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Comparing the effects of eight weeks of low and high-volume HIIT on lactate response and some performance indicators of soccer players

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Abstract

Purpose: High-intensity interval training (HIIT) is an effective training method for improving the aerobic and anaerobic power of athletes; however, the role of activity volume in high-intensity interval training efficiency is still unclear. Therefore, in the present study, the effects of low- and high-volume HIIT on aerobic power, anaerobic power, and lactate response in young soccer players were compared. **Method:** In this study, 24 professional soccer players aged 20 to 22 who had no history of illness or taking supplements were chosen and randomly assigned to two groups of high-volume and low-volume HIIT. High-intensity interval training was completed for eight weeks. Training sessions included 5 min of warm-up, the main training phase, and cooling down. The training phase in the first week included 8 repetitions of 15 s of running with maximum power and 15 s of rest. Every week, the number of repetitions was increased by two. High-volume interval training was conducted for six sessions per week while low-volume interval training was performed for three sessions per week. After the training intervention, aerobic power was measured using the one-mile running test, and anaerobic power was evaluated using the Running-Based Anaerobic Sprint Test (RAST). Moreover, the level of blood lactate resulting from the RAST test was also measured using a lactometer. To statistical analyses repeated measure ANOVA was used. **Results:** Blood lactate levels were reduced by 12% (p=0.001) in the high-volume interval group and by 10% (p=0.001) in the low-volume interval group in response to

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exercise. In addition, statistical analysis revealed that the blood lactate levels in response to exercise after 8 weeks of training were similar in both groups. On the other hand, despite the rise in aerobic and anaerobic power in both groups, there was no significant difference in aerobic and anaerobic power between the high-volume and low-volume groups after eight weeks of interval training. **Conclusions:** Overall, the findings of the present research indicated that high-intensity interval training will reduce lactate and increase aerobic and anaerobic capacity, regardless of the training volume.

***Keywords**:* High-intensity interval training, training volume, aerobic power, anaerobic power.

INTRODUCTION

In order to design the training program for athletes, it is essential to understand the physiological requirements of each sport and to know the suitable and efficient training methods to improve sports performance (Birrer & Morgan, 2010; Kraemer & Fleck, 2005). Today, physical education researchers have a more comprehensive and scientific view of soccer, unlike in the past, when this popular sport was viewed as a typical sport (Datson et al., 2022). Nowadays, the success of soccer teams in various events is attributed to having optimal physiological conditions and performance in sports training (Kraemer & Fleck, 2005; Reilly, Bangsbo, & Franks, 2000). One of the key factors that is effective in increasing the efficiency of soccer players is improving their aerobic and anaerobic power (Boraczyński, Boraczyński, Podstawski, Wójcik, & Gronek, 2020; Giv, Aminaei, & Nikoei, 2022). According to the research conducted on soccer players, although aerobic metabolism is the dominant energy system in soccer, there are a variety of activities in a soccer game, including fast and explosive running, quick movements with and without the ball, heading, changing the speed and direction of movement, different kinds of jumps and tackles, and quick returns, and the dominant energy system of all these types of activities is phosphagen and lactic acid energy (Morgans, Orme, Anderson, & Drust, 2014).

In recent years, the use of high intensity interval training (HIIT), which includes short-term activities (10 to 30 s) with maximal and ultra-maximal intensity and recovery periods between them, instead of continuous aerobic exercises has become popular among athletes and patients with cardiovascular diseases (Guiraud et al., 2012; Wisløff, Ellingsen, & Kemi, 2009). Although there is no comprehensive definition of HIT, it can be defined as periods of sports activity that are characterized by fluctuations in the intensity of the activity at a certain time(Mucci et al., 2013). HIT is often comprised of repeated periods of very intense activity alternated with low- or moderate-intensity exercise or, at times, complete inactivity (Biddle & Batterham, 2015; Gist, Freese, & Cureton, 2014). Depending on the characteristics of the sports activity, high-intensity interval training induces favorable anaerobic and aerobic adaptations in the muscle. HIT produces the same oxidative adaptations in skeletal muscle as traditional endurance training, with the difference that the duration and volume of training are substantially reduced.

