CAN MUSCLE OXYGEN SATURATION PROVIDE REAL-TIME INSIGHTS INTO THE GYCOLYTIC CONTRIBUTION DURING INTERVALS IN THE SEVERE INTENSITY DOMAIN?

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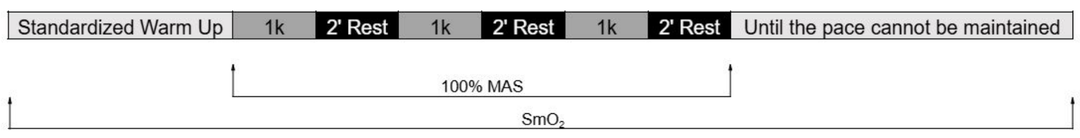
Introduction

Severe-intensity training improves VO_2max, elevates physiological thresholds, and enhances mitochondrial respiration (Granata et al., 2018). Buchheit et al. (2013) provided intensity-duration guidelines to control the degree of glycolytic contribution during severe-intensity sessions, though these rely on blood lactate changes, which have limitations. Advances in near-infrared spectroscopy (NIRS) allow non-invasive muscle oxygenation (SmO_2) assessment on a 0–100% scale, provided device placement and adipose tissue thickness are controlled. SmO_2 breakpoints, or inflection points in oxygenation trends, reflect changes in the balance between oxygen delivery and utilization and can help monitor glycolytic energy contribution in real time (Buchheit et al., 2013; Perrey et al., 2024). However, they have not been studied yet in the context of severe-domain intensity exercise. The aim of the study was two-fold: 1) To identify and analyse SmO_2 breakpoints during repeated 1-km runs at 100% of maximal aerobic speed (MAS) and 2) To assess the reliability of SmO_2 breakpoints across the 1km repetitions.

Methods

Twelve national level triathletes (age 26 ± 6; VO_2max 61.8 ± 8.6 ml·min^{-1}·kg^{-1}; ATT 3.5 ± 2.1 mm; MAS 19 ± 1.1 km·h $^{-1}$). All participants underwent a VAM EVAL test. Seven days later, they performed a high intensity interval training. This consisted of a standardized warm-up followed by 1km repetitions at 100% MAS with 2 minutes rest in between until the pace couldn't be maintained. SmO_2 was measured using a continuous wave NIRS device placed on the right vastus lateralis (MOXY, Fortiori Design LLC, USA). Following the training session, breakpoints for SmO_2, were identified using an automated segmented linear regression model with three pre-specified knot points analogous to the method used by Spencer et al. (2012). The initial and final knots marked the onset and termination of the 1km sets, respectively, while the intermediate knot represented a key breakpoint for SmO_2 (BP_{SmO_2}).

Figure 1. Severe intensity domain training session.



Results

Figure 2. Mean time courses and SD of SmO2 (%) in the first (white dots and grey shaded area) and last 1km repetition (black dots and black shaded area).

