MUSCLE OXYGEN SATURATION BREAKPOINTS AS PREDICTORS OF VENTILATORY THRESHOLDS IN TRIATHLETES

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Introduction

To optimize endurance training, individualized training zones should be determined based on physiological thresholds. NIRS technology has made it possible to non-invasively assess muscle oxygen saturation during physical exercise. Four phases of muscle oxygenation dynamics during incremental exercise have been documented [1]. This predictive behaviour has led to the comparison of ventilatory thresholds (VT) with SmO_2 thresholds (BP). The aim of the study was: to evaluate the relationship between ventilatory thresholds (VT_1 and VT_2) and SmO_2 thresholds (BP_1 and BP_2) in triathletes during a running incremental test.

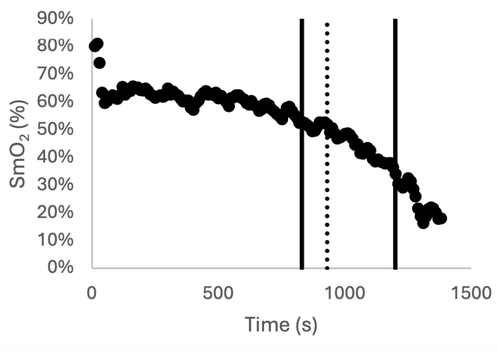
Methods

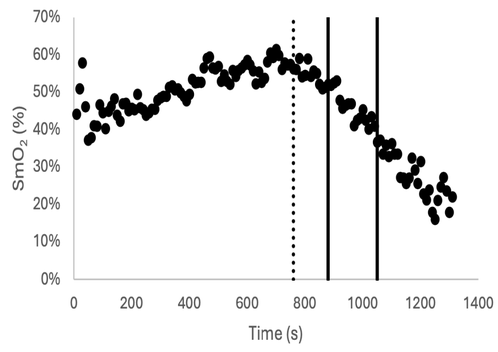
Twelve national level triathletes (age 24 ± 5; VO_{2max} 61.5 ± 8.4 ml·min^{-1}·kg^{-1}; ATT 3.6 ± 1.4 mm; SmO_{2end} 16.4 ± 13%) were assessed during a VAM EVAL test. Breath by breath gas exchange was recorded using a portable gas analyser (Cosmed K5), SmO_2 was measured using a continuous wave NIRS device (MOXY) placed on the right vastus lateralis, and heart rate was recorded using a chest strap (Polar H10). BP were determined using a piecewise double linear regression model because this model provided a superior fit in over 90% of the cases [2]. A paired samples t-test was performed to compare the VO_2, HR, SmO_2 and velocity at the VT – BP. Bland Altman Plots were performed to assess the agreement between VT_1- BP_1 and VT_2- BP_2 with upper and lower LoA set at 95% CI. A stepwise multiple linear regression analysis was performed among the variables associated with SmO_2: BP_1 and SmO2end (SmO2 at the end of the ramp test) and VT_1 and VT_2 to determine which combination yielded the highest predictive accuracy.

Results

The SmO_2 reflected changes due to the increased velocity during the VAM EVAL test and different SmO_2 behaviours could be identified: ten monotonic (Fig 1a) & two parabolic (Fig 1b).

Figure 1. SmO2 responses. Monotonic decrease (a) and parabolic variation (b). Solid lines represent the VT and dashed lines the BP.





BP and VT did not show significant differences when compared based on HR (VT_1 165.2 ± 14.9 bpm; BP_1 164.2 ± 18.7 bpm p= 0.771 and VT_2 168.8 ± 19.4 bpm; BP_2 171.3 ± 14.4 bpm p= 0.504), VO_2 (VT_1 51.3 ± 6.3 ml·kg^{-1}·min^{-1}; BP_1 52.5 ± 7.6 ml·kg^{-1}·min^{-1} p= 0.471 and VT_2 58.1 ± 6.3 ml·kg^{-1}·min^{-1}; BP_2 59 ± 4.6 ml·kg^{-1}·min^{-1} p= 0.349), velocity (VT_1 15.1 ± 1.1 km·h^{-1}; BP_1 14.9 ± 1.5 km·h^{-1} p= 0.614 and VT_2 17.9 ± 0.6 km·h^{-1}; BP_2 17.9 ± 1.1 km·h^{-1} p= 1.000) and SmO_2 (VT_1 40.4 ± 19.1 %; BP_1 43.3 ± 13.2 % p= 0.279 and VT_2 11.9 ± 20 %; BP_2 9.4 ± 17.6 % p= 0.171). The results of the Bland Altman plots for the first threshold displayed a low mean error but a wide 95% CI while for the second threshold, the low mean error was coupled with a much narrower 95%. The multiple linear regression analysis displayed the most suitable equations to predict the VT_1 and VT_2 from the SmO_2 data (HR, velocity and SmO_2 at the BP_1 and SmO_2 at the end of the test). Our results indicated the following prediction percentage: 93% SmO_2 VT_1 and 92% SmO_2 VT_2. The relevant equations are shown:

$$SmO_2\ VT_1\ (\%) = -85.207 + (1.366 * SmO_2\ BP_1) + (4.463 * \text{velocity } BP_1) \quad \text{(Eq. 1)}$$

$$SmO_2\ VT_2\ (\%) = 5.949 + (1.337 * SmO_{2end}) \quad \text{(Eq. 2)}$$

Discussion

The relationship between BP and VT exhibited considerable variability among participants. In some, these thresholds occurred nearly simultaneously, while in others, there was a noticeable separation, indicating that this relationship is highly individualised. The inability to detect a clear second breakpoint (BP_2) in most participants highlights the challenge of using SmO_2 as a standalone marker for performance thresholds. While BP_1 often coincided with VT_1, the varied SmO_2 profiles suggest that a range of physiological factors, including muscle fibre recruitment strategies and overall aerobic capacity, play a significant role in determining these thresholds [3]. Consequently, SmO_2 alone may not provide a comprehensive picture of an athlete's performance potential or the precise point of metabolic transition.

Conclusions

The findings of this study suggest that SmO_2 thresholds identified by NIRS can serve as reliable predictors of ventilatory thresholds in highly trained athletes, despite the variability in individual muscle oxygen saturation responses. This approach holds potential for optimising performance assessment and training regimens in high-level athletes.

References

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