THE RELATIONSHIP BETWEEN THE LACTATE TURNPOINT AND THE TIME AT VO_{2max} DURING A CONSTANT VELOCITY RUN TO EXHAUSTION

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The aim of present work was to examine the relationship between the running velocity at the lactate turn-point (vLTP) and the time at which VO can be sustained (TVO) during a continuous run to exhaustion at a minimal running velocity that yields VO (vVO). Pearson's correlation coefficient was used to determine the association between vLTP and TVO and between other selected physiological variables. Correlations between the relative vLTP and v VO was significant (r=0.63) at the p<0.04 level, TVO and T vVO (r=0.91) at p<0.001 level, and T vVO and TAVO (r=0.80) at p<0.01 level.

Key words: Maximum oxygen uptake, running, time to exhaustion, lactate turnpoint

INTRODUCTION:

The minimal running velocity at which the maximal oxygen uptake is elicited during an incremental test to exhaustion (vVO_{2max}) has been used to prescribe training for competitive middle-and long-distance runners (Billat et al., 1999). The rationale for using such intensity in training is that to optimally enhance VO_{2max}, an athlete should train at VO2 (Hill and Rowell, 1996). The physiological rational for training at or near VO_{2max} to most effectively enhance VO_{2max} is that myocardial pressure and volume overload are maximal when the exercise intensity is equivalent to that associated with the attainment of VO_{2max} (Gledhill et al., 1994; Zhou et al., 2001; Karjalainen et al., 1997). This mechanical overload is the main stimulus for myocardial adaptation associated with the enhancement of maximal stroke volume (Demarle et al., 2001), an imported determinant of VO_{2max} (Basset and Howley, 2000).
Other physiological variables that reach maximal values at VO_{2max} and therefore, may provide the maximal stimulus for adaptation are skeletal muscle capillary pressure and shear stress (Hudlicka et al., 1992), oxymyoblobin desaturation (Mole et al., 1992), and respiratory muscle work (Neilsen 2003). If attaining and sustaining VO_{2max} during training is an important factor in optimizing its enhancement, it is of interest for exercise physiologists to know which physiological factors predominantly influence the time at which VO_{2max} can be sustained (TVO_{2max}). One such factor could be the accumulation of lactic acid and the associated protons in active skeletal muscle. Lactic acid accumulation has been implicated as a major factor in the development of fatigue during maximal intensity exercise (Hargreeves et al., 1998). The velocity at the lactate turnpoint (vLTP) is the point in the blood lactate velocity curve associated with a second sudden and sustained increase in blood lactate concentration (Smith and Jones, 2001), and thus gives an indirect indication of the exercise intensity at which lactic acid rapidly accumulates in the muscle (Karlsson et al., 1982). Above the vLTP, the rapidity of lactate accumulation is a positive function of exercise intensity. Consequently, when running at vVO_{2max}, lactic acid should accumulate faster in individuals with greater difference between vLTP and vVO_{2max} wiyh a concomitant reduction in time to exhaustion.
The main aim of this study was to examine the relationship between the vLTP, expression as a percentage of vVO_{2max} (the relative vLTP), and the TVO_{2max} during a continuous run to exhaustion at vVO_{2max}.

METHODS:

Eleven elite distance runners at national team level (9 male, 2 female) volunteered to participate in this study. Subjects had the following characteristics (mean $\pm$ SD): age, 24 $\pm$ 3.67 yr; height, 173 $\pm$ 7 cm; body mass, 63.25 $\pm$ 7.27. Each subject participated in three running tests to exhaustion on a treadmill set at 0% grade, on three different days, with each test separated by a period of at least 48h. On each occasion, the test was preceded by a 5-min self selected warm-up, typically at a speed between 8 to 10 km.h $^{-1}$. The time between completion of warm-up and the start of any test was approximately one minute. The first test was a continuous incremental test to determine $VO_{2max}$and vVO_{2max}: the second, a single velocity continuous run at vVO_{2max} to determine T_{lim} vVO_{2max}, $TAVO_{2max}$ and TVO_{2max}: and the third to determine vLTP.

Metabolic data was collected using an online gas analysis system (k4b^2 Cosmed Italy) through the treadmill exercise test periods. Breath-by-breath data was retrograde stationary time-averaged over 15s, 5s, and 60s for tests 1, 2, 3, respectively.

Determination of VO_{2max}, vVO_{2max}, T_{lin} vVO_{2max}, $TvVO_{2max}$, and $TAvVO_{2max}$.

Initial treadmill velocity was set between 8 and 10 km.h^{-1} (0% slope) for 5 minutes, depending on individual completion performance times, and was increased by 1 km.h^{-1} every minute thereafter, until volition exhaustion. The vVO_{2max} was identified as the lowest running velocity that elicited VO_{2max}.

Determination of T_{lim} vVO_{2max}, $TvVO_{2max}$, and $TAvVO_{2max}$.