In this regard, Czuba et al. (2004) reported that a period of interval training enhances hemoglobin levels and maximal oxygen consumption (VO_2 max) in basketball players(Czuba et al., 2013). Burgomaster et al. (2008) showed that six sessions of speed interval training conducted for more than two weeks increased the activity of citrate synthase enzyme and endurance capacity(Burgomaster et al., 2008).

The aforementioned studies examined the impact of HIT on physiological adaptations in the shortest period of time. However, few investigations have evaluated the role of interval training volume on the performance of athletes and the lactate changes in their bodies. Therefore, this study aimed to investigate the effect of eight weeks of low- and high-volume high-intensity interval training on lactate response and several performance indicators of young soccer players.

METHOD

A total of 24 young soccer players aged 20-22 years, who had a history of playing in at least three seasons of the professional second-division league, were selected in the general preparation season before the start of the games. After filling out the health questionnaire, the participants were randomly divided into two groups: low and high-volume HIIT. None of the subjects had taken sports supplements or any specific medications for a month prior to the start of the study. They were also requested not to take any dietary supplements or drugs throughout the research period. The height and weight of the participants were assessed without shoes and wearing light sports clothes. The characteristics of the participants in both groups are presented in Table 1. The participants were given the necessary training on how to perform the sports tests. In the same session, the aerobic and anaerobic power and the lactate response of the participants were also measured. It should to be noted that subjects who were absent for more than two consecutive exercise sessions were excluded from the study.

Table 1: general characteristics

Groups	Variable	Pre-test	Post-test
		Mean ± SD	**Mean ± SD**
High-volume interval training	Weight (kg)	72.10 ± 2.75	70.56 ± 1.78
Low-volume interval training		69.24 ± 1.37	68.16 ± 0.68
High-volume interval training	BMI (kg/m2)	23.74 ± 1.71	23.01 ± 0.28
Low-volume interval training		23.05 ± 1.52	22.76 ± 0.13
High-volume interval training	Fat percentage	15.25 ± 2.22	13.31 ± 0.34
Low-volume interval training		14.68 ± 3.84	13.74 ± 0.81

Data are expressed as mean±SD.

Determination of body mass index (BMI) and body fat percentage

BMI was calculated based on the formula of body weight in kilograms divided by the square of height in meters. In addition, to determine the body fat percentage, a skinfold caliper was used. In this method, the thickness of the subcutaneous fat of the subjects was measured and each measurement was conducted twice with 15 s intervals at the triceps, supraspinatus, abdomen, and thigh. Then using the Jackson-Pollack four-point formula, the body fat percentage of the participant was calculated.

$$= (0.29288 \times \sum) - (0.0005 \times \sum^2) + (0.15845 \times X) - 5.76377$$

Measurement of aerobic power using the one-mile (1609 m) running test

The submaximal and field test of one-mile running was employed to determine aerobic power. After warming up, the study subjects ran a distance of 1 mile at the fastest possible submaximal speed while their heart rates were measured using a Polar heart rate monitor. After completing the track, the time spent by each subject was recorded. Then the VO_2 max value was estimated in milliliters per kilogram of body weight per minute (mL/kg/min) using the following formula(Arazi, Farzaneh, & Gholamian, 2012).

$VO_2max = 132.853 - (weight \times 0.0769) - (age \times 0.3877) + (sex \times 6.315) - (time \times 3.2649) - (heart\ rate \times 0.1565)$

Measurement of anaerobic power using the RAST test

Subjects were selected after warming up a distance of 35 m with enough space on both sides. The subjects took turns to run a distance of 35 m as fast as possible after hearing the command "go". After running 35 m, each participant rested for 10 s and immediately ran 35 m again at his maximum speed. This step was repeated three times, that is, each subject ran the course six times in total. The obtained time was recorded all six times. The anaerobic power of each subject was determined based on the recorded times and using the following formula. Moreover, the maximum, minimum, and average anaerobic power of the subjects was calculated(Zagatto, Beck, & Gobatto, 2009).

