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The effects of three different recovery postures during the half-time break on fatigue and body temperature in football players

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Abstract

Background: In football, research on halftime recovery methods is limited.
Aim: The aim of this study was to investigate the effects of three different recovery postures during the half-time break on blood lactate and pH, RPE and body temperature of football players.
Materials and Methods: Thirty-four male division I Tabriz football players, with an average age of 25.82±4.1 years and Vo_2max of 56.30±8.61 ml/kg/min were randomly assigned to three recovery posture groups: (1) seated posture (Sit, n=11), (2) supine posture (Sup, n=11), and (3) supine posture with elevated legs (Sup Lu, n=12). Each group followed their specific recovery protocol 10 min after a simulated half-football game. Measurements were taken before (T1), immediately after (T2), and five minutes after (T3) recovery.
Results: Both the Sup and Sup-Lu groups exhibited a significant decrease in blood lactate and an increase in pH from T1 to T3, but there was no significant difference between these two groups ($P > 0.05$). Body temperature did not show significant variation within or between the groups ($P>0.05$). A significant difference was observed in the mean changes of RPE from T1 to T3 between the groups ($P<0.05$).
Conclusion: Both the Sup and Sup Lu recovery postures were found to effectively reduce the fatigue level of football players during the half-time break compared to sitting, without lowering body temperature.

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1. Introduction

Repetitive high- intensity activity during a football match, leads to changes in acid-base balance and gradual fatigue [1]. Poor recovery between halves can affect players' performance in the second half due to changes in body temperature, blood sugar, and acid-base balance. Studies show that approximately 20% of professional football players exhibit reduced work intensity during the first 15 min of the second half of a football match [2, 3].

Researchers have investigated the effects of different recovery postures on physiological responses during recovery [4, 5]. For example, one study investigated the effect of lying, sitting, and standing recovery postures on parasympathetic reactivation after exercise [6]. Posture during recovery can affect the autonomic nervous system's function and facilitate quicker recovery [7]. Research has shown enhanced supine heart rate recovery (HRR) following repeated high-speed running in young football players [8]. Different HRR recovery protocols suggest that lying down may be more effective for transient HR and vagal modulation recovery compared to sitting or active recovery (such as cycling), and is also safer in preventing syncope [9].

Toya et al. (2016) found that the blood flow velocity in the common femoral vein during ankle pumping exercises varied in different postures, such as lying with legs elevated or head elevated [10]. According to the reports of Kwon et al. (2003) ankle movement with deep breathing while lying down increased blood flow speed in the femoral arteries [11]. Changes in blood flow can aid in lactate breakdown, which mainly occurs in the liver (60%) and partly in the kidneys (30%) and other organs like the heart and skeletal muscle [12]. Lying down with legs elevated may enhance blood flow to central body parts and organs involved in reducing lactate and blood acidity. Studies suggest that decreased liver blood flow could hinder lactate breakdown [13].

Research has explored the impact of football games on players' pH levels [3, 14], lactate levels [14, 15], body temperature [16, 17], and perceived exertion (RPE) [18]. Blood lactate concentrations from 2 to 10 mM have been observed during football matches [14]. A connection between lactate levels and Rate of Perceived Exertion (RPE) has been established in football matches, supporting the use of RPE as a gauge for overall exercise intensity in football [15, 18]. Studies indicate that body temperature significantly impacts football players' performance. A drop in muscle and body temperature during halftime may reduce speed capacity at the start of the second half [17]. Elevated body temperature is linked to enhanced exercise intensity [16], but this effect differs at higher temperatures. Mohr et al. (2012) found that player performance decreases when muscle temperature surpasses 41°C in the last 15 minutes of a match [19].

