Muscle activation and oxygenation in cycling

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Summary

This study evaluated the concordance between muscle activation and muscle oxygen saturation (SmO_2) during a graded exercise test on a cycle ergometer, considering muscles with different roles. Fifteen cyclists and triathletes (22 ± 6 years, 175 ± 8 cm, 12 ± 4 h/week of training) participated. Surface electromyography (sEMG) and SmO_2 signals were recorded from the vastus lateralis, tibialis anterior, gastrocnemius medialis, and biceps femoris. Results showed that, in general, RMS increased while SmO_2 decreased ($p < 0.05$), except for the gastrocnemius medialis, which remained stable. The vastus lateralis and biceps femoris showed moderate concordance between RMS and SmO_2 (CCC_{Lin}: 0.70 and 0.50, respectively), while stabilizing muscles showed weak agreement. In conclusion, power-generating and stabilizing muscles respond oppositely in terms of SmO_2 and RMS during progressively increasing intensity exercise until exhaustion induced by graded exercise testing.

Introduction

Near-infrared spectroscopy (NIRS) is widely used in sports science to assess muscle oxygenation and oxidative capacity [1]. SmO_2 reflects the balance between oxygen delivery and extraction, decreasing as exercise intensity increases. Concurrently, motor unit recruitment increases, suggesting a potential link between SmO_2 and muscle activation. While previous studies have explored the relationship between NIRS and sEMG, they focused on single muscles or the same muscle group [2]. However, muscles with different functions during cycling show distinct SmO_2 profiles.

This study aimed to evaluate the concordance between SmO_2 and sEMG during graded cycling exercise in power-generating and stabilizing muscles. We hypothesized that SmO_2 in power-generating muscles would correlate more strongly with sEMG root mean square than in stabilizing muscles, given its role in characterizing muscle activation amplitude.

Methods

15 cyclists and triathletes (age = 22 ± 6 years, stature = 175 ± 8 cm and training hours = 12 ± 4 hours·week^{-1}) carried out a graded exercise test on a cycle ergometer. NIRS (Moxy, USA) and electromyography (mDurance, Spain) devices were placed on the preferred sides in: vastus lateralis, tibialis anterior, gastrocnemius medialis, and biceps femoris.

Results and Discussion

The results of the study showed that, in general, while average root mean square (RMS) was increasing during graded exercise testing, SmO_2 was decreasing ($p < 0.05$), except for the gastrocnemius medialis which was stable. Then, vastus lateralis and biceps femoris showed similar signal correspondence between average root mean square and SmO_2 with a moderate CCC_{Lin} (vastus lateralis: 0.70; biceps femoris: 0.50), and stabilizing muscles showed weak agreement (gastrocnemius medialis CCC_{Lin} = 0.32; tibialis anterior CCC_{Lin} = 0.39).

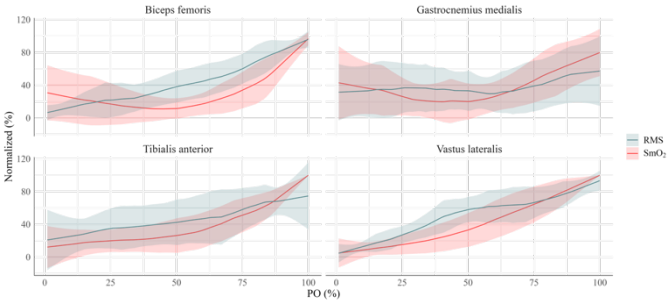

***Figure 1**: Average root mean square (RMS) and muscle oxygen saturation (SmO_2) profiles for biceps femoris, gastrocnemius medialis, tibialis anterior, and vastus lateralis during GTX cycling.*

During GXT, muscle activation increased while SmO2 decreased, showing moderate concordance in power-generating muscles (vastus lateralis, biceps femoris) and weak concordance in stabilizing muscles (tibialis anterior, gastrocnemius medialis) (Quesada et al., 2015).

Conclusions

In conclusion, power-generating and stabilizing muscles respond oppositely in SmO2 and RMS during progressively increasing intensity exercise until exhaustion induced by graded exercise testing.

References

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