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Effect of six months resistance training on lactate threshold in distance runners

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ABSTRACT

The lactate threshold (LT) is the highest level of effort an athlete can sustain for an extended period without causing a substantial increase in blood lactate levels. During prolonged-distance running, muscles increase their utilization of lactate, which contributes to the removal of lactate from the bloodstream. This study aimed to investigate the effect of six months of resistance training based on lactate threshold in distance runners. It involved 100 subjects (57 male and 43 female), randomized into experimental (age 24.72±3.26) and control group (age 24.56±3.07). Pre and post data collected at 0 and at the end of 6 months with warm up and cool down for 10 mins each. Statistically significant differences were seen in experimental group compared with control group in outcomes such as LT stage (3.82 vs 3.18), mean HR (160.02 vs 157.02), time taken to complete 5000m (18:13.8 vs 19:00.1) and running pace (4.5 vs 4.3) ($p<0.005$). The result of the study suggests that the six months of resistance training on lactate threshold improve the distance running performance. It would be helpful for researchers to further investigate how different resistance training protocols and durations influence lactate threshold and endurance performance in diverse athletic populations.

KEYWORDS

Lactate Threshold; LT; Resistance Training; Athlete; Distance Runners

1. INTRODUCTION

Track and field events originated in the late 19th century, typically involving athletes representing rival educational institutions and sports clubs. Competitive sports and athletics at national and international levels sparked significant interest in exercise physiology (Jain, n.d.). Numerous efforts have been made over the past century to understand human physiology by studying champion athletes and record-breaking performances (Joyner & Coyle, 2008). Competitive distance running is a multifaceted discipline that includes endurance, mental resilience, and strategic execution, making it a rich area for research and exploration. Distance running ranges from 5000m to full marathon (42.19km/26.21miles). Resistance training is an exercise aimed at strengthening muscles in the body to achieve increased muscular strength, endurance, and power through resistance from external forces or weights. It may be a resistance band, free weights like dumbbells and barbells, weight machines, or other forms of loads through which body weight could serve as a form of resistance.

Although long-distance running is primarily an endurance-based activity, integrating resistance training into a runner's program leads to physiological and biomechanical improvements that translate to better performance by improved running economy, increased muscular strength, enhanced endurance performance, injury prevention, improved power, stride length and increased fatigue resistance (Kisner et al., 2017).

Anaerobic metabolism arises in the body when glucose breaks into the energy compound without enough oxygen, resulting in lactate synthesis. Lactate is initiated to serve both as a source of energy and a functional indicator of metabolic stress during prolonged high-intensity efforts, such as long-distance running (Svedahl & Macintosh, 2003). Once exercise intensity is great, the lactate production rate will exceed the lactate clearance rate signifying a shift from largely aerobic metabolism towards greater reliance on anaerobic mechanisms. The most common cause of lowered muscle pH (metabolic acidosis) is the increase in hydrogen ion concentration that is associated with accumulation of excess lactate. This given acidotic environment switches off muscle contraction, for instance by blocking the activity of energy-producing systems and reducing muscles' capacity to produce force (Carter et al., 2001). In exhaustive all-out exercise, it is the lactate concentration which exceeds the rate at which effective clearance and elimination occur from the blood, the so-called lactate threshold (LT) (Nikseresht et al., 2017). This is shown by a pH dip from 7.4 to 6.8, which is believed to impair performance and induce weariness. In essence, lactate threshold training (LT) makes the body's physiology more robust in terms of lactate generation and lactic acid clearance

(Nummela et al., 2007). It serves as a reliable gauge of how well the body converts chemical energy into mechanical energy. Blood lactate concentration measurements have been used widely for training control and performance detection. The metabolic processes of LT, VO2 max, and running economy are essential for endurance exercise and performance. Despite growing evidence supporting the role of lactate threshold in endurance performance, limited studies have examined how structured resistance training over an extended duration directly influences LT in competitive distance runners. This gap underscores the need for further investigation to enhance performance optimization strategies. The lactate threshold is regarded by many researchers as the main predictor of endurance performance (Kenney et al., 2022).

Previous studies have examined the relationship between endurance training and lactate threshold; however, limited research has focused on the impact of sustained resistance training, particularly over a six-month period, on LT adaptations in distance runners. Six months allows for sufficient time to observe physiological changes and performance outcomes. Understanding how resistance training influences LT is crucial, as LT is a reliable predictor of endurance performance and training effectiveness.

