*Section A-Research paper*

# Lactate Training (LT) Protocol to Enhance Distance Running – Review Paper

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## Abstract

Lactate threshold (LT) can be defined as the situation during exercise when the rate of formation of lactate that settle than the removal from muscle. It is anvaliant indicator for determining maximal exercise capacity and is used to measure and monitor endurance training. The physiology of LT is complex and involves changes in the muscle metabolism, cardiovascular and endocrine systems, and is a result of the increasing intensity of exercise. At rest, the muscle fibres use primarily fats as their energy source, but as exercise intensity increases, there is a progressive shift towards carbohydrate metabolism.

Track and field events are oldest competitive sports way back since the ancient Olympic games in Greece 776 BC. Indian athletics came into light in the decades between 1940 – 1950 and Indian track performance are still dormant at Olympic level. Track events are categorized asshort distance/sprints (100, 200 and 400 m), middle distance (800, 1500 and 3000 m) and long distance (5000 and 10000 m). Distance covered beyond long distance are half (21.09 kms) and full marathon (42.19 kms).

Importance oflactate threshold is that it can be used to predict and monitor endurance performance, and to inform training strategies. It can also be used to identify an individual's optimal exercise intensity for a given workload and to monitor an individual's progress in training. Understanding the physiology of the lactate threshold is important for athletes, coaches, and researchers alike as it provides insight into the metabolic and physiological changes that occur during exercise and can be used to optimize training and performance.

Many studies were done to study different Lactate Threshold (LT) to assess and improve the long-distance running performance. After giving close attention towards different methods, it had been found that a seven-stage run on treadmill with 3 min as an effective with minimally available materials.

Key Words: Lactate Threshold, Distance Running, Lactate Training Protocol

## History

The biochemistry of muscular contraction and energy consumption has been extensively researched by a number of scientists. Measurement of maximal oxygen utilization was the main metric used to gauge aerobic endurance in the start of the 20th century. A V Hill 1923) [1], however several concerns were raised regarding the effectiveness $VO_2$ maxas tool. Even

though two subjects having similar VO2 max they differ in their field performance. After some years a method came to identify the capacity by drawing ventilation against oxygen intake in heart patients called the term "Lactate Threshold" (LT). Continuous gaseous flow calculations were increasingly widespread, in hospital settings, and testing of blood lactate concentrations (bLa) was connected with a number of challenges. As a result, metabolic analysis for the detection of Lactate Threshold gained popularity (Wasserman, K. 1964) [2].

The enzymatic technique from capillary blood samples to find lactate level was created in the 1960s. This raised the interest to use blood lactate as a parameter to evaluate endurance performance (Wells 1957 & Hollmann 2001) [3].It has been suggested that rather than exhibiting a distinct threshold during progressive exercise, bLa grow continually. Moreover, the flow of aerobic and anaerobic metabolism for energy generation demonstrates a continual transition rather than a rapid change, so the term "threshold" may be deceptive (Myers 1997) [4].

**Physiology**

Billat et al (1996) studied the metabolism of carbohydrates and non-essential amino acids depends heavily on lactate as one of the key intermediates. Because of the complex nature of cellular relationships and metabolism, lactate may be regarded as a by-product by one cell but as a valuable substrate for another.[5]

The balance between lactate synthesis and absorption into tissues is reflected in blood lactate levels. Anaerobic glycolysis converts pyruvate into lactate, which is then broken down by lactate dehydrogenase (LDH) and converted to pyruvate, which is then broken down further in the mitochondria to produce carbon dioxide and water.Cohen and Woods distinguished between types A and B of lactic acidosis based on the underlying cause, which is the existence or lack of tissue hypoxia (Cohen, R 1976) [6].

**Lactate Threshold Protocol**

Several blood lactate indicators, including as the Lactate Threshold (LT), the MLSS, or the beginning of lactate accumulation in blood stream, was proposed to quantify the capacity to exercise without collection oflactate (OBLA) (Santos-Concejero et al. 2013) [7]. Numerous studies are conducted to analyse the athletes and record holders for about a century.Three main deciders play an important role in endurance performance such as $VO_2$ max, Lactate Threshold and Running Economy (Joyner 2008) [8].

A previously well-trained runner's performance increase is not likely to be due to changes in running economy. Moreover, it has been proposed that improvements in pacing or physiological adaptations not included in the $VO_2$ maxtest may be a factor in training-induced gains in running efficiency [9].

Sjodin et al studied alterations in muscle enzymes and blood lactate accumulation (OBLA) following training at OBLA with 8 male runners amongmiddle- and long-distance, running velocity at blood lactate level ($V_{OBLA}$) calculated with4 $mmol * l^{-1}$ and the enzymes before and after 14 weeks of training, the levels of citrate synthase (CS), phosphofructokinase (PFK), lactate dehydrogenase (LDH), and LDH isozymes in the vastus lateralis muscle were

examined. There was significant increase in $VO_2$ max (2.2%), LT/OBLA (4.3%) and running economy (2.8). [10]

Constant value of c0mponents which limit peak cycle ergometer in $VO_2$maxwith reference to training level. This corresponding adjustment and training level can be managed on restricted ground without looking reduction in ability on 10 km run [11]. The intensity was kept stable with reference to maximal aerobic power and training on 10 km run time.

