Original Article

The influence of 8 weeks of endurance training on blood lactate threshold for male handball players

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ABSTRACT

The blood lactate transfusion activity is characterized by triphasic nature. The required counterbalance between glycolysis and metabolism determines the flow of lactate into the muscles. Exercise (>80% of VO_{2max}) has been observed to elevate the level of glycolysis and the gradual accretion of lactate to steadily higher levels, which consequently leads directly to fatigue. The purpose of this study was to investigate the influence of endurance training on the accumulation of lactate and whether it depends on the intensity of training or not. This study involved Sixteen participants, with mean age; 19.18 ± 1.0 years. Participants were asked to run at four various paces (9 km/h, 10.8 km/h, 12.6 km/h, and 14.4 km/h) for 60 minutes. After each exercise, blood lactate is immediately measured using Accusport and Polar devices. Statistically significant differences were seen in heart rate (HR), blood lactate (BL) and maximum lactate steady state (MLSS) after training (72.64 vs. 61.88), (158.22 vs 133.19), and (13.02 vs 8.41) > .01 respectively. Our results suggest that endurance training for 8 weeks can improve lactate threshold and blood lactate accumulation.
Keywords: Sport medicine; Lactate threshold (LT); Maximum lactate steady state (MLSS); Endurance training; Blood lactate (BL).

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INTRODUCTION

Handball is one of the fastest and most endurance sports nowadays; it is characterized by peculiar manoeuvres such as attempting fast breaks despite fatigue, posing against hard defence players, and jumping under pressure (Wagner et al., 2014). Competitive handball is considered an intermittent intensive body contact team sport, requiring anaerobic as well as aerobic fitness in order to accomplish successive well-coordinated movements. Based on the handball players' running profile in a regular game, we can notice the movement patterns and sum of distances of the following activities: standing still (0 km/h) and walking (4 km/h), jogging (8 km/h), running (13 km/h), fast-running (17 km/h), sprinting (24 km/h), sideways movement (10 km/h) and backward running (10 km/h) (Chelly et al., 2011).

During exercises of increased intensity, blood lactate concentration tends to increase rapidly in plasma up to 20 mM/ L. The increase in extracellular lactate may seem to have no influence on force production. It has been noticed that the rapid accumulation of blood lactate due to high-intensity exercises may lead to muscle fatigue and may negatively affect performance subsequently (Cairns et al., 2005; Goodwin et al., 2007).

Many researchers have demonstrated that running with no accumulation of lactate during performance endurance is more significant compared to maximum oxygen consumption (VO_{2max}) (Ghosh 2004). Lactate threshold perception was initially proposed to identify the absence of a linear relationship between ventilation and oxygen uptake (VO_2), which coincides with the accumulated lactate. Recently, this perception has been redefined to refer to oxygen uptake or work rate below the point when the lactate starts to grow consistently from resting to exercise value throughout the incremental training test (Xu et al., 1999). Various blood lactate indices were presented to determine the ability to run with no accumulation of lactate, such as the maximum lactate steady state (MLSS)(Jakobsson et al., 2019).

Muscular fatigue is considered a physiological problem occurring in sports training and is not only multi-faces or complex, but its incidence also differs according to the degree, type, intensity, as well as interval of the performed muscular work. The muscular fatigue experienced by players in handball games leads to the reduction of productive quality at each match (the last 10 min), and the incapacity of players to maintain their performance during the match as well as their inability to finish at a good level either technically or functionally; not to mention their inability to fulfil all tactical requirements during offense and defence (Wan et al., 2017).

Despite the ambiguity of the cause-effect relation between lactate as well as fatigue, it has been noticed that lactate accumulation might indirectly contribute to a decline in performance since the change of lactic acid to lactate secretes H+, in turn leading to metabolic acidosis, contractility of skeletal muscles, and inhibited glycolytic rate-limiting enzymes (Cairns et al., 2006).

