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DO THE CLASSICAL ESTIMATORS: LACTATE THRESHOLD AND ONSET OF BLOOD LACTATE ACCUMULATION ASSESS ENDURANCE IN A SIMILAR WAY?

ALI KLASIČNA KAZALCA: LAKTATNI PRAG IN ZAČETEK AKUMULACIJE LAKTATA OCENJUJETA VZDRŽLJIVOST NA PODOBEN NAČIN?

ABSTRACT

Lactate curves varied in their position in relation to the x and y axes and inclination of their steeper part when they are represented in diagrams of lactate concentration related to running velocity. If they varied more in their position and less in their inclination, then there were parallel variations of both characteristic points: Lactate Threshold (LT) and Onset of Blood Lactate Accumulation (OBLA). In that case, correlation between both velocities should be significant and stable. If curves varied significantly also in their inclination, then there should be non-significant and varied correlation between LT and OBLA. To test this hypothesis, seven runners participated in a standard testing protocol on the treadmill to determine LT and OBLA. They repeated the same test four times in the training period from June to September. The calculated correlation coefficients showed a very unstable relationship between LT and OBLA. In June it was 0.12, in July 0.83 ($P<0.05$) in August 0.46 and in September 0.82 ($P<0.05$). There was no significant change of running velocity determined by LT and OBLA. The reason for such great variability was inter-subject changes of observed velocities, caused mostly by changes in the inclination of the steeper parts of the lactate curves, which were more pronounced than were changes of their position. The independence of changes of both velocities was only noticed for some subjects. Some others showed very parallel changes of both velocities, throughout the four months period of training. It seems that both characteristic points don't estimate endurance in the same way, or there are different types of running endurance. Some types may be more related to LT, others more to OBLA.

Key words: lactate curve, lactate threshold, onset of blood lactate accumulation, interrelationship, training effect

IZVLEČEK

Laktatne krivulje se spreminjajo v diagramih odvisnosti koncentracije laktata ([LA]) od hitrosti teka (v). Spremembe se kažejo v njihovem položaju glede na obe osi, v spremembah oblike laktatne krivulje, pa tudi v strmosti njihovega strmejšega dela. Če spreminjajo bolj svoj položaj, kot omenjeno strmost, potem so spremembe hitrosti, ki jih določata oba kriterija: Laktatni prag (LT) in Prag izraženega povečanja koncentracije laktata (OBLA) skladne, kar je mogoče zaznati z visokimi vrednostmi medsebojnih korelacijskih koeficientov. Če pa krivulje bolj spreminjajo svojo strmost, potem se lahko zgodi, da se vrednosti korelacijskih koeficientov zelo spreminjajo. Za testiranje resničnosti te hipoteze, je sedem tekačev sodelovalo v štirih standardnih testih, v obdobju štirih mesecev priprav na tekmovalno obdobje. Hitrosti, ki jih določata oba kriterija: LT in OBLA, se dejansko lahko skladno ali pa neodvisno spreminjajo. Korelacije med obema hitrostima so na primer v juniju 0.12, v juliju 0.83 ($P<0.05$), v avgustu 0.46 in v septembru 0.82 ($P<0.05$). Pri tem se obe povprečni hitrosti nista statistično značilno spremenili. Razlog za takšno izraženo variabilnost korelacij med obema hitrostima je mogoče pripisati neskladnim spremembam strmejših delov krivulj. Zgleda, da obe hitrosti ne ocenjujeta vzdržljivosti na enak način ali, da obstajajo različne vrste vzdržljivosti (najmanj dve), na katere vadba specifično učinkuje.

