TITLE:
Evaluation of vascular responsiveness after prolonged ischemia: comparative analysis between continuous wave and time-domain NIRS devices

SHORT TITLE:
Comparing NIRS devices for vascular responsiveness after ischemia

KEYWORS:
microvascular responsiveness, near-infrared spectroscopy, tissue oxygenation, hemodynamic monitoring

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INTRODUCTION. Near-infrared spectroscopy (NIRS) is a non-invasive tool used to evaluate heme and other chromophores concentration changes occurring within biological tissue according to near-infrared light absorption and scattering [1, 2]. At skeletal muscle level, NIRS has been used to monitor changes of heme indexes during vascular ischemia and reperfusion, leading authors to draw conclusions about endothelial function with physiological and clinical significance [3]. However, changes in oxy-[heme] and deoxy-[heme] that occur during vascular ischemia and reperfusion affect tissue scattering characteristics, possibly worsening accuracy of NIRS indexes [4].
AIM. In this study, we compared parameters obtained by a time-domain (TD) NIRS device, which directly measures both absorption and scattering coefficients, with continuous wave (CW) NIRS, which assumes constant tissue scattering. The hypothesis to be tested is that absolute and functional indexes assessed during vascular ischemia and reperfusion could differ between NIRS technologies due to changes in tissue light scattering.
METHODS. Healthy active male participants (n=9; 23±4 years, 79±7 kg) with adipose tissue thickness values lower than 10mm were recruited. Tissue saturation index (TSI) of quadriceps muscle was monitored using CW (Train.Red Plus, Train.Red BV) and TD (NIRSBOX, PIONIRS srl) devices during the vascular occlusion test (VOT). Baseline (BAS), minimum (MIN), and maximum (MAX) absolute values were recorded. Desaturation rate (Slope_1) and reperfusion rate (Slope_2) were estimated. Differences between CW and TD estimates were evaluated by two-way RM ANOVA (time x device). Slopes were compared by paired student t-test. Statistical significance was declared when $p<0.05$.
Results. TSI determined by CW was significantly lower at BAS (CW: 67.4±3.9%; TD: 75.3±2.8%), MIN (CW: 34.7±11.5%; TD: 57.9±5.4%) and MAX (CW: 74.8±1.5%; TD: 79.9±2.3%), compared to TD (all $p<0.05$). Slope_1 (CW: -0.25±0.17 $\%\cdot s^{-1}$; TD: -0.13±0.07 $\%\cdot s^{-1}$) and Slope_2 (CW: 1.97±0.60 $\%\cdot s^{-1}$; TD: 1.10±0.40 $\%\cdot s^{-1}$) resulted significantly different between devices (all $p<0.05$), with TD values about 45% lower than CW.
Conclusions. Our findings show significant differences between CW and TD NIRS measurements, suggesting caution when both absolute values and functional outcomes obtained by different devices are compared. The present data confirm previous results comparing frequency domain NIRS data with those obtained by assuming constant tissue scattering characteristics [4]. Thus, it is essential to establish a reference framework that is specific to the instrument and that can reliably distinguish between physiological and altered values. This is particularly important when these indexes are used to identify endothelial dysfunction in ageing, disuse and clinical populations.

References
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