$Power\ (w) = body\ mass\ (kg) \times displacement^2 / time^3$

The training sessions had three phases: warm-up, the main training phase, and cool-down. Warming up and cooling down included slow running and stretching movements for 5 min. In the training phase, the participants ran for 15 s with their full power in the gym and had an active rest for 15 s between each repetition. In the first week, each participant performed eight repetitions including 15 s of training and 15 s of active rest between repetitions. The number of repetitions was increased by two each week.

The participants who were in the low-volume training group had three training sessions per week, whereas the number of training sessions for the high-volume training group was six sessions per week.

In order to evaluate lactate changes before and after the 8-week training period and after the RAST test, lactate levels were measured in the subjects using a lactate kit.

Statistical analysis

Statistical analysis of the data was performed using SPSS software version 23. Data normal distribution was confirmed by Shapiro-wilk test. Repeated measure ANOVA test was employed to compare intra-group changes and inter-group values. The data are reported as mean ± standard deviation (SD), and the significance level was considered $p \leq 0.05$.

RESULTS

The results of statistical analysis revealed that lactate levels were not different between the two groups before and after eight weeks of interval training (F=1.34, p=0.7). Intra-group changes showed that the levels of lactate after RAST activity decreased by 10% (p = 0.001) in response to low-volume interval training and by 12% (p = 0.001) in response to high-volume interval training (Table 2).

On the other hand, there was no significant difference between the two groups in terms of maximum (F=0.2, p=0.9), minimum (F=2.45, p=0.34), and average anaerobic power (F=6.8, p=0.4) before the training. In addition, these parameters were not different between the two groups after the training. It should be noted that the minimum, maximum, and average power in response to both types of training increased significantly by an equal amount compared to before the start of interval training (Table 2).

Table 2: Lactate and anaerobic power in experimental groups.

Groups	Variable	Pre-test	Post-test
		Mean ± SD	Mean ± SD
High-volume interval training	lactate	7.15±1.52	6.29±1.1*
Low-volume interval training		7.51±1.05	6.75±1*
High-volume interval training		310.31±18.06	345.16±23.75*

Low-volume interval training	Mean Anaerobic power (W)	305.16±19.48	339.52±21.55*
High-volume interval training	Maximum anaerobic power (W)	395.14±12.37	458.34±18.34*
Low-volume interval training		410.27±15.71	442.21±21.25*
High-volume interval training	Minimum Anaerobic power (W)	265.41±9.21	301.45±12.32*
Low-volume interval training		248.04±15.12	296.15±21.62*

* Significant difference vs. pre-test. Data are expressed as mean±SD.

Furthermore, the results demonstrated that aerobic power before and after the training were not significantly different between the two groups. However, it was found that high-volume and low-volume training enhanced aerobic power by 11.5% and 11.3%, respectively (Table 3).

Table 3: Aerobic power in experimental groups.

Groups	**Variable**	**Pre-test**	**Post-test**
		Mean ± SD	**Mean ± SD**
High-volume interval training	Aerobic power	52.23 ± 3.24	58.42 ± 2.2*
Low-volume interval training		53.12 ± 5.24	59.27± 3.22*

* Significant difference vs. pre-test. Data are expressed as mean±SD.

DISCUSSION

Increasing aerobic and anaerobic power before the start of the soccer league is one of the most important goals of coaches and athletes. New games at the professional level appear to be more stressful than what is reported in the existing scientific literature. Therefore, a more scientific approach to training is required. High-intensity interval training is now recognized as an effective strategy for improving aerobic and anaerobic power (Ito, 2019). While less well studied, low-volume HIIT can also stimulate physiological remodeling comparable to moderate-intensity continuous training despite a substantially lower time commitment and reduced total exercise volume (Wisløff et al., 2007). However, the effect of training volume in this type of training is still unknown. Thus, in this study, we compared the effects of low-volume and high-volume high-intensity interval training on the anaerobic power, lactate levels, and aerobic power of young professional soccer players.