Furthermore, the LT seems to be the physiological measure that responds to endurance training the best, when compared to VO2 max and economy (McArdle et al., 1996). Lactate is a continuously produced and utilized essential fuel and potential signaling molecule, even under fully aerobic conditions, rather than being a waste product of anaerobic metabolism (Denadai & Greco, 2022). Reduced lactate clearance, increased activation of fast-twitch motor units, and an imbalance between mitochondrial respiration, glycolysis, and ischemia (low blood flow) or hypoxia (low blood oxygen concentration) are important causes of poor performance (Robergs & Roberts, 1997).

This study aims to investigate the effect of six months of resistance training based on lactate threshold in distance runners.

2. METHODS

2.1. Participants

100 subjects volunteered for the study, and they were grouped using simple random sampling from a pool of endurance-trained distance runners. They were randomized into the Experimental (n=50) and control group (n=50). Random assignments were done using the randomizer software to ensure unbiased group allocation. Subject’s physiological data such as age, height (cms), weight (kgs), Body Mass Index (BMI), Resting respiratory rate, and practice hours (Table 1) have been

collected. Baseline measurements were compared between the two groups to confirm there were no significant differences prior to the intervention. Figure 1 illustrates the mean average of male and female. Participants suffered any recent trauma, neurological conditions, pregnancy, comorbidity such as hypertension, diabetes mellitus, cardiac issues and use of any ergogenic aids were excluded. Data collected in and around the sports complex of Navi Mumbai with prior filled consent form.

Table 1. Demographic and physiological characteristics of subjects at baseline

	Group	n	Mean	S.D.	t	*p* value
Age	Experimental	48	24.72	3.264	0.252	.801#
	Control	47	24.56	3.072		
Height (cms)	Experimental	48	172.98	3.335	0.232	.817#
	Control	47	172.78	5.108		
Weight (kgs)	Experimental	48	68.56	3.759	1.596	.114#
	Control	47	67.28	4.248		
BMI	Experimental	48	22.90	1.127	1.501	.136#
	Control	47	22.54	1.261		
Resting RR	Experimental	48	15.24	2.153	0.502	.617#
	Control	47	15.02	2.227		
Practice Hours	Experimental	48	2.28	0.497	2.237	.028*
	Control	47	2.56	0.733		

Note. *#p > 0.05 (non-significant); *p < 0.05 (Significant); **p < 0.01 (Highly Significant)*

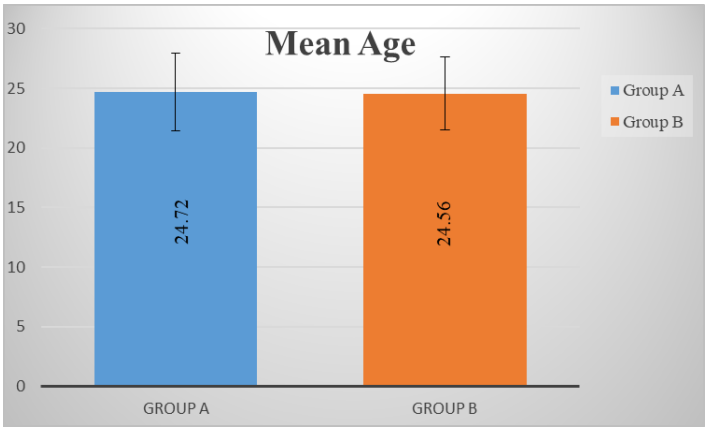

Figure 1. Mean age comparison between groups

2.2. Measurements and Interventions

Randomizer software is used to allot the subjects by 1:1 with SNOSE technique, single blinded. Subjects Lactate Threshold (LT) were measured by making them run on the computerized treadmill (AFTON) based on Bruce Protocol and the blood sample drawn at the end of each stage.

Blood lactate (BL) threshold is considered when the subject BL level shows 4 mmol/L. StatStrip Xpress 2 handheld lactate analyzer (NOVA Biomedical, USA) used to read the blood lactate level with the help of Lancet at fingertip. The heart rate was recorded by Polar H9 to record the mean heart rate. Dietary chart has been maintained as per guidelines by dietician (Hamilton et al., 2006; Sjödin et al., 1982; Tanaka et al., 1986).

