Arkray, Koka-shi, Japan). Heart rate was continuously monitored throughout the test.

Statistical Analysis

Statistical analysis was performed using Microsoft Excel 2021. A paired t-test was used to compare blood lactate removal patterns between active and passive recovery, with the significance level set at $P < 0.05$. Additionally, a logistic model was applied to the data to identify the most effective recovery method for U-17 soccer players.

Results

Statistical analysis indicated a significant difference in blood lactate removal patterns between active and passive recovery ($P < 0.05$). Blood lactate removal was highest immediately after 5 minutes of active recovery and again after 20 minutes. In contrast, during passive recovery, the maximum removal was observed at the 10th and 40th minutes. However, neither recovery method restored blood lactate to baseline within one hour, indicating that complete recovery was not achieved under these testing conditions.

Table 1 presents the descriptive statistics for age and physical characteristics of U-17 soccer players from Tripura. The mean age was 15.6 ± 0.52 years, height was 167.25 ± 6.09 cm, and weight was 53.45 ± 4.07 kg.

Table 1. Descriptive statistics of age and physical measurements of soccer players

Variables	N	Range	Mean ± SD
Age (years)	10	15–16	15.6 ± 0.52
Height (cm)	10	160.5–181	167.25 ± 6.09
Weight (kg)	10	48–60	53.45 ± 4.07

Figure 1 illustrates the accumulation and removal patterns of blood lactate in soccer players. The blood lactate pattern was formed based on mean values recorded at different phases of the program. During exercise, lactate accumulated progressively, and its removal followed the given exercise protocol. The figure demonstrates similar blood lactate removal patterns in both recovery processes.

In the active recovery process, the highest lactate removal occurred between phases III-IV and V-VI, with percentage reductions of 28.44% and 28.04%, respectively. The lowest removal rate (13.73%) was recorded between phases VI-VII at the 30th minute. In passive recovery, the maximum removal (23%) occurred between phases IV-V, with a steady removal rate of 15% observed after 50 minutes. This indicates that low-intensity active recovery initiates lactate clearance earlier than passive recovery.

Table 2 presents the percentage change in blood lactate removal for both recovery processes. The values clearly show that low-intensity activity promotes faster lactate clearance compared to passive recovery (Shavasana). Active recovery facilitated a 96% lactate removal after 60 minutes, whereas passive recovery resulted in 91% clearance.

Table 2. Percentage Change in Blood Lactate Removal During Active and Passive Recovery

Phase	Time (min)	Active Recovery (%)	Passive Recovery (%)
IV	5	33.46	21.45
V	10	52.13	45.78
VI	20	70.64	59.08
VII	30	77.35	71.15
VIII	40	84.93	80.38
IX	50	91.51	85.97
X	60	96.14	91.12

Logistic model analysis yielded a p-value of 0.06, indicating that the slope was not significant at the 0.05 level but was significant at the 0.10 level. Consequently, a logistic model was developed at the 0.10 significance level, which may help determine the most effective recovery method for soccer players.

$$\text{Model: } P = \frac{1}{1 + e^{-[\beta_0 + \beta_1 x_1]}}$$

$$\text{Model: } P = \frac{1}{1 + e^{-[-7.5169 + 0.5310x_1]}}$$

Discussion

Blood lactate removal is a critical factor in sports recovery, particularly in high-intensity sports such as soccer, swimming, and judo. Various studies have investigated the efficacy of different recovery methods, providing valuable insights into optimal lactate clearance strategies.

Active recovery combined with compression therapy and neuromuscular electrical stimulation (NMES) has been shown to be more effective than passive recovery and massage therapy [9]. Evans and Cureton reported that optimal lactate removal occurred at 25% to 65% of VO₂ max during treadmill and bicycle ergometer exercises [10]. Another study demonstrated that, in the initial phase of recovery, active recovery at 60% of maximum heart rate was more effective than at 55% or 65% of maximum heart rate, as well as passive recovery [11]. Additionally, motivational music during non-structured recovery enhanced activity levels, improved lactate clearance, and reduced perceived exertion [12]. Furthermore, increased inspiratory resistance during recovery from intense exercise has been shown to accelerate lactate removal. Bakers and King [4] suggested that continuous activity was more beneficial for lactate removal than intermittent activity.

The current study showed that 25% active recovery was more beneficial for Tripura's U-17 National-level football players in the early stages of recovery compared to passive recovery. Xie et al. [11] supported these findings, which are consistent with the present study.