Various methods have been suggested to reduce football post-match fatigue [20], but there is limited research on player recovery between halves in football matches. Common activities during halftime include players returning to the locker room, briefly relaxing to recover from the first half's demands, hydrating, refueling, addressing injuries and equipment issues, and receiving tactical instructions from the coach [21]. Making extensive changes to halftime routines is not practical due to time constraints, coach-player coordination, and player mental readiness concerns [22, 23]. Therefore, a simple and minimally intrusive protocol is recommended for optimal halftime recovery.

The use of various postures during the half-time break should be quick and achievable without special equipment. Limited research exists on recovery methods between halves. This study aims to examine how three recovery postures during half-time affect blood lactate and pH levels, perceived exertion, and axillary temperature in football players.

2. Materials and Methods

2.1. Participation

A total of 34 male football players (age 25.82±3.47 years and a training history of 7.58±2.60 years; maximum oxygen consumption [Vo_2max]>44) with no history of major injury in the knee or ankle who played from 2021 to the Tabriz First Division League in Iran participated in this Quasi-experimental study. Participants were randomized into three groups: (1) seated posture (the most common recovery posture used in the teams) (Sit, n=11), (2) supine posture by performing ankle movements and deep breathing (Sup, n=11), and (3) supine posture with raised legs and ankle movements and deep breathing (Sup Lu, n=12). The participants performed the desired rest for 10 min without drinking liquids.

All players underwent a biomedical examination prior the protocol and completed a medical history questionnaire. Participants did not smoke, drink alcohol, or take other medications or stimulant substances and drugs, that could alter hormonal responses. In addition, no participant took any dietary supplements during the research tests. All participants were fully informed of all study procedures and signed an informed consent form. This study was conducted in accordance with the Declaration of Helsinki (2008) and the Fortaleza update (2013) [24]. The study was approved by the Human Research Ethics Committee at the Sport Sciences Research Institute (SSRI) of Iran (number: IR.SSRC.REC.1402.043).

2.2. Procedure

Immediately after a 45 min simulated half-football protocol, participants recovered for 10 min without drinking fluids. The simulated football game used in this study was a field exercise protocol designed for an England team in 2011 by Russell [25] (Figure 1).

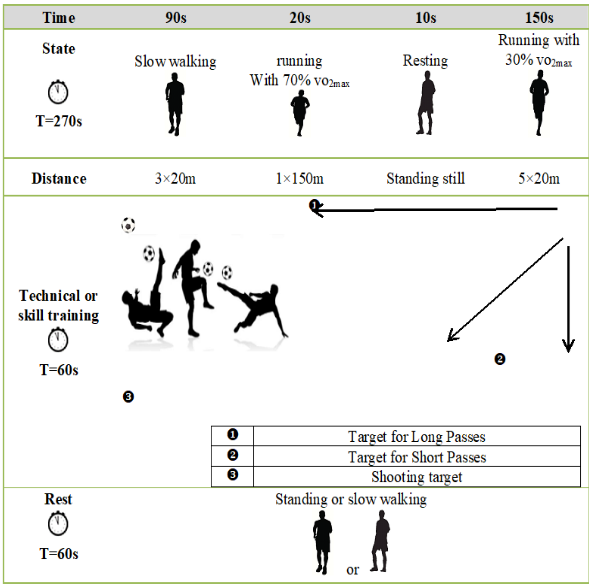


Figure 1. A 45 min simulated half-football exercise protocol consisting of 7 repeated blocks of 390 sec

The blood samples were taken in three phases. First, blood samples were taken after a simulated football match to measure basal lactate and blood pH (T_1) before participants performed the desired recovery. In the next step, blood samples were taken again immediately after recovery (T_2). In the final phase, blood samples were taken 5 min after recovery (T_3). In addition to blood sampling, the RPE value, and axillary body temperature were also measured in these three phases. In order to take into account, the time constraints and the possible effects on the variable values, all measurements such as body temperature, fatigue assessment (RPE) and blood sampling from the arm were carried out simultaneously by three people.