Once the LT level been estimated through Bruce Protocol (Table 2) ((Acevedo & Goldfarb, 1989; Purcell, 2013; Academy of Nutrition and Dietetics, n.d.), the experimental group received the training protocol (Table 3), where they made to run at their mean HR of LT ± 5 bpm for 3 months, based on the lactate threshold training principle that exercising near the LT enhances metabolic adaptation and endurance performance (Nummela, Hämäläinen, & Rusko, 2007), and their intensity increased by 5% of mean HR of LT ± 5 till six months. The frequency of one session per week was chosen to prevent overtraining, considering participants' ongoing regular endurance training schedules, and to isolate the specific effects of LT-based resistance training (Table 3). The training intensity increased between 4-6 months by ± 5% of Mean HR with no change in session per week. Training sessions were supervised, and compliance was ensured by recording heart rate data using Polar H9 during each session. The routine training sessions were conducted on the control group, and the data was collected at the end of six months and compared for the significance of the study. Five subjects lost the follow-up in the study due to personal reasons (Figure 2).

Table 2. Estimation of Lactate Threshold (Bruce Protocol) (Acevedo & Goldfarb, 1989; Purcell, 2013; Academy of Nutrition and Dietetics, n.d.)

Stage	Speed (mph/kmph)	Grade (Inclination)	Duration	Interpretation
1	1.7/2.7	10 %	3 min	-60 sec recovery b/w each stage to collect blood sample and to record mean HR -LT stage is where the lactate level is ≥ 72 mg/dl (4 mmol/L)
2	2.5/4.0	12 %	3 min	
3	3.4/5.5	14 %	3 min	
4	4.2/6.8	16 %	3 min	
5	5.0/8.0	18 %	3 min	
6	5.5/8.9	20 %	3 min	
7	6.0/9.7	22 %	3 min	

Table 3. Lactate Threshold Training Protocol (Acevedo & Goldfarb, 1989; Purcell, 2013)

Month	Training Intensity	Frequency
0-3	Mean HR of LT (±5)	1 session/week
4-6	Increase in 5% Mean HR of LT (±5)	1 session/week