Initial treadmill speed was set at10 km.h^{-1}, at which speed, the subject stepped onto the moving treadmill belt and then the treadmill velocity was increased at a rate of 0.44 ms^{-1} and for 5seconds to reach the subject's vVO_{2max} of18 km.h^{-1}. The time between the subject releasing the grip on the hand rail and the subject pressing the emergency stop button at the end of the test, was recorded to nearest second as $T_{lim}vVO_{2max}$. The $TvVO_{2max}$ was evaluated by inspecting the gas analyzer output and was defined as $TvVO_{2max}$ minus $TAvVO_{2max}$. The vLTP was then defined as the running velocity before the observation of a second sudden and sustained increase in blood lactate concentration that coincided with a blood lactate concentration of between approximately 2-5 mmol-L^{-1}, and was expressed as a percentage of vVO_{2max} (the relative vLTP).

RESULTS AND DISCUSSION:

Pearson's correlations between selected physiological responses are shown in Table 1 and figure 1. Correlations between the relative vLTP

Table1 Pearson's correlations for selected physiological index

	1	*2*	*3*	*4*	*5*
1.*vVo2max*	-	**0.53**	**0.55**	**0.39**	**0.63****
2.TlimvVO2max		-	**0.80****	**0.91****	**0.27**
3.TAVO2max			-	**0.52**	**0.65**
4.TVO2max				-	**0.23**
5.vLTP(%vVO2max)					-

**P<0.05 .

vVO2max-minimal velocity that elicited VO2max during an incremental test to volitional exhaustion .Tlim vVo2 max –time sustained during a continues run to exhaustion at vVO2max. TAVO2max-time to attain VO2max. TVO2max-time at VO2max .vLTP -velocity

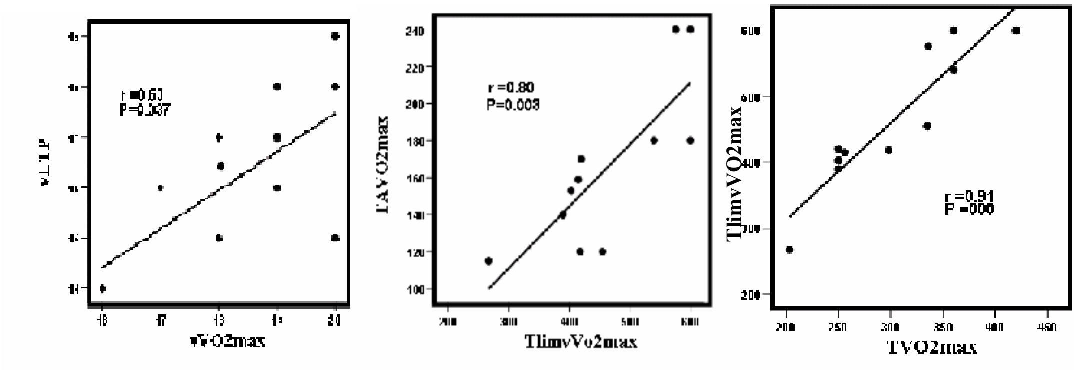

Figure 1 Pearson's correlations between selected physiological responses

and TVO_{2max} expressed as percentage of $T_{lin}vVO_{2max}$ (the relative TVO_{2max}: r=0.63) and between TVO_{2max} and $T_{lin}vVO_{2max}$ (r=0.91) were significant at the $p<0.05$ level. The correlation between $T_{lin}vVO_{2max}$ and $TAVO_{2max}$ (r=0.80) was significant at the p=0.003. All other correlations between selected measured physiological variables were found to be statistically insignificant. Our results agreed well with the results of Medgley et al., (2006). It was hypothesized that a vLTP that was closer to individual's vVO_{2max} would increase TVO_{2max} predominantly by extending $T_{lin}vVO_{2max}$. This would account for some of the unexplained variance in $T_{lin}vVO_{2max}$ not accounted for by the forty percent explained by inter-individual variability in anaerobic capacity (Renoux et al., 1999).

This hypothesis was based on the assumption that the further above the vLTP a runner exercises, the faster blood lactate accumulate (Skinner and McLellan, 1980), and therefore, the closer the individual's relative vLTP is to the vVO_{2max}, the slower lactate accumulation will occur. However, although TVO_{2max} was found to be significantly positively correlated with $T_{lin}vVO_{2max}$ (r=0.91), a very low insignificant correlation existed between the relative vLTP and $T_{lin}vVO_{2max}$ (r=0.065). This is in contrast to what Billat et al., (1998) had obtained (r=0.30). A possible explanation for the contrasting result is that the significant correlation found by Billat et al., (1998) using the results of the T_{lim} test, but not the second, may be a type of error, which may occur by chance alone once in every 20 comparisons when alpha is accepted as 0.05, Cohen, (1992).

CONCLUSION:

This study has demonstrated that the correlation between the relative vLTP and TVO_{2max} was not statistically significant, although a lack of statistical power probably influenced this finding. A significant positive correlation did exist between the relative vLTP and the relative TVO_{2max} indicating that a potential physiological effect TVO_{2max} via the relative vLTP does exist. Further research with greater sample sizes is required to substantiate these findings, before final conclusions can be made.

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Acknowledgement

The authors would like to thank Mr. Amir Hosseini, the Secretary General of Olympic Academy and Dr. Bahrami Nejad and Dr. Alijani for the facilities they provided to pursue this project.