Venous blood lactate and pH were measured using an analyzer (Instrumentation Laboratory Co. GEM 3000 Premier Laboratory, USA). GEM Premier 3000, is a compact and portable system for rapid analysis of pH, pCO_2, PO_2, Ca^{2+}, Na^{2+}, K^{+}, lactate, glucose, and hematocrit [26].

A mercury thermometer (Alonzo Company, MT101R, People's Republic of China) was used to measure axillary temperature. After shaking and lowering the mercury below 35°C, the mercury thermometer was inserted in to the axilla, and the body temperature was read. The measurement was repeated by placing the thermometer in the previous location, and the readings were recorded [27]. Fatigue (RPE) was assessed using the RPE (CR10-scale) [28].

2.3. Statistic

The variables of the study were expressed as mean±standard deviation. The data were analyzed with IBM SPSS Statistics version 23.0. The normality of the data distribution was tested using the Shapiro-Wilk test. A mixed ANOVA was used to compare differences in means between groups, split between two "factors" (time and recovery), where time was a "within-subjects" factor and recovery (groups) was a "between-subjects" factor. A significance level of $P<0.05$ was used.

3. Results

3.1. Baseline data

According to the results of the one-way ANOVA, the characteristics of the three groups studied did not differ significantly in the pre-test (Table 1).

3.2. Main study data

Blood lactate, pH, body temperature and RPE levels at T_1, T_2 and T_3 in the tree groups are presented in Table 2. It was found that there were no significant differences between the groups in pH, lactate levels or body temperature. However, a significant difference in perceived exertion (RPE) was found ($P=0.005$; Table 3). Time had a significant effect on all variables except body temperature ($P=0.629$; Table 3). pH levels increased and lactate levels and fatigue decreased significantly from T1 to T3 in the Sup and Sup-Lu groups ($P<0.05$). Pairwise comparisons revealed significant differences in RPE between the Sit and Sup groups ($P=0.045$; Table 2).

4. Discussion

This study investigated the effects of three different recovery positions during football halftime on blood lactate and pH, RPE, and body temperature in male football players. According to the results, both the Sup and Sup LU postures were effective in lowering RPE and blood lactate levels and increasing Ph. There are few studies looking at the effects of different recovery postures as a form of immediate recovery from exercise training.

Table 1. Basic characteristics of the study participants and their similarity in the study groups

Variable	Sit (n=11) M±D	Su (n=11) M±D	Sup Lu (n=12) M±D	ANOVA (sig)	F	95% CI
Age (Years)	26.91±3.14	25.73±4.29	24.92±3.47	0.398	0.95	24.61-27.03
VO_2max (ml. kg/m)	55.71±7.63	56.28±9.77	56.85±9.04	0.954	0.048	53.29-59.30
BMI (kg/m^2)	24.24±2.42	22.80±2.42	23.12±1.01	0.233	1.528	22.66-24.11

*Significant Difference ($P<0.05$)

Table 2. Changes in fatigue factors in the three different recovery postures during the half-time

Variable	Group	T_1	T_2	T_3	$P^£$	$P^¥$
Blood lactate (mmol/L)	Sit	5.12±0.61	4.17±0.40	3.96±0.48	0.10	-
	Sup	5.49±0.61	4.79±0.44	3.91±0.41	0.00*	
	Sup Lu	6.18±1.00	5.44±0.78	4.73±0.60	0.00*	
Blood acidity (PH)	Sit	7.353±0.07	7.365±0.02	7.365±0.02	0.15	-
	Sup	7.321±0.04	7.354±0.07	7.379±0.05	0.04*	
	Sup Lu	7.336±0.04	7.367±0.01	7.370±0.01	0.00*	
Body temperature (C°)	Sit	36.13±1.27	35.93±0.86	35.38±1.84	0.39	-
	Sup	35.60±1.17	35.78±1.04	35.65±0.96	0.41	
	Sup Lu	35.13±0.71	35.60±0.62	35.47±0.73	0.12	
RPE (AU)	Sit	5.00±0.35	4.45±0.24	4.09±0.38	0.01*	*P* [Sit, Sup] =0.04*
	Sup	4.91±1.22	3.64±0.67	2.63±0.68	0.00*	*P* [Sup, Sup Lu] =0.98
	Sup Lu	4.58±0.90	3.58±0.66	2.33±0.49	0.00*	*P* [Sup Lu, Sit] =0.00*