MATERIAL AND METHODS

Participants

The current study include Sixteen participants volunteered for the study (age; 19.18 ± 1.0 y, body mass; 77.09 ± 4.0 kg, height; 181.5 ± 4.2 cm. All participants had received moderate training before and the participant completed a familiarization session before any testing. Participants were excluded if they would suffer from metabolic disease or renal, pulmonary, or cardiovascular problems. Before the initiation of any testing or training session, it was required to obtain the oral and written signed consent of participants. The study was approved by the Institutional Review Board.

Table 1. Descriptive statistics of the participant age, height and body fat.

Age (year)	Height (cm)	Body mass (kg)
19.18 ± 1.0	181.5 ± 4.2	77.09 ± 4.0

Note. Values are mean (SD). HR, heart rate.

The procedures of laboratory testing

Participants are invited to the Physiology Laboratory located in the Faculty of Physical Education, Mansoura University. The first test consists of 60 min running on a treadmill to continually determine the MLSS at different paces (9 km/h, 10.8 km/h, 12.6 km/h, and 14.4 km/h). Heart rate (HR) is measured after the last 5 minutes of each run. During a break for 3 min, a blood sample was withdrawn from the fingertip and analysis was done by an Accusport device to measure blood lactate.

Training program

The training consists of a treadmill running for 60 minutes at the MLSS level a day continuously for 8 weeks (three times per week). Training sessions are carried out under supervision, and the alarm is activated to prevent any changes in the cadence of intensity. The treadmill test results carried out midway during the training quantification interval are decided by three intensity zones.

Table 2. The training intensity zone distribution for the sessions.

Weeks	Training Zone	Exercise	Time	Training Number	Intensity	Heart Rate	Work:Rest
1	A1 - A2	Ergometer treadmill	**8 min ***10 min	1	75%*	120:130	1:1
				2			
				3			
2		Ergometer treadmill	**10 min ***12 min	4	90%*	140:155	
				5			
				6			
3	E1 - E2	Ergometer treadmill	**12 min ***14 min	7	95%*	155:165	1:2
				8			
				9			
4		Ergometer treadmill	**14 min ***16 min	10	97%*	165:170	
				11			
				12			
5		Ergometer treadmill	**14 min ***16 min	13	100%*	170:175	
				14			
				15			
6		Ergometer treadmill	**16 min ***18 min	16	102%*	175:180	
				17			
				18			
7	An1 - An2	Ergometer treadmill	**18 min ***20 min	19	105%*	180:189	1:2
				20			
				21			
8		Ergometer treadmill	**20 min ***22 min	22	112%*	189:200	
				23			
				24			

*Note. *100% from Heart Rate Deflection Point (HRDP). **Twice time a week. ***Three time a week.*

The first interval (A1-A2), which lasts for two weeks, aims to improve aerobic capacity, so the intensity is set in the light of the anaerobic threshold, whereas the second interval (E1-E2), lasting for four weeks, aims to proceed with aerobic adjustments (endurance and capacity) as well as to enhance anaerobic capacity. The aim of the third interval (An1-An2), which lasts for two weeks, is to determine the training test rate (Peter 2001).

Statistical analysis

The SPSS software 15 is utilized to perform the statistical analysis. Data are illustrated as means ± standard deviation. Non- parametric tests corresponding to sample size and variables distribution are used. Using Friedman ANOVA, each intensity's average values are compared for the same participants (using repeated measures). Then, Wilcoxon test comparisons are carried out. The significance level is determined at (.01).

RESULTS

The descriptive statistics of participants are illustrated in Table 1. The average height is 181.5 ± 4.2 cm, the average age is 19.18 ± 1.0 years, and whereas average body mass is 77.09 ± 4.0 kg. Figure 1 illustrates the data of heart rate, blood lactate, and MLSS group means for performance endurance. Statistically significant differences were seen in heart rate (HR), blood lactate (BL) and maximum lactate steady state (MLSS) after training (72.64 vs. 61.88), (158.22 vs 133.19), and (13.02 vs 8.41) < .01 respectively.