Note. *Warm up and cool down included for 10 min each in every exercise session*

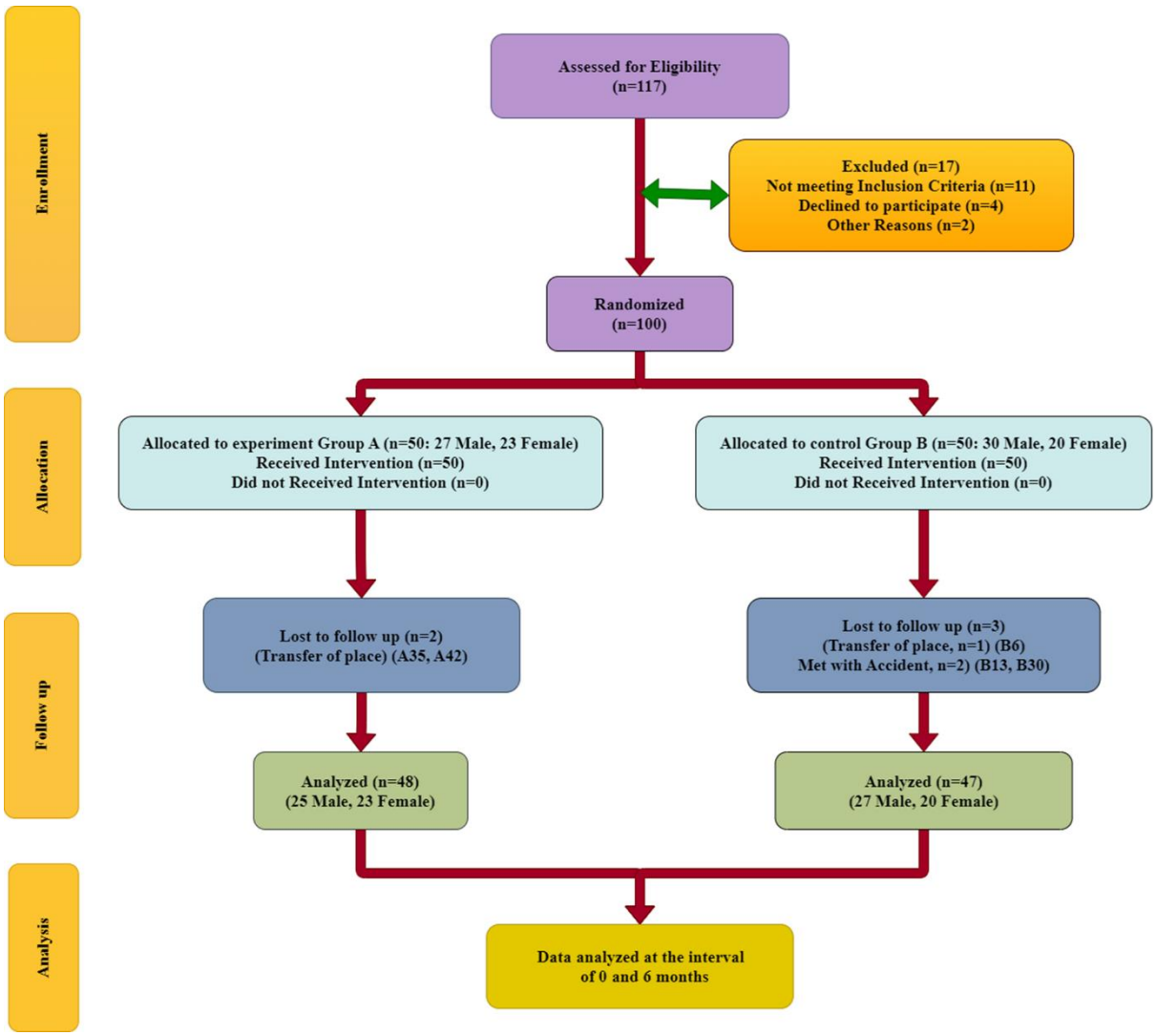

Figure 2. CONSORT Flow Chart

2.3. Statistical Analyses

The SPSS (Version 26) software tool was used for statistical analysis. Means and standard deviations are used to represent the data. To compare groups, the unpaired t test is employed.

3. RESULTS

There were no discernible differences between the groups at the start of the trial, except for practice hours where the control group practiced (2.56 h/day) more than the experimental group (2.28 h/day). Although the mean value shows a difference in practice hours, it was statistically non-significant ($p > 0.05$). This difference was pre-existing and not part of the intervention; both groups continued their regular training routines throughout the study. The added LT-based resistance training was the only structured difference introduced to the experimental group (Table 4).

Table 4. The comparison of parameters at baseline (0 months)

Outcome	Group	N	Mean	SD	t	*p* value
LT Stage/Level (1/2/3/4/5/6/7)	Experimental	48	2.95	0.41	0.47	0.562#
	Control	47	2.91	0.37		
Mean HR	Experimental	48	154.27	3.45	0.92	0.356#
	Control	47	154.63	2.51		
Time Taken to 5000m(in secs)	Experimental	48	1185.67	73.03	0.81	0.412#
	Control	47	1181.91	66.65		
Time Taken to 5000 m (hh:mm:ss.000)	Experimental	48	19:45.6	00:41.2	0.71	0.212#
	Control	47	19:41.9	00:39.6		
Pace (m/s)	Experimental	48	4.2	0.25	0.41	0.314#
	Control	47	4.2	0.23		

At the end of the six-month training session, the experimental group showed significant improvements in all outcomes, including LT stage, mean HR, time taken to complete 5,000 m, and pace. The experimental group could reach the given target of 5000m by 124.39% more reduction in time (1 min 32 secs) than the control group, which improved by only 41 secs (t value 10.79, $p<0.05$). Their running pace also increased by 7.14%, from 4.2 to 4.5 m/s, with a significant 29.49% increase in lactate stage from 2.95 to 3.82 (Table 5).

Table 5. Comparison of parameters at 6 months

Outcome	Group	N	Mean	SD	t	*p* value
LT Stage/Level (1/2/3/4/5/6/7)	Experimental	48	3.82	0.388	10.79	0.000**
	Control	47	3.18	0.388		
Mean HR	Experimental	48	160.02	2.412	10.065	0.000**
	Control	47	157.02	3.292		
Time Taken to 5000m(in secs)	Experimental	48	1093.68	47.654	6.831	0.000**
	Control	47	1140.04	30.724		
Time Taken to 5000 m (hh:mm:ss.000)	Experimental	48	18:13.8	00:47.6	6.822	0.000**
	Control	47	19:00.1	00:30.7		
Pace (m/s)	Experimental	48	4.578	0.2063	6.714	0.000**
	Control	47	4.382	0.1304		