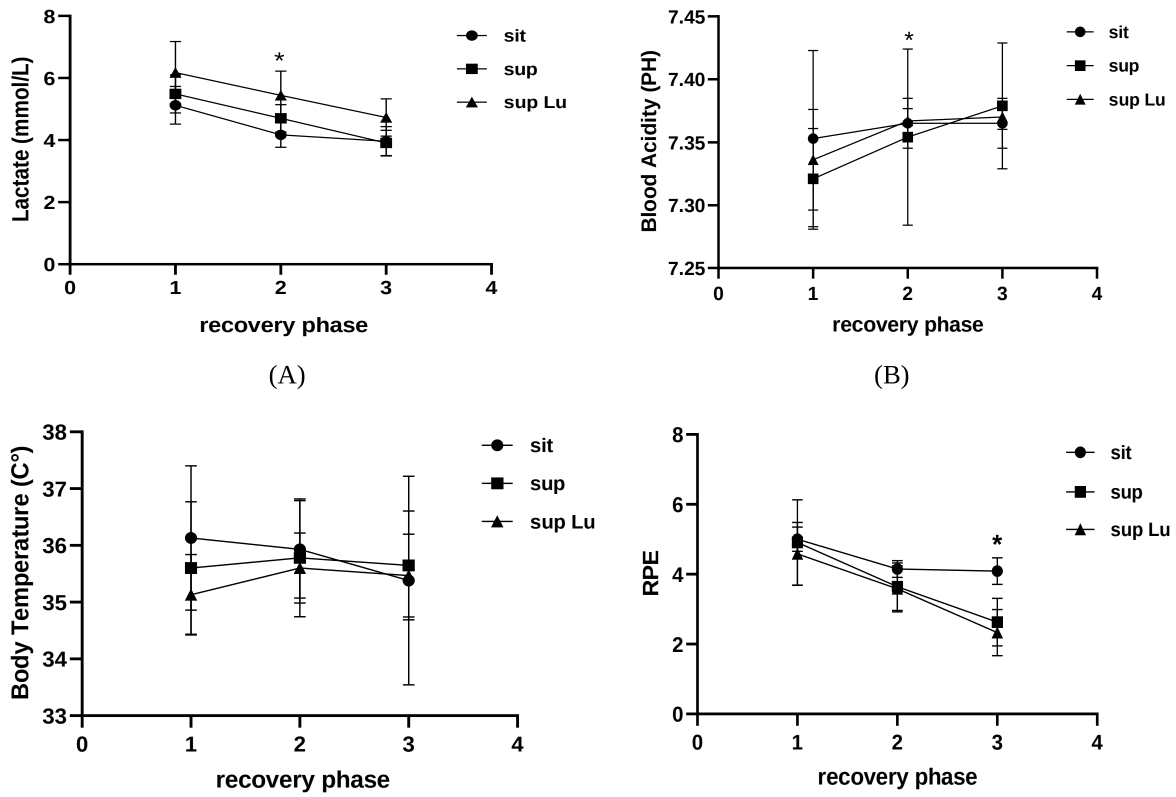
*Significant difference $P<0.05$

£ *P* value of difference between three times

¥ *P* value for pairwise comparisons between groups (post-hoc Bonferroni test)