Ključne besede: laktatna krivulja, laktatni prag, prag izraženega povečanja koncentracije laktata, medsebojna zveza, učinek vadbe

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INTRODUCTION

It is well known that the Lactate Threshold (LT) and other criteria which use fixed lactate concentrations, such as Onset of Blood Lactate Accumulation (OBLA), are very related to the endurance performance in running (4,8,10,11,12). The two criteria base on different characteristics of the lactate curve in diagrams of the lactate concentration ([LA]) dependence on running velocity. LT is determined by the initial increase of [LA], which is related to a marked increase of lactate turnover in muscles and the whole organism, which results in greater [LA] appearance over its disappearance, which causes lactate accumulation in blood (1,2,5). The criterion OBLA uses a different base, a predetermined [LA]= 4 mmol/l (6,7). This criterion may indicate (or is related to) the highest velocity of running where [LA] is still in a steady state, even if the exercise continues for a longer time (approximately 1-2 hours)(1,2). Both criteria determine two clearly different points on the lactate curve in the diagrams of dependence of [LA] on running velocity (6,12). The difference was shown by [LA] which was about 1-2 mmol/l at the point of LT and exactly 4 mmol/l at the level of OBLA. The difference was shown also by running velocity which was approximately 10% higher at OBLA than at LT (12). The position of the LT and OBLA points in diagrams could change if the position or/and shape of the lactate curve changed. The position of lactate curves in diagrams of [LA] dependence on running velocity is related to endurance in running. The position of the lactate curve is located more in the higher running velocity range and the lower [LA] with more endurance runners. For subjects with low endurance, the position of the lactate curve is located more to the lower running velocities area and to the higher [LA] (1,5,10,12). Lactate curves can also be different in the gradient of their steeper part, maybe independently of other characteristics. This variability influences only the value of running velocity determined by OBLA and not the velocity determined by LT. Both criteria do not necessarily determine endurance in a similar way if we base this idea on the really strong correlation of both velocities with endurance in running. It is possible to test this hypotheses in two ways. Firstly, we made a comparison between running velocity determined by both criteria. Secondly, we related both velocities with each other for each subject, that participated in the study, during the training period of four months, to find if stability or instability occurs for the same person.

SUBJECTS AND METHODS

Subjects

A group of 7 cross-country skiers voluntarily participated in the study after all had given written informed consent.

Testing protocol

The used protocol is a part of their usual testing procedure. Each runner participated in a standardised exercise protocol on the treadmill. The running velocity was increased each time for 0.2 m/s in five or more runs of 5 min duration. The initial running velocity was selected so that the heart rate did not surpass 120 b/min. The final running speed is defined as that which produced either a heart rate greater than180-190 b/min, or exhaustion. The runs were interrupted by breaks of up to 30 s for blood sampling. The number of runs depended on the initial running speed and on the runner's endurance. The same testing protocol was repeated four times (once per month) during the preparatory period.

Blood collection and biochemical analysis

Capillary blood samples (20 μl) were collected after each run from an hyperemied ear lobe. The concentration of blood lactate ([LA]) was determined using a Kontron 640 Lactate Analyser (Kontron, Austria).

Data processing and analysis

The criterion LT was determined by using the two component analysis of [LA] kinetics. The method used was based on the principles described by Beaver et al (2,12). LT was defined as the intersection point of the two best fitted exponential interpolating curves, calculated from data in the diagram of [LA] dependence on running speed (Fig. 1). Data was firstly transformed by using a semilog (log[LA]/velocity) transformation for accurate determination of LT and then was represented in the original diagram as two exponential curves. The intersection point is described by the corresponding running speed (v_{LT}), the value of [LA] (LA_{LT}), and by the corresponding HR (HR_{LT}). Analysis of the [LA] kinetics also included the use of the OBLA criterion, which used a constant value of [LA]= 4 mmol/l

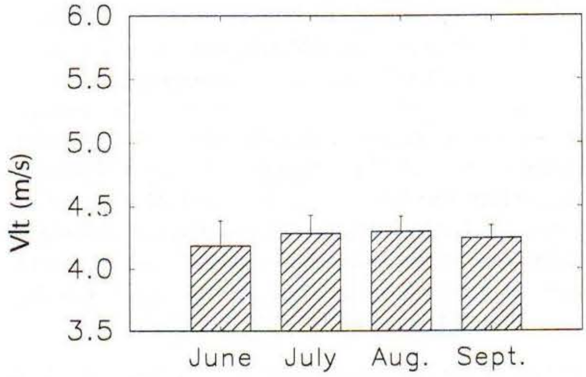

Fig. 1
Running velocity Vlt showed nonsignificant changes during the experimental period. At first there was a tendency for the values to increase (June through August) and in the last month (September) to decrease.