4. DISCUSSION

Resistance training played a significant role in improving lactate threshold (LT) in distance runners, as evidenced by improvements in completion time, pace, mean heart rate, and lactate tolerance. These findings align with and extend previous work that linked LT-based training to improved endurance performance metrics, particularly in trained runners (Ghosh, 2004; Tanaka et al.,

1986). However, this study uniquely demonstrates these benefits over a sustained six-month resistance training period, which has been less explored. The running efficiency of experimental could be improved due to better lactate clearance, enhanced blood flow and mitochondrial density enable faster lactate removal and thus delaying its accumulation. LT training raises the intensity level at which lactate begins to accumulate, allowing runners to sustain higher speeds before fatigue sets in. Improved buffering capacity led to adaptations in the muscles ability to neutralize hydrogen ions, mitigating the effects of acidosis (Ghosh, 2004).

Resistance training at LT exhibited a stronger correlation and the ability to sustain a high fractional utilization of VO_2 max for a longer length of time postpones the onset of metabolic acidosis. distance running performance is superior to maximum aerobic capacity (VO_2 max). Training at LT intensity increases both aerobic and anaerobic capacity through improvement in efficiency of the body's handling of lactate accumulation (Ghosh, 2004). This in turn results in some physiological adaptations, all contributing, among which are increased blood volume, increased capillary density, and greater mitochondrial density, that lead to improved endurance performance. Our observed improvements in lactate clearance and heart rate efficiency are consistent with previous studies showing increased mitochondrial density and oxidative enzyme activity following LT-based training (Holloszy & Coyle, 1984; Costill et al., 1976). Importance is attributed to increased stroke volume in optimizing cardiovascular efficiency and endurance capacity (Morin et al., 2012; Kanstrup & Ekblom, 1984).

Several factors influence low plasma lactate levels during a competition: muscle fiber type, VO_2 max, running economy, and the ability to maintain high VO_2 max levels during races (Kounalakis et al., 2008). VO_2 max utilization strongly correlates with performances across various distances such as 5 km and 10 miles (Costill et al., 1973; Londeree, 1986). Endurance training also allows the muscles to use lactate, where its removal from circulation is improved (Gladden, 2000). After endurance training, there is generally a decrease in lactate production during a given workload because of increased mitochondrial size, number, and enzymatic activity (Holloszy & Coyle, 1984). Collectively, these adaptations increase the energy production from mitochondrial respiration, thereby reducing lactate accumulation at a given intensity of work. Unlike short-term interventions in earlier studies, our six-month protocol allowed for progressive overload, resulting in measurable endurance gains, supporting the theory that longer durations may lead to more robust physiological adaptation. This provides new insights into how resistance training tailored to LT can contribute to long-term endurance improvement.

Running places considerable stress on the cardiovascular and musculoskeletal systems. Endurance athletes are usually characterized by an efficient oxygen transport system, increased heart volumes, and higher capillary densities (Keul et al., 1982). These structural adaptations are thought to enhance cardiac pumping efficiency, leading to a greater stroke volume and cardiac output—factors determining maximal oxygen uptake (Blomqvist & Saltin, 1983). Several mechanisms have been proposed for the increase in lactate threshold (LT) associated with endurance training, such as an increase in blood flow to the trained muscles, enhanced oxidative capacity of muscle cells, and changes in muscle fiber recruitment patterns that preferentially activate red and oxidative muscle fibers.

In this study, we measured blood lactate levels throughout extended running sessions and discovered that the pace rose with time. In light of the results presented, Tanaka et al. discovered that lactate readings allowed them to determine running speed at the onset of lactate accumulation, allowing them to predict running performance beforehand. That is, lactate readings can determine an individual's performance, regardless of whether he is a swimmer or a runner (Tanaka et al., 1986). The long-distance runners' gastrocnemius muscle had a larger percentage of type I muscle fibers (79%) following resistance exercise training. Furthermore, the long-distance group had a considerably larger ($p < 0.05$) oxidative potential as determined by the activity of the mitochondrial enzyme succinate dehydrogenase (Costill et al., 1976). The capillary density in muscle tissue also showed a favorable correlation with this. Running can be made quicker, more efficient, and injury-free by improving running economy, stride mechanics, ground contact time, ground reaction force (GRF), and fatigue resistance (Brooks, 2009).