Table 3. Mixed-model ANOVA results

Dependent variable	Between subjects' effects		Within subjects' effects			
	Group		Time		Time*group	
	F	*P*	F	*P*	F	*P*
Blood acidity (PH)	0.29	0.75	27.19	0.00*	3.89	0.03*
Blood lactate (mmol/L)	1.08	0.35	23.76	0.00*	0.17	0.84
Body temperature (C°)	0.62	0.54	0.23	0.63	1.71	0.19
RPE (AU)	6.2۴	0.00*	83.44	0.00*	5.09	0.01*



(A) (B) (C) (D)

Figure 2. Lactate (A), pH (B), body temperature (C); and rating of perceived exertion (D) in the recovery phases: before recovery=1, immediately after recovery=2, and 5 min after recovery=3 in the groups (*Significant difference between the groups $P<0.05$)

Michaelson et al. (2019) investigated the effects of two different recovery postures, hands on head (HH) and hands on knees (HK), as a form of immediate recovery from high intensity interval training (HIIT) and found that, recovery in the HK posture had a better effect on resting heart rate and CO_2 excretion immediately after high-intensity interval training than the HH posture [29]. The mechanisms of the effect of postures in reducing acidity could be related to changes in blood flow to the kidney, liver and lungs and their involvement in controlling the acid-base balance of the blood.

The kidneys play a crucial role in lactate metabolism. After the liver, the renal cortex appears to be the most important organ that utilizes lactate in the body [30]. It has been shown that under normal physiological conditions, the kidneys are the second most important organ after the liver for removing and metabolizing lactate from the bloodstream [31]. The kidneys regulate the body's acid-base balance by excreting hydrogen ions and producing bicarbonate to maintain the pH of blood plasma within a normal range [32].

Research also highlights the crucial role of the pulmonary system in maintaining pH balance in the human body. The brain and lungs can adjust the rate and depth of breathing to minutely regulate the pH of the blood [33]. Therefore, the high blood flow in the supine position to the central parts of the body, including the brain, lungs, kidneys, and liver, compared to the seated position may be an influential factor in reducing blood acidity during recovery [34].

In this study, the significant decrease in lactate levels and increase in pH after recovery in the Sup and Sup-Lu positions, as compared to the Sit position, suggests that the Sup and Sup-Lu positions clear lactate and increases pH at a faster rate. This may be attributed to improved blood flow from the legs to the body's core due to the elevated leg position.

Previous studies have also reported the body's central role in clearing lactate. Navalta et al. (2007) concluded that core stabilization exercises enhance the removal of lactate after high-intensity exercise by increasing blood flow or uptake into the body core muscles [35]. In addition to the role of lactate elimination by the central organs by increasing blood flow in the supine position, deep breathing and movement of the ankles in the Sup or Sup-Lu position may have been an effective active comparative posture for recovery in the seated position.

The dynamic stretching of the legs in the Sup and Sup-Lu positions compared to the seated recovery posture may have effectively increased pH. In this case, Pitt KT et al. (1995) showed that blood lactate was significantly lower after high-intensity exercise during cycling and stretching than in the seated recovery posture [36]. Accompanying studies have shown that the removal of metabolic waste (H^+) is greater during active recovery (20%, maximum power output for 12 min) than during passive recovery [37]. In this sense, the seated posture in this study was more passive than the other two postures. Therefore, an attempt was made to bring the body out of its passive state by moving the ankles in both the Sup and Sup-Lu postures. On the other hand, deep breathing can help to eliminate more blood acid.

It is believed that the excretion of carbon dioxide during recovery is associated with deep inhalation and exhalation. Excess acid is normally excreted through inhalation and exhalation, as well as sweating and urination [3]. Deep breathing increases the amount of exhaled carbon dioxide and raises blood pH [38, 39]. Lactate buffering by bicarbonate to maintain a normal $PaCO_2$ occurs through increased lung ventilation [40]. Reduced ventilation due to impaired conscious breathing during post-exercise recovery has been reported to lead to a reduction in muscle lactate catabolism [41]. It has long been hypothesized that inspiratory muscle activity may influence lactate clearance, and reduce lactate levels during recovery from dynamic exercise [42].