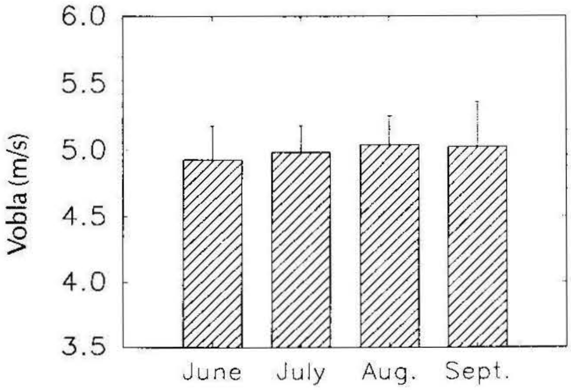

Fig. 2
Running speed V_{OBLA} showed nonsignificant changes during the experimental period. There was a tendency for the values to increase.

(6,7,10). The corresponding velocity was then denoted as V_{OBLA} and HR_{OBLA}.

Statistics
Arithmetic means, standard deviations, standard errors of estimation and correlation coefficients were calculated using a CSS: STATISTICA statistical package (Statsoft, USA).
The differences in running velocity determined by LT and that determined by OBLA throughout the experimental period were analysed using a Kruskal - Wallis ANOVA test. The significance level of P=0.05 was selected for testing the significance of differences and also for proving the significance of the correlation coefficients.

RESULTS

The running velocity Vlt is 4.2±0.2 m/s (mean, SD) in June (Fig 1). Velocity V_{OBLA} was 4.9±0.2 m/s (Fig. 2). The correlation between both velocities was r=0.12 (Fig. 3a).

There was an insignificant increase of Vlt to the level of 4.3±0.1 m/s (Fig. 1) and of V_{OBLA} to the level of 5.0±0.2 m/s (Fig. 2), after one month of endurance training. The correlation between both velocities in this case was r=0.83 (Fig. 3).

There was a tendency for a continuous increase of both running velocities in relation to their values in June and July (Fig 1 and 2). But this increase was not significant. Running speed Vlt was 4.3±0.1 m/s and V_{OBLA} was 5.0±0.2 m/s. The correlation between them was r= 0.46 (Fig. 3).

There were only 5 subjects in tests in September. Running speed Vlt was 4.2±0.1 m/s and V_{OBLA} was 5.0±0.2 m/s. The correlation between them was r=0.82 (fig. 3).

According to very dramatical changes in the correlation coefficients between both running velocities from month to month and non-significant changes of the observed running velocities it can be concluded that both velocities changed their values relatively independently, which can be seen when both running velocities were represented for each subject, during the experiment (Fig. 4,5,6,7). Some subjects showed similar and parallel changes of both