A study had been carried by Tanaka et al (1986) to find corresponding relation between distance running performance and lactate capacityin 4 months period of intense training on competitive male middle distance runners. Training intensity was kept at 2 or more times of ventilatory lactate(vLL) or above vLL (60 to 90 min) along with regular training (ie.$vLT = 70 \pm 5\% \, VO_{2max}$) and they could see significant change in $VO_2$max with 4.8% and anaerobic threshold of 3.8% compared with pre-test. Also found that conventional training improved from 90 km/week to 120 km/week for study period. This conclude that Anaerobic Threshold intervention lead to betterment of running performance, may with improved muscle functional capacity. [12]

A study conducted to see the impact of Maximum Steady State speed of run on 12 male cross-country runners. The running speed of MSS pace is thought to be 2.2 $mmol.l^{-1}$ calculated from weekly 3.22 km runs utilizing the prediction equation of La Fontaine et al (1981) [13]. The running intensity was 104% of 10 km pace and 109% of 10 km pace respectively for experienced and novice runners for 4 days per week and the study duration of 7 weeks. Trial conducted o see the effect of maximum steady-state pace on running distances of 15m, 600m, 3.22 km and 10 km. 12 male runners volunteered with seven weeks of intervention. It had been noted that improved performance in 3.22 and 10 km (i.e., distance running) and no significant change in 15m and 600m (i.e.,short distance) [14].

Acevedo et al (1989) [15] determined the effect of increasing running intensity on competitive distance runners, O2 consumption, blood plasma lactate build up, upon ventilatory threshold (VT), and performance. The increase in intensity was at 90-95% HR max with 3 days/week and found that reduced the 10 km lap time by 63 seconds, and extended the treadmill run till exhaustion. It also concluded that previously trained athletes may increase exercise performance to enhance their running capacity by reducing lactate at the same level where although no variations in oxygen consumption and VT.

Competitive walkers and distance runners ability is based on LT and OBLA. Takayoshi et al (1990) [16] used treadmill incremental exercise added with regular training for the speed equal to 4 mM blood lactate for 8 weeks. Lehmann et al (1991) [17] tried to stimulate an excess training effect in middle- and long-distance runners by increasing training volume of average speed of 85.9 km (wk 1), to 115.1 km (wk 2) and 143.1 km (wk 3) to 174.6 km/wk (wk 4). The outcome measures were on cardiovascular, metabolic and hormonal parameters on the days of 0,14 & 28. The study resulted with rise in exercise stimulated noradrenaline plasma readings.

Efforts made to find the suitable intensity between low and excess training in terms of intensity and duration. The normal training (NT) included with five repetitions of run at 50% of VO2 max with recovery of the same duration at 60%vVO2 max for 4 weeks. Whereas the over training (OT) group had three interval training sessions at VO2 max. they found there

was significant improvement in VO2 max (2.1 %), LT (1.1 %) and running recovery (6.1 %). The study concluded that the performance aerobic indicators related with the performance were not changed by the 4 weeks of vigorous training at $VO_2$ max even though the rise of plasma noradrenaline [18].

A 10 week of aerobic and strength exercise (ES) and aerobicprogram done on 12 female distance runners and the parameters of oxygen consumption, running performance, body composition and strength had been analysed. They found that running economy shown difference in ES group, but no change in aerobic training group. Also, it was seen that when strength training added with aerobic running increased performance with no change in oxygen consumption or body composition [19].

Smith et al. (1999) found that utilization between 60 & 75% of Time maximum (T max) and ventilatory maximum (Vmax) as an intensityare important indicators for designing exercise among distance runners [20]. Richard et al. determined training elicited favourable performance for ventilatory threshold (VT) training. Run on treadmill to decide $VO_2$ peak and VT experimented on eight distance runners. It had been proved that VT is a better method to improve middle distance running.

Working in all-out supra-lactate threshold runs would reduce the link between physical stride determinants (stride rate and stride rate variability) and the oxygen consumptionutilization. This involved six long-distance runners in the study ofeight weeks withabove lactate threshold intensity in a gradual level and a test with a table load at 50% of speedin the rangeof lactate threshold and maximum oxygen uptake. It had been noted that Compared to the runners' baseline levels, endurance training has resulted in a drop in $VO_2$ max of stride rate variability [22].

Increased intensity and treadmill running training impact on 3000m & 5000m studied at the intensity were 60% Tmax, 70 % Tmax and control group. A notable change between before and after training values in 3000m time trial performance in 60% Time max group analysed to 70% Time max and control group. It concluded that 3000m running performance can be improved using 4 weeks treadmill training program at $VO_2$ max along with 60% of Tmax [23].

We analyzed running effects on blood lactate, substrate, and time exhaustion balance at the maximal lactate state velocity (MLSSv) with incremental test to measure velocity at lactate threshold and for six weeks, the maximum oxygen consumption ($VO_2$ max) (vLT). The strength was set at a 40-minute test with two stages of 20 minutes each, at 95 and 105% of vLT.The results showed demonstrated MLSS training considerably enhanced time until fatigue (endurance) at MLSSv (+50%) but only marginally raised MLSSv and $VO_2$ max [24].

Professional road cyclists felt gain in sprints and aerobiccapacity with interval training. Hamilton et al. experimented with competitive phase training with 3 sets of single leg jumps (20 each leg) along with 3 sets of treadmill sprints (5 x 30 sec alternating 30 sec recovery). There was improved lactate threshold 0.5% and concluded that this intervention produced beneficial results in running efficiency [25]. The effect of explosive strength exercise to improve 5 km running time carried by paavolainen et al. with an outcome measure on running economy and muscle power. The interventional group received 32% of normal activity replaced with sport-specific explosive strength exercise [26].

A recent analysis done to draft a protocol to assess and improve the long-distance running performance. Running on a treadmill in seven stages (3 min for each stage) with 60 seconds recovery between each stage to collect blood sample and determine heart rate at end of stage and beginning of subsequent stage had shown better method [27].

## Conclusion

This study recommends that the resistance training on treadmill is seen to be better training protocol, even though direct scientific evidence is limited. It had been noted that a treadmill running with seven stages of 3 min each Lactate Threshold (LT) protocol can be used to assess and train the long-distance runners.

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