

Dual Wavelength Diffuse Correlation Spectroscopy: A Novel Tool for Identifying Determinants of Oxygen Consumption

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ABSTRACT

Near-infrared diffuse correlation spectroscopy (DCS) is a novel method for measuring microvascular skeletal muscle blood flow. Our lab recently found excellent agreement between single wavelength DCS and Doppler ultrasound of the brachial artery during rhythmic handgrip exercise. **PURPOSE:** Here, we report new data utilizing a dual wavelength DCS system (785nm and 852nm), which extends our prior work by combining novel microvascular perfusion assessment with real-time quantification of tissue oxygenation. **METHODS:** We enrolled eight individuals (male/female: 3/5, mean: age 48 ± 22 (range: 22-76 years), height 170 ± 8 cm, and weight 75 ± 12 kg). Subjects were instrumented with the DCS probe placed over the belly of the flexor digitorum profundus. Duplex ultrasound of the brachial artery was performed concurrently to provide an additional measure of skeletal muscle blood flow. Each subject performed two bouts of rhythmic hand grip exercise at 20% of their maximum voluntary contraction (MVC). Resting baseline data were acquired prior to each bout of exercise, and each period of data collection were separated by a minimum of 10 minutes of rest. The data derived from both rest and exercise periods were averaged. **RESULTS:** As reported previously using our single wavelength DCS device, blood flow index (BFI, the primary output from DCS) increased significantly ($119 \pm 37\%$) with exercise. We also observed a $1.9 \pm 1.1\%$ change in oxyhemoglobin and $21.8 \pm 10.0\%$ change in deoxyhemoglobin resulting in a $-5.9 \pm 2.6\%$ change in tissue saturation with exercise. Using these data, relative muscle oxygen consumption ($rmVO_2$) was calculated and found to increase by $160.2 \pm 55.4\%$. The novelty of this new approach is best illustrated by a case-comparison between two subjects, who performed nearly equivalent absolute (11 vs 10 kg) and relative work (20%), and yet achieved strikingly different levels of oxygen utilization during exercise ($\Delta rmO_2 = 307\%$ vs. 214% , Case A vs. Case B respectively). This disparity appears to be attributable to muscle oxygen extraction as both brachial artery blood flow and microvascular perfusion (by DCS) were similar in both subjects. By contrast, Case A exhibited a much greater change in StO_2 (-17.8%) compared to Case B, whose StO_2 more closely mirrored the group average (-6.8%). To aid in the interpretation of these results, we evaluated skeletal muscle oxidative capacity in both subjects using an established NIRS-based cuff occlusion protocol (Rosenberry et al. 2018. JoVE). Remarkably, these additional data corroborated our hypothesis; Case A exhibited a much faster muscle oxygen consumption recovery time (34 seconds) whereas Case B's recovery time was 93 seconds. **CONCLUSION:** Taken together, these data establish strong proof-of-concept that dual wavelength DCS can provide valuable mechanistic insight into the determinants of oxygen consumption