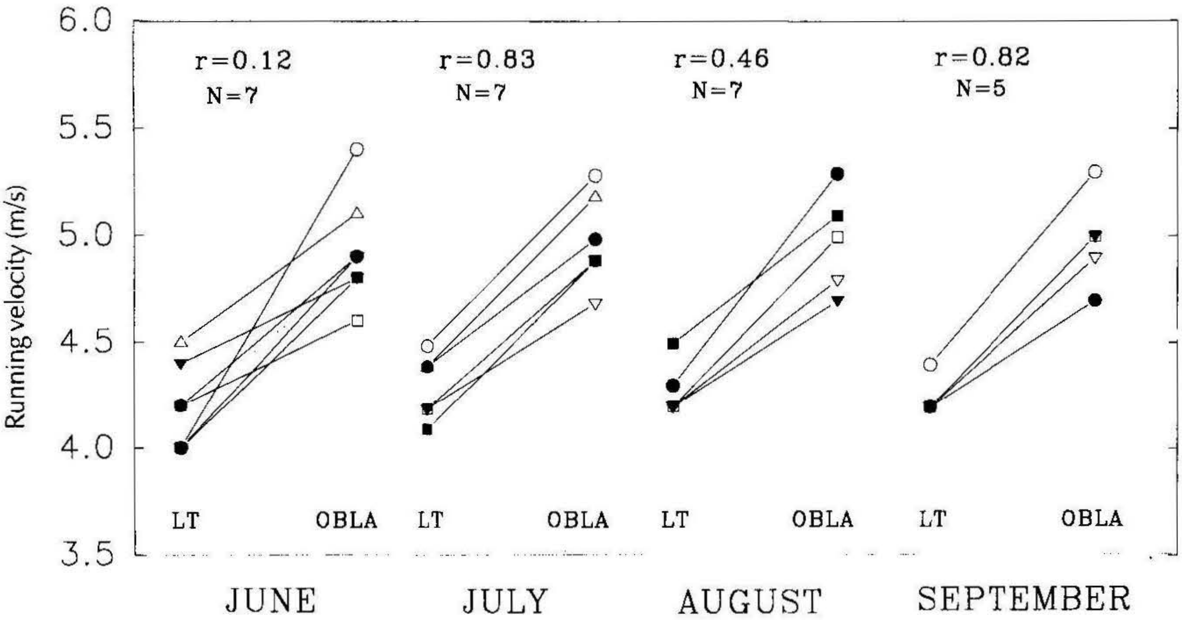

Fig. 3
Correlation relationship between Vlt and V_{OBLA} in each of the observed months of the experimental period. Values changed dramatically from month to month because of the changes in the relationship between both velocities in the group as a whole.