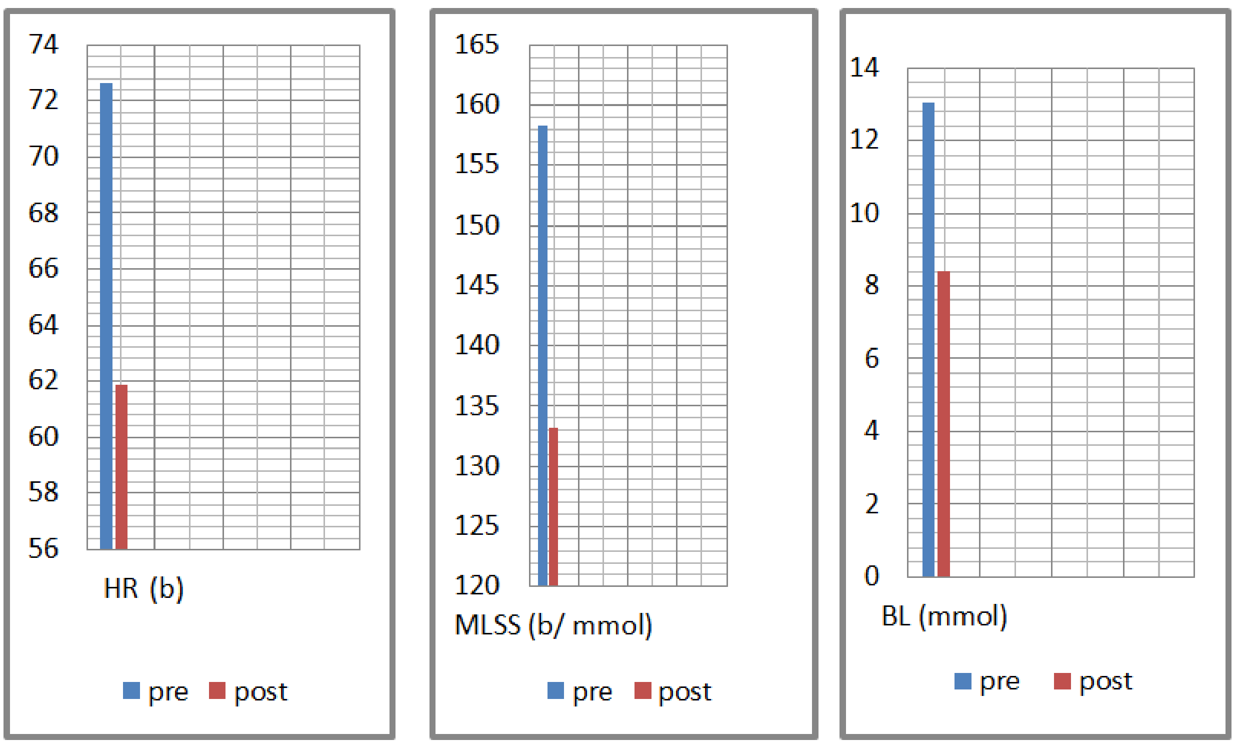

Figure 1. Group means for Heart Rate (HR), Blood Lactate (BL), and MLSS.

Correlation analysis revealed a significant relationship between performance endurance and subjects' blood lactate values (r = 0.95; *p* < .01), performance endurance and subjects' heart rate values (r = 0.89; *p* < .01), as well as performance endurance and subjects' maximal lactate steady-state values (r = 0.98; *p* < .01).

DISCUSSION

The present study demonstrates that the response of lactate threshold in handball players increases significantly during training periods. A positive correlation is detected between the alternation in the capacity of running as well as the alternation in the speed of running at the lactate threshold, which indicates that better performance can be achieved with this parameter. A difference in training response is detected after moderate and highly intensive training. Nonetheless, high-intensity training only improves the speed of running at the lactate threshold as well as endurance performance. The findings here correspond to those of (Peter 2001; Stöggl et al., 2017) in terms of the improvements in physiological variables caused by high-intensity training, which contributes to reducing and eliminating lactate in the blood. What really happens is that the vital organs of the body equalize blood lactate within the blood in order to maintain the stability of PH level as well as control the concentrations of hydroxyl and hydrogen ions in the blood. It is noteworthy that the anaerobic action of lactate is due to the increased functional efficiency of the body, and then lactate is converted into protein or oxidized and turns into urine and sweat, which leads to maintaining the performance level as long as possible and delaying tiredness as possible (Faria et al., 2005; Dienel 2012).