In summary, the results of this research indicated that both high-volume and low-volume interval training improve aerobic and anaerobic power in young soccer players to the same extent. To our knowledge, one study has compared the effects of high-intensity interval training with two different volumes on the performance capacities of athletes. Daniel et al. (2019) investigated the short-term (three weeks, nine sessions) effects of low- and very-low-volume HIIT on perceived exertion, affective response, and fitness outcomes in active men with no previous experience in HIIT (da Silva Machado et al., 2019). They reported that the very-low-volume HIIT enhanced anaerobic capacity and was perceived as less strenuous and more pleasurable than low-volume HIIT (da Silva Machado et al., 2019). The majority of the studies that evaluated the effect of interval training were conducted for eight weeks and mainly reported the improvement of aerobic and anaerobic indicators (Foster et al., 2015; Sporis, Ruzic, & Leko, 2008). On the other hand, Katrina et al. (2021) reported an improvement in functional capacity in response to four weeks of interval training (Minnebeck et al., 2021). Arazi et al. (2017) showed that two different types of interval training (heart rate-based and speed-based HIIT) for eight weeks increased aerobic and anaerobic capacity in female soccer players (Arazi et al., 2017). New findings have revealed that intermittent exercises with short rest periods reduce the intracellular buffering capacity, while intermittent exercises with long rest periods result in an increase in the intracellular buffering capacity (Edge, Bishop, & Goodman, 2006). In line with the present study, five weeks of intense training on a bicycle decreased muscle lactate and subsequently reduced the accumulation of hydrogen ions (Bishop, Edge, Thomas, & Mercier, 2008). These findings are mostly related to the reduction of lactate production or the increase of lactate uptake by tissues such as the heart and liver (Phypers & Pierce, 2006). Additionally, it has been indicated that glycogenolysis decreases after endurance exercise, and this decline in anaerobic glycogenolysis leads to a reduction in lactate levels (Bishop et al., 2008). Moreover, the study by Qare Daghi et al. (2013) revealed that lactate levels decreased by 20% after residual activity at the end of aerobic exercise following four weeks of interval training (Gharahdaghi, Kordi, & Gaeini, 2013). The possible mechanism for this reduction can be that under conditions of maximal aerobic power, lactate accumulation in type I muscle fibers are less than in type II fibers. It seems that training increases glycogen utilization during activities with maximal oxygen consumption, such as interval training, and the key factor in this adaptation might be the pyruvate dehydrogenase enzyme, which modulates carbohydrate metabolism by regulating the entry of pyruvate-derived acetyl into the carboxylic acid cycle (Rodas, Ventura, Cadefau, Cussó, & Parra, 2000). This leads to the increase of acetyl coenzyme A input to the Krebs cycle and the decrease of lactate production. However, further research must be conducted in this field in the future.

The increase in anaerobic power as a result of intermittent training with high and low volume can be due to the rise in structural alterations in muscles and nerve changes, such as an increase in nerve conduction, an increase in the call of motor units, an increase in synchrony of motor units, and a decrease in nerve inhibition (Timmons et al., 2010). Abe et al. (2015) showed that interval training for six weeks (five sessions per week) boosts the glycolytic capacity of gastrocnemius muscles by promoting HIF-1 gene expression (Abe et al., 2015). They found that HIF-1 enhances the gene expression of glycolytic and glycogenolysis enzymes (Abe et al., 2015). Nonetheless, there are few studies related to the impact of high- and low-volume interval training on anaerobic power, and the mechanism underlying the rise in anaerobic power due to these exercises is not well understood.

CONCLUSIONS

In summary, high intense interval training has a significant impact on improving aerobic performance, anaerobic markers, and lactate response in young soccer players, and there is no superiority between high- and low-volume high intensity interval training.

Conflict of interest

The authors declared no conflict of interests.

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