A study on judokas demonstrated a similar recovery pattern after active and passive recovery. In competitive situations, judokas required approximately one hour to return to baseline levels of blood lactate, heart rate, and respiratory rate following a bout [13]. A recent study found that, 24 hours after a lactate tolerance exercise test, elite male swimmers exhibited blood lactate levels below baseline [14]. Devlin et al. reported that maximal lactic acid removal occurs within 1 hour and 15 minutes of passive recovery following maximal exercise [15].

In the present study, soccer players removed approximately 96% of blood lactate after 5 minutes of active recovery, whereas around 91% was cleared after 5 minutes of passive recovery. These results indicate that a 5-minute active recovery is more effective for blood lactate removal, while passive recovery shows a slower clearance rate.

A logistic model was applied to determine the optimal recovery method for U-17 soccer players at a 0.10 level of significance. However, further studies with a larger sample size are recommended to refine the model and enhance its applicability.

The study's findings demonstrate a significant difference in blood lactate removal patterns

between active and passive recovery ($P < 0.05$). Active recovery facilitated faster lactate removal, with peak clearance observed at the 5th and 20th minutes. This aligns with previous research indicating that active recovery enhances blood circulation, thereby accelerating lactate clearance through oxidation or gluconeogenesis [11]. In contrast, passive recovery exhibited peak lactate removal at the 10th and 40th minutes. Despite these patterns, neither recovery method restored lactate levels to baseline within one hour, suggesting that this duration was insufficient under the given testing conditions [16].

The developmental stage of adolescent athletes plays a crucial role in recovery, as physiological adaptations significantly impact performance. These factors are essential when assessing lactate dynamics, as body composition and metabolic capacity influence the rate of lactate removal [17].

During active recovery, the highest removal rates occurred between phases III-IV (28.44%) and V-VI (28.04%), aligning with findings from [20], which suggest that moderate-intensity activities enhance lactate metabolism. The passive recovery process exhibited a peak removal rate of 23% between phases IV-V, followed by a consistent but slower clearance after 50 minutes. This slower pace is attributed to the lack of circulatory stimulation in passive recovery, corroborating studies by Baldari et al. [18]. Active recovery achieved a clearance rate of 96.14% within 60 minutes, surpassing the passive recovery rate of 91.12%. The faster clearance in active recovery highlights its effectiveness in promoting lactate metabolism, supporting previous studies on the role of low-intensity exercise in maintaining muscle contraction and venous return [19]. Passive recovery methods, such as Shavasana, rely on natural metabolic processes, resulting in slower clearance rates.

These findings provide practical insights for soccer coaches and sports scientists. Implementing active recovery protocols, such as light jogging or dynamic stretching, between intense training sessions or matches can accelerate lactate removal, enhance recovery, and optimize performance. However, further research is needed to determine whether extending the recovery duration beyond one hour could facilitate baseline lactate clearance and improve post-exercise recovery outcomes.

Conclusions

The study found that low-intensity active recovery (at 25% intensity) significantly improves

blood lactate clearance rates compared to passive recovery strategies such as Shavasana among Tripura U-17 national football players. Active recovery showed a faster onset and higher efficiency in lactate elimination, with approximately 96% clearance within 60 minutes. In contrast, passive recovery resulted in around 91% clearance over the same period. However, neither approach was successful in totally restoring lactate levels to baseline within the one-hour monitoring period. This emphasises the better efficacy of active recovery while simultaneously highlighting its limitations in reaching complete recovery within the period.

Study Limitation

A limited sample size of ten male participants limits the generalisability of the study's findings. Furthermore, the study focused primarily on two recovery modalities and only tracked recovery for an hour. To address these limitations, future research should investigate a larger range of recovery approaches, lengthen the monitoring period, and evaluate additional physiological and biochemical markers to gain a more complete understanding of recovery processes.

Future Research Direction

While the logistic model employed to predict recovery efficiency was statistically significant at the 0.10 level, additional refining and validation with a larger sample size may improve its resilience and dependability. Future research that incorporate more diverse populations, different recovery protocols, and more variables may improve the practical applicability of our findings, assisting in the optimisation of recovery techniques for football players and athletes in other sports disciplines.

Acknowledgement

We express our sincere gratitude to all those who have contributed to the completion of this study. We are profoundly grateful to our academic mentors and colleagues for their valuable guidance, critical feedback, and encouragement throughout the research process.

Conflict of Interest

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

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Cite this article as:

Katoch R, Farooque S, Dhar K, Das PK. Effectiveness of two different recovery process on blood lactate removal pattern of soccer players. *Pedagogy of Physical Culture and Sports*, 2025;29(1):62–67. <https://doi.org/10.15561/26649837.2025.0107>

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Received: 07.01.2025

Accepted: 18.02.2025; Published: 28.02.2025