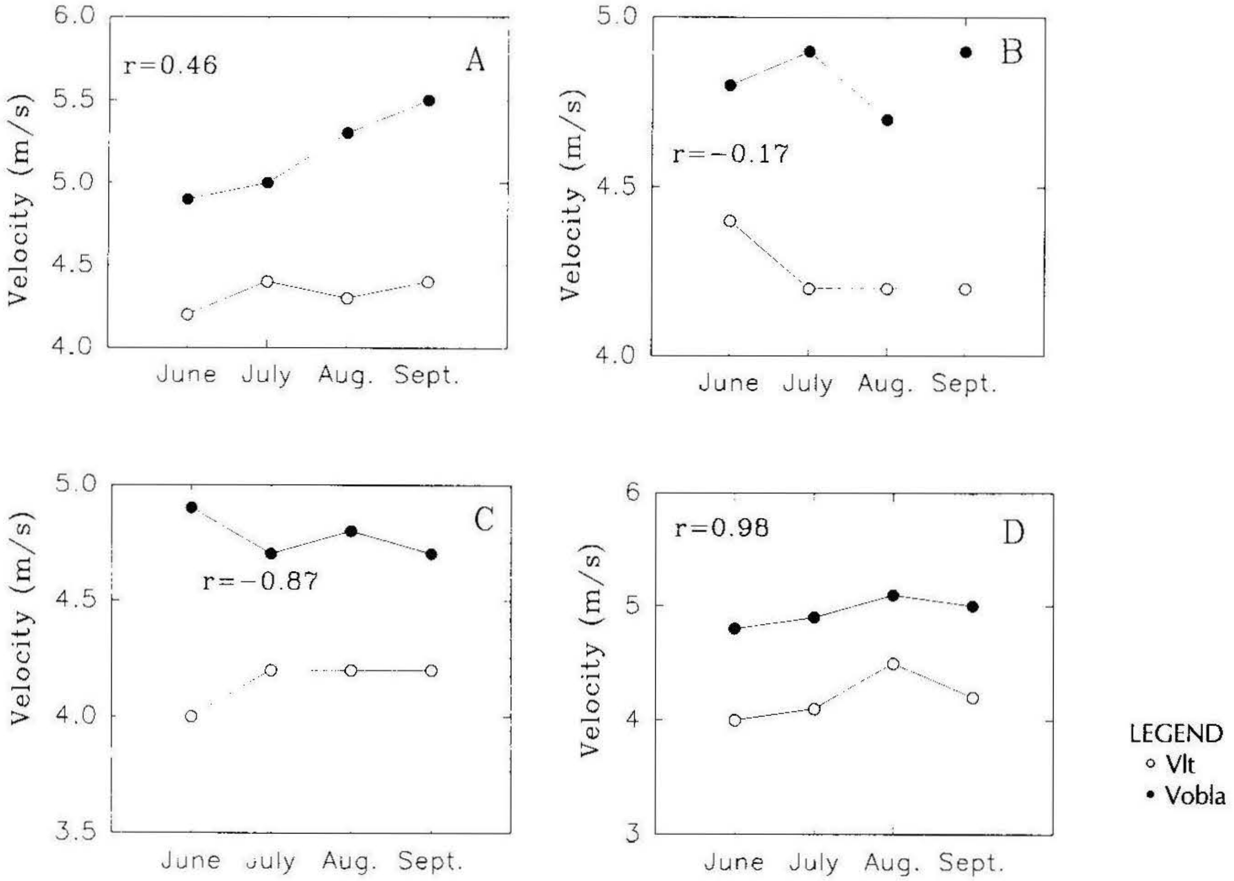

Fig. 4
Changes of Vlt and V_{OBLA} during the experimental period for four particular subjects showed great variability in response to very similar training. The changes of Vlt and V_{OBLA} could be very similar, or very different for individual.

velocities from June throughout September and a high correlation between the individual points, determined by the two criterions (Fig. 5,7). On the other hand, some of the subjects showed independent variations in the selected velocities for the same period and a very low correlation (Fig. 4,6).

DISCUSSION

Endurance in running is defined as the highest possible running speed on distances between 5 km and 42.195 km (marathon). As it is a complex multifactorial ability, it is unrealistic to expect that the same type of endurance is the most important factor in running on 5 km and 42.195 km. Also, the best world-ranked runners are not present at the top in both running disciplines. So it may be necessary to understand and define running endurance as performance, which can be distance-and intensity-specific. According to this premise, it is possible to separate endurance in general into two groups: short (SE) and long endurance (LE). Physiological characteristics representative of SE are: a high level of maximal oxygen consumption (Vo_2 max), lower lactate production and a greater lactate degradation (greater turnover), more developed buffer systems and maybe also better adaptation to increased metabolic acidosis (9,12). On the other hand, the most evident characteristics that represent LE are: a lower glycogen uptake; a greater uptake of fat as free fatty acids (FFA) and glycerol than glucose; and a lower lactate production (3,9).

Intense correlation between lactate curve characteristics such as LT and OBLA, and running endurance is well known and accepted (4,8,11,12). LT and OBLA defined two significant different running velocities (the difference varied between 8 – 15 %) (12). Running speed for the 5 km distance and the marathon are also clearly different. Because of these dissimilarities it is possible to make a hypothesis that sometimes both criteria individually relate more to specific endurance. Because trained runners have developed a specific endurance, the correlation between both SE and LE on one; and LT and OBLA on the other side, can't always be significant.

That endurance training increases endurance is very clear for non-trained subjects. Running velocity determined by LT and OBLA increased in a more or less similar way. In a homogenous group of endurance trained runners, the effect of training may not be unidirectional. Differences in absolute values may be small, but relative to the values inside the group, there can be relatively large variability, which can be seen from the rather marked variability of correlation coefficients from month to month in our study. Effect of the training is also individual, which can be seen very clearly from the different responses for both running velocities, when they were related to each other for the same subject throughout the experimental period. All these specific responses of a trained group of runners show the necessity for relatively independent use of LT and OBLA and special care must be taken when lactate curves are interpreted. All these specificities come from the relative independence of changes of lactate curve in diagrams of [LA] dependence on running velocity. The position of curves seems to be relatively independent of their shape, especially when represented by the steeper part. The first characteristic (position) affects both LT and OBLA values. The second characteristic (gradient) affects only the speed determined by OBLA.

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