High running economy is physiologically necessary for distance running performance; in terms of biomechanics, this high economy results from the execution of optimal mechanical patterns that prevent inefficient movements while applying forces in the proper amount, direction, and timing. Veteran athletes have lower blood lactate concentrations, which can be explained by a lower proportion of type II muscle fibers, decreased lactate dehydrogenase activity, and increased oxidative enzyme activity. These factors help to clear lactate by reducing lactate production and carbohydrate utilization (Coggan et al., 1990).

Training just above the anaerobic threshold is known to increase aerobic capacity and anaerobic threshold levels (Ghosh, 2004). Improvements in submaximal endurance performance occur mostly by increasing muscle oxidative capacity (Dantas & Doria, 2015). Changes in oxidative enzyme activity, rather than changes in maximal oxygen uptake, appear to influence running

performance by endurance athletes and are implicated in substrate utilization during submaximal exercise (Jansson & Kaijser, 1987; Moore et al., 1987). Previous research pointed to a strong relationship between increases in blood or plasma lactate and performance in distance running. Additionally, it has been shown that endurance training lowers blood lactate levels at a given absolute or relative exercise intensity, which may indicate an increased reliance on fat metabolism and/or an improved aerobic breakdown of energy substrates (Holloszy & Booth, 1976).

5. CONCLUSIONS

This study demonstrated that six months of resistance training at the Lactate Threshold (LT) led to significant improvements in distance runners' performance, specifically in time taken, pacing, mean heart rate, and lactate tolerance. Further, it underscores the importance of tailoring resistance training to an athlete's needs, in order to include not only physiological but also psychological factors in an effort to gain the maximum gains in performance. Future research should explore individualized resistance training protocols across various sports levels and examine their long-term effects on both physiological and psychological performance markers.

6. REFERENCES

1. Academy of Nutrition and Dietetics. (n.d.). *Sports nutrition for Indians*. Indian Nutrition and Dietetics.
2. Acevedo, E. O., & Goldfarb, A. H. (1989). Increased training intensity effects on plasma lactate, ventilatory threshold, and endurance. *Medicine and Science in Sports and Exercise, 21*(5), 563–568.
3. Blomqvist, C. G., & Saltin, B. (1983). Adaptations to physical training. *Annual Review of Physiology*, *45*, 169–189.
4. Brooks, G. A. (2009). Cell–cell and intracellular lactate shuttles. *The Journal of Physiology*, *587*(23), 5591–5600.
5. Carter, S. L., Jansson, E., & Kaijser, L. (2001). Changes in skeletal muscle in males and females following endurance training. *Canadian Journal of Physiology and Pharmacology, 79*(5), 386–392.
6. Coggan, A. R., Spina, R. J., Rogers, M. A., King, D. S., Brown, M., Nemeth, P. M., & Holloszy, J. O. (1990). Histochemical and enzymatic characteristics of skeletal muscle in master athletes. *Journal of Applied Physiology, 68*(5), 1896–1901.
7. Costill, D. L., Fink, W. J., & Pollock, M. L. (1976). Muscle fiber composition and enzyme activities of elite distance runners. *Medicine & Science in Sports & Exercise, 8*(2), 96–100.
8. Costill, D. L., Thomason, H., & Roberts, E. (1973). Fractional utilization of the aerobic capacity during distance running. *Medicine and Science in Sports*, *5*(4), 248–252.
9. Dantas, J. L., & Doria, C. (2015). Detection of the lactate threshold in runners: What is the ideal speed to start an incremental test? *Journal of Human Kinetics, 45*, 217–224. https://doi.org/10.1515/hukin-2015-0022