Considering the drop in performance and the increased risk of injury at the beginning of the second half, recovery interventions during the halftime break [43], for maintaining muscle temperature are crucial [22].

This study showed no significant difference in body temperature between groups. Given that, the subjects' body temperature did not drop significantly after the recovery, it appears that maintaining temperature during the recovery period may reduce the risk of muscle injury and ensure better performance in the second half.

Previous studies have shown that the performance of athletes increases depending on the environment and muscle temperature [44, 45]. Maintaining body temperature during the intended recovery phases could therefore be considered a competitive advantage. To maintain muscle temperature at half-time, Russel et al. (2015) used warm clothing and stretching in conjunction with warm-up exercises before the start of the second half. They found that decreased cognitive and physical function and increased risk of injury could occur at the start of the second half due to decreased muscle temperature. To prevent this phenomenon, they allocated 8 to 9 min of the halftime break to maintain core body temperature. They also found that active recovery at halftime-maintained body temperature and increased the performance of strength, jump power, and speed of football players in the first 15 min of the second half [22].

It has been reported that dynamic lower body movements and stretching exercises may be beneficial for keeping the body warm and eliminating blood acidity compared to passive rest [21, 46]. In this study, the movement of the ankle and the involvement of the leg muscles as well as the involvement of the respiratory muscles in the Sup and Sup-Up positions were potentially effective in maintaining body temperature. This can be beneficial for sustaining performance and lowering injury risks at the beginning of the second half [17].

In this study, the rating of perceived exertion (RPE) decreased significantly in all three groups during the recovery phases. RPE can be influenced by various factors, including the type of recovery, blood lactate levels, heart rate, $\%VO_2max$, and respiration [47]. RPE is a complex process in which signals from the external environment and the central and peripheral parts of the body are integrated to form a multifactorial composition [48, 49, 50], therefore the influence of environmental and psychological factors on RPE should not be overlooked.

One of the limitations of the present study was the lack of control of environmental and psychological factors influencing RPE, and it seems that future studies are needed in this regard. The comparison between the groups showed that the RPE in the T3 recovery phase was lower in the Sup or Sup Lu position compared to the Seated position. This suggests that these postures are more effective at lowering RPE than sitting.

Charry et al. (2023) suggest that the supine position is more beneficial for recovery after high-intensity interval training than standing postures such as hands on head, hands on knees, or slow walking with hands on hips [51]. Tessitore et al. (2008) found that both active and passive recovery methods significantly reduce RPE in football players [51]. Based on the studies by Cruz-Montecinos et al. (2019) [52] and Zhao et al. (2022) [53], the RPE scale is a valid tool for assessing fatigue. It can be concluded that supine recovery effectively reduces fatigue in football players during the half-time break compared to sitting. Furthermore, there were no significant differences in the reduction of fatigue between the supine position and the supine position with raised legs. Therefore, it is recommended that teams choose either the supine position or the supine position with legs elevated during the halftime break of a football matches.

5. Conclusions

Both active recovery protocols during the football halftime break, the supine posture and supine posture with raised legs are effective in lowering RPE and blood lactate levels and elevate pH; however, no superiority was shown for recovery in either Sup or Sup Lu positions. So, both recovery protocols could be desirable methods during football half-time.

Conflict of interest

The authors declared no conflicts of interest.

Authors' contributions

All authors contributed to the original idea, study design.

Ethical considerations

The authors have completely considered ethical issues, including informed consent, plagiarism, data fabrication, misconduct, and/or falsification, double publication and/or redundancy, submission, etc. The study was approved by the Human Research Ethics Committee at the Sport Sciences Research Institute (SSRI) of Iran (number: IR.SSRC.REC.1402.043). https://ethics.research.ac.ir/EthicsProposalView.php?id=361978.

Data availability

The dataset generated and analyzed during the current study is available from the corresponding author on reasonable request.

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