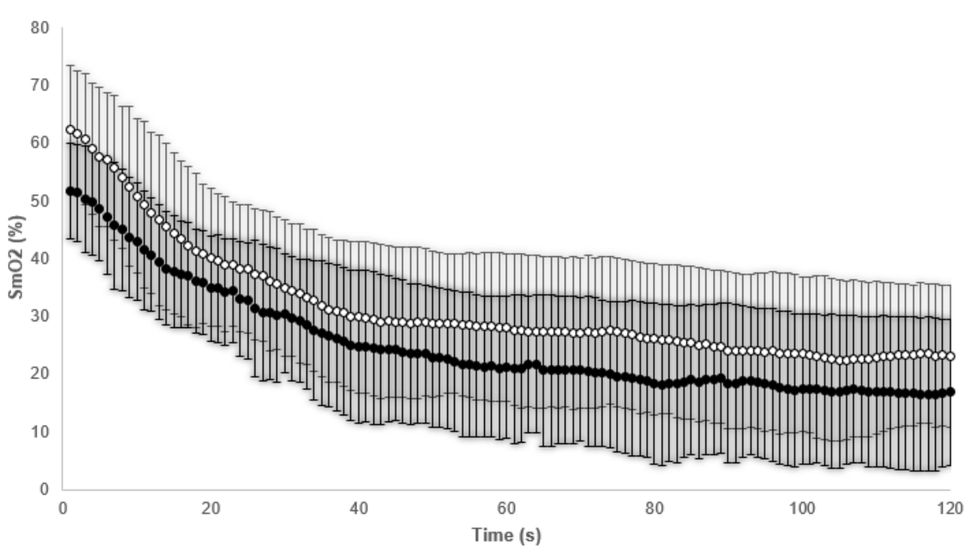
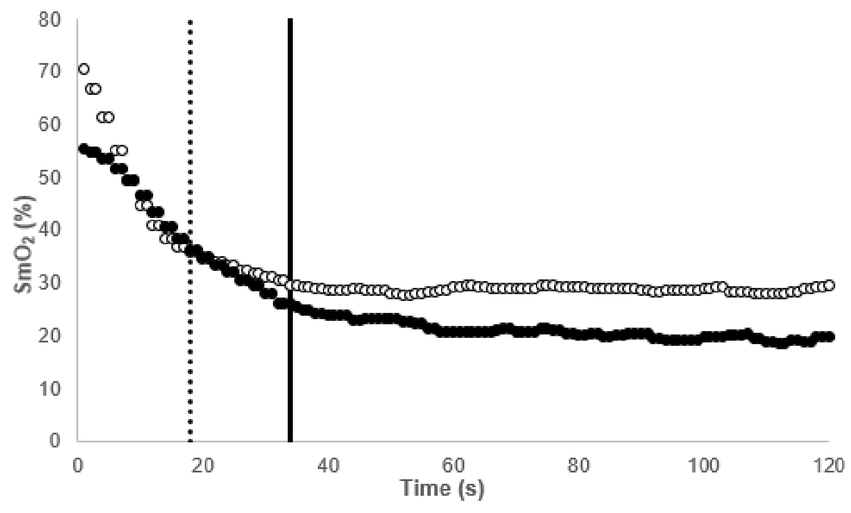


Table 1. Descriptive data, significant differences and reliability for BP_{SmO2} parameters across the 1km repetitions. Values are mean ± SD. Statistical significance is set at $p < 0.05$. Letters (a, b) indicate significant differences when compared to the penultimate set (a) and the last set (b), respectively.

	First set	Penultimate set	Last set	ICC
BP_SmO_2 (%)	28.9 ± 13.7$_b$	25.9 ± 14.4	22.3 ± 11.9	0.67
BP_SmO_2_T (%)	36.3 ± 11.4	41.8 ± 12.3	48.2 ± 19	0.25
Pre_BP_slope (%/s)	1.1 ± 0.7$_b$	0.9 ± 0.6	0.7 ± 0.5	

Figure 3 . Time courses of SmO_2 (%) in the first (white dots) and last 1km repetition (black dots) in a representative subject



Discussion

On one hand, O_2Hb dissociation is facilitated by the progressive increase in fatigue inducing metabolites across the sets, consistent with the Bohr Effect, leading to a significant decrease in SmO_2 (%) at the breakpoint ($p < 0.05$) from the first to the last set. On the other hand, the muscle deoxygenation rate during the final set is significantly slower compared to the first set ($p < 0.05$), as evidenced by the SmO_2 slope, which reflects improved muscle oxygen delivery during the pre-breakpoint phase (Goulding et al., 2023). The ICC calculation for the timeframe of breakpoint occurrences revealed poor reliability (ICC=0.25). However, when the ICC was calculated for the physiological values at which the breakpoints occurred, reliability improved to a moderate range (ICC=0.67). According to Buchheit et al. (2013), during repetitions at 100% MAS, the glycolytic contribution remains low to mild for efforts lasting up to 30–60 seconds, but once this duration is exceeded, the glycolytic contribution increases progressively. Interestingly, the SmO_2 breakpoint during the 1 km repetitions consistently emerged between the 30–50 second mark. SmO_2 demonstrated day-to-day reliability comparable to VO_2 and HR across various exercise intensities (Perrey et al., 2024) but to address intra-session variability of BP_{SmO2} it would be beneficial to establish a SmO_2 zone (range %) related to the breakpoint.

Conclusion

To our knowledge, we are the first group to conduct a detailed analysis of SmO_2 breakpoints within the context of a severe-intensity training session. While further studies are needed, the moderate intra-session reliability observed in SmO_2 breakpoint values is encouraging. These findings highlight the potential use of SmO_2 as a non-invasive marker for real-time monitoring of the glycolytic contribution during exercise. This approach could aid in optimizing training session design and improving athletes' ability to autoregulate based on individual SmO_2 responses.

References

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