高強度のウォームアップ運動が活動筋の酸素動態に及ぼす影響

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Effects of High-Intensity Warm-Up Exercise on Balance for Oxygen Delivery and Utilization in Exercising Muscles

by

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ABSTRACT

Heavy priming exercise reduces the oxygen deficit during the subsequent heavy exercise. Current theories for the etiology of the oxygen deficit following the onset of exercise include increased bulk and local blood flow and O_2 delivery ($\dot{Q}$) via residual

vasodilation and academia/temperature-induced rightward shift of the hemoglobin (Hb) O_2 dissociation curve. We used a method to quantify absolute [deoxy(Hb + Mb), HHb] of superficial- and deeper regions of the rectus femoris (RF) muscle in 6 participants during cycle exercise, using time-resolved NIRS with adipose tissue correction. HHb of the deeper RF for both the priming- and subsequent heavy exercise showed steady state responses toward the end of exercise, suggesting matching of oxygen consumption ($\dot{V}_{O2}$) and $\dot{Q}$ kinetics. Compared with the superficial RF, peak deoxygenation of the deep RF was not significantly different, however deoxygenation kinetics were slower (mean response time, priming exercise, 35 ± 11 s vs. 66 ± 26 s; subsequent exercise, 32 ± 8 s vs. 44 ± 22 s, $p<0.05$). These data revealed temporal and spatial disparities in muscle deoxygenation responses to exercise and suggested matching of $\dot{V}_{O2}$ and $\dot{Q}$ kinetics, thus the oxygen deficit reduced in the deeper region RF muscle, compared with the superficial RF. Further, these results suggest that deep region muscle has a greater $\dot{Q}$ / $\dot{V}O_2$, which led to improve matching of $\dot{Q}$ -to-$\dot{V}_{O2}$ thereby raising muscle and microvascular oxygen pressure and enhancing blood-myocyte O_2 flux.

要　旨

高強度のウォームアップ（W-up）運動を用いると，W-up 運動後の主運動における活動筋の酸素消費量（$\dot{V}O_2$）の増加が速くなり，酸素不足が減少する．本研究では，表層筋に加えて深層筋も含めた活動筋の酸素動態を計測し，高強度の W-up 運動が活動筋の酸素動態に及ぼす影響を明らかにした．時間分解・近赤外分光装置を用いて，活動筋における脱酸素化ヘモグロビン＋ミオグロビン（HHb）を計測した．大腿直筋深層部の HHb は第 1 運動と第 2 運動の開始後の約 5 分目において定常状態を示し，$\dot{V}O_2$ と $\dot{Q}$ の増加速度のマッチングが生じたことが示唆された．さらに，第 1 運動と第 2 運動において大腿直筋深層部における HHb の時定数と平均応答時間は表層部に比べて有意に遅かった．HHb は $\dot{V}O_2/\dot{Q}$ を反映するので，表層筋に比べて遅筋線維が多く含まれ，運動中の筋温がより高い深層筋では，酸素供給が十分になって活動筋全体の $\dot{V}O_2$ と $\dot{Q}$ のバランスが改善され，酸素不足が減少したと推測される．