A statistically significant difference ($p < .01$) was detected, and it was shown that the reduction of blood lactate might be due to increased utilization of muscle or decreased production. Thus, the improvement of lactate utilization can decrease the maximum lactate resulting from continuous training. In other words, the reduction of lactate accumulation due to high-intensity exercises- namely, the higher lactate threshold- is due to the decrease in lactate production at certain intensity (Brooks et al., 1996). Improved O_2 supply, as well as reduced need for the production of anaerobic ATP, must be considered. As a result, it has been suggested that the more endurance training is performed, the less lactate accumulates (Bonen et al., 2000; Joyner et al., 2008).

Caution must be maintained when interpreting blood lactate data; the appearance and disappearance of lactate are responsible for lactate concentration. For instance, an adequate rate of lactate disappearance may help players who have decreased concentration of blood lactate to work at a comparable or elevated intensity in those who have high blood lactate concentration, which is evidenced in the study conducted by (Delamarche et al., 1987). This study has recruited two players; nevertheless, one of them had a lower concentration of blood lactate (4.0 mmol) and a lower heart rate (188 beats), whereas the other player had a higher blood lactate concentration (6.4 mmol), in addition to a higher heart rate (195 beats). It has been found that players can use anaerobic and aerobic metabolism in a different way when playing at similar intensity. The difference may result from various fitness standards, genetic differences, and other factors (Delamarche et al., 1987).

Further studies should examine the performance of handball under various fatigue conditions. Players in handball matches should display the best performance in different fatigue conditions. It is known that high fatigue may inhibit sports performance, such as rapid movements, endurance, as well as strength (Michalsik et al., 2021). Consequently, handball studies should apply various test protocols that assess physical abilities under fatigue conditions. Handball and conditioning coaches should be directed to adopt an appropriate approach to select test protocols and devices. Coaches have to consider the physiological conditions of players and their objectives as well. In order to achieve that, they must rely on tests that provide the most useful information (Wagner et al., 2019).

The above-cited studies indicate that several factors determine blood lactate removals, such as local blood flow and muscle capillary content, whole-body muscle mass, arterial lactate availability, and gluconeogenesis capacity, and these factors are enhanced significantly by endurance training (Brooks 1991). Moreover, blood lactate turnover was seven times more elevated than the outcomes recorded by Bangsbo et al., (1995). It was also found that higher lactate accumulation does not depend on the type of effort but on the increase in NAD/NADH that results from reduced rates of oxidative phosphorylation due to inadequate levels of O_2 that lead to poor transport of lactate to muscles which are less active for oxidation. Consequently, this leads to increased concentration of blood lactate as well as fatigue. This explains the lower concentration of blood lactate detected in our results (Hargreaves et al., 2020).

CONCLUSIONS

It has been demonstrated that endurance training could lead to effective physiological responses and decrease in accumulation of lactate. The following variables should be kept in mind to reconcile with endurance training programs: the number of exercises, length of specific exercises, repetitions per set, sets per session, sessions per week, and the relative stress and difficulty of exercises. The increase in NAD/NADH due to the diminished oxidative phosphorylation rate from insufficient O_2 level may lead to higher accumulation, which in turn leads to inefficient lactate transport to less active muscle cells for oxidation, lactate concentration in blood increases, as well as fatigue.

AUTHOR CONTRIBUTIONS

Ramadan, W., contributed to conceptualization, formal analysis, methodology, supervision, validation, visualization, writing-review & editing. Mustafa, R. contributed to investigation, data extraction, data analysis and manuscript writing, results discussion. Ramadan, W., and Mustafa, R. contributed to supervision, writing-original draft, writing-review & editing. All authors read and approved the final manuscript.

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DISCLOSURE STATEMENT

No potential conflict of interest were reported by the authors.

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