10. Denadai, B. S., & Greco, C. C. (2022). Could middle- and long-distance running performance of well-trained athletes be best predicted by the same aerobic parameters? *Current Research in Physiology, 5*, 265–269. https://doi.org/10.1016/j.crphys.2022.05.003
11. Ghosh, A. K. (2004). Anaerobic threshold: Its concept and role in endurance sport. *Malaysian Journal of Medical Sciences, 11*(1), 24–36.
12. Gladden, L. B. (2000). Muscle as a consumer of lactate. *Medicine and Science in Sports and Exercise, 32*(4), 764–771.
13. Hamilton, R. J., Paton, C. D., & Hopkins, W. G. (2006). Effect of high-intensity resistance training on performance of competitive distance runners. *International Journal of Sports Physiology and Performance, 1*(1), 40–49.
14. Holloszy, J. O., & Booth, F. W. (1976). Biochemical adaptations to endurance exercise in muscle. *Annual Review of Physiology, 38*, 273–291.
15. Holloszy, J. O., & Coyle, E. F. (1984). Adaptations of skeletal muscle to endurance exercise and their metabolic consequences. *Journal of Applied Physiology, 56*(4), 831–838.
16. Jain, A. K. (n.d.). *Human physiology and biochemistry for physiotherapy* (3rd ed., p. 467).
17. Jansson, E., & Kaijser, L. (1987). Substrate utilization and enzymes in skeletal muscle of extremely endurance-trained men. *Journal of Applied Physiology, 62*(3), 999–1005.
18. Joyner, M. J., & Coyle, E. F. (2008). Endurance exercise performance: The physiology of champions. *Journal of Physiology, 586*(1), 35–44.
19. Kanstrup, I. L., & Ekblom, B. (1984). Blood volume and hemoglobin concentration as determinants of maximal aerobic power. *Medicine and Science in Sports and Exercise, 16*(3), 256–262.
20. Kenney, W. L., Wilmore, J. H., & Costill, D. L. (2022). *Physiology of sport and exercise* (7th ed.). Human Kinetics.
21. Keul, J., Dickhuth, H. H., Lehmann, M., & Staiger, J. (1982). The athlete's heart—Haemodynamics and structure. *International Journal of Sports Medicine, 3*(S1), S33–S43.
22. Kisner, C., Colby, L. A., & Borstad, J. (2017). *Therapeutic exercise: Foundations and techniques* (7th ed.). F.A. Davis.
23. Kounalakis, S. N., Nassis, G. P., Koskolou, M. D., & Geladas, N. D. (2008). The role of active muscle mass on exercise-induced cardiovascular drift. *Journal of Sports Science & Medicine, 7*(3), 395–401.
24. Londeree, B. R. (1986). The use of laboratory test results with long-distance runners. *Sports Medicine, 3*, 201–213.
25. McArdle, W. D., Katch, F. I., & Katch, V. L. (1996). Skeletal muscle: Structure and function. In *Exercise physiology* (pp. 314–316). Williams & Wilkins.
26. Moore, R. L., Thacker, E. M., Kelley, G. A., Musch, T. I., Sinoway, L. I., Foster, V. L., & Dickinson, A. L. (1987). Effect of training/detraining on submaximal exercise responses in humans. *Journal of Applied Physiology, 63*(5), 1719–1724.
27. Morin, J. B., Bourdin, M., Edouard, P., Peyrot, N., Samozino, P., & Lacour, J. R. (2012). Mechanical determinants of 100-m sprint running performance. *European Journal of Applied Physiology, 112*, 3921–3930.
28. Nikseresht, A., Yabande, I., Rahmanian, K., & Jahromi, A. S. (2017). Blood lactate level in elite boy swimmers after lactate tolerance exercise test. *Biomedical Research and Therapy, 4*(5), 1318–1326.

29. Nummela, A., Hämäläinen, I., & Rusko, H. (2007). Comparison of maximal anaerobic running tests on a treadmill and track. *Journal of Sports Sciences, 25*(1), 87–96.
30. Purcell, L. K. (2013). Sport nutrition for young athletes. *Paediatrics & Child Health, 18*(4), 200–205.
31. Robergs, R. A., & Roberts, S. O. (1997). *Exercise physiology: Exercise, performance and clinical applications*. Mosby-Year Book.
32. Sjödin, B., Jacobs, I., & Svedenhag, J. (1982). Changes in onset of blood lactate accumulation (OBLA) and muscle enzymes after training at OBLA. *European Journal of Applied Physiology and Occupational Physiology, 49*(1), 45–57.
33. Svedahl, K., & Macintosh, B. R. (2003). Anaerobic threshold: The concept and methods of measurement. *Canadian Journal of Applied Physiology, 28*(2), 299–323.
34. Tanaka, K., et al. (1986). Longitudinal associations between anaerobic threshold and distance running performance. *European Journal of Applied Physiology and Occupational Physiology, 55*(3), 248–252.
35. Tanaka, K., Watanabe, H., Konishi, Y., Mitsuzono, R., Sumida, S., Tanaka, S., Fukuda, T., & Nakadomo, F. (1986). Longitudinal associations between anaerobic threshold and distance running performance. *European Journal of Applied Physiology and Occupational Physiology, 55*(3), 248–252.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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