EVALUATION OF VASCULAR RESPONSIVENESS AFTER PROLONGED ISCHEMIA:
COMPARATIVE ANALYSIS BETWEEN CONTINUOUS WAVE AND TIME-DOMAIN NIRS DEVICES

Alessio Marciano[1], Chiara Motto[2], Andrea Pilotto[1], Marianna Neri[1], Maddalena Crecchi[1],Michele Lacerenza[2], and Simone Porcelli[1]

[1]Department of Molecular Medicine, University of Pavia, Pavia, Italy; [2]PIONIRS s.r.l., Milano, Italy

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]. **Different NIRS** technologies quantify light attenuation within the target tissue based on **distinct assumptions** derived from the modified Beer-Lambert law. At skeletal muscle level, NIRS has been **used to monitor** changes of heme indexes during arterial 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].

In this study, we compared parameters obtained by a time-domain (TD) NIRS device, which directly measures both absorption and scattering coefficients providing absolute heme concentration, with continuous wave (CW) NIRS, which assumes constant tissue scattering providing only relative measuremeents. We hypothesized that **functional indexes assessed during vascular ischemia and reperfusion could differ between NIRS technologies due to changes in tissue light scattering**.

METHODS

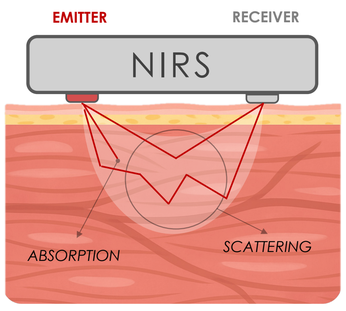
Participants

	AGE	WEIGHT	HEIGHT
YOUNG N = 18	year	kg	cm
	26±5	74±9	179±7
ELDERLY N = 18	68±3	86±14	176±6

Experimental set-up

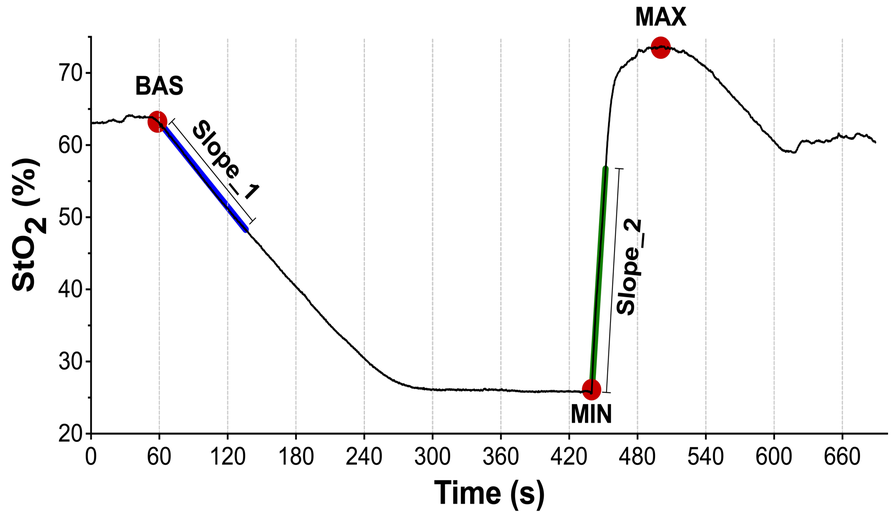
Participants sat with hips and knees flexed at 90° and 180°, respectively. They were equipped with CW and TD NIRS devices on vastus lateralis and vastus medialis muscles, respectively. A rapid-inflation pressure-cuff was placed at the inguinal crease of the thigh and attached to an electronically controlled rapid cuff-inflator.

CW spectroscopy assumes constant scattering, providing concentration changes from baseline absorption



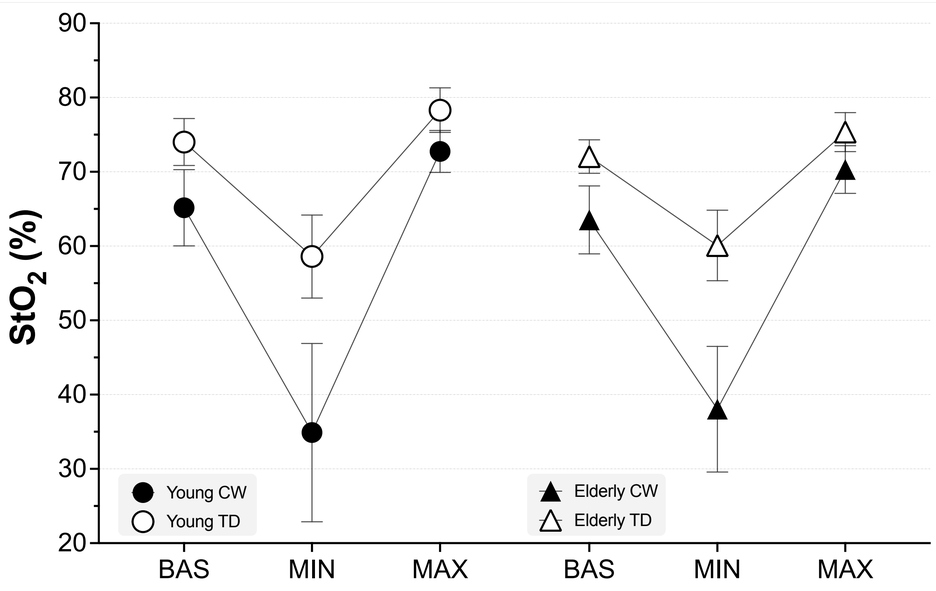
TD spectroscopy directly measures absolute heme concentrations via absorption and scattering.

Functional indexes assessed to evaluate muscle microvascular function



Vascular Occlusion Test (**VOT**) consisted of 1-minute resting **baseline (BAS)**, arterial prolonged ischemia until **StO_2 desaturation** reached stable values for at least 30 seconds (**MIN**), and complete **vascular reperfusion** to identify the maximal StO_2 value (**MAX**). The initial rate of StO_2 change following occlusion (**Slope_1**) was calculated using linear regression applied to the first 60 seconds of the ischemic phase and utilized as an indicator of muscle oxygen consumption ($m\dot{V}O_2$). The **reperfusion rate** (**Slope_2**) was identified as the linear 10s rise of StO_2 after cuff deflation and used as proxy for endothelial function.

RESULTS



3WAY-ANOVA (TIME x INSTRUMENT x GROUP)	
Time	*.001*
Group	*.483*
Instrument	*.001*
*Time * Group*	*.058*
*Time * Instrument*	***.001***
*Time * Instrument * Group*	*.693*

Figure 1. StO_2 values at different stages of the VOT. StO2 changed during the protocol. CW vs TD **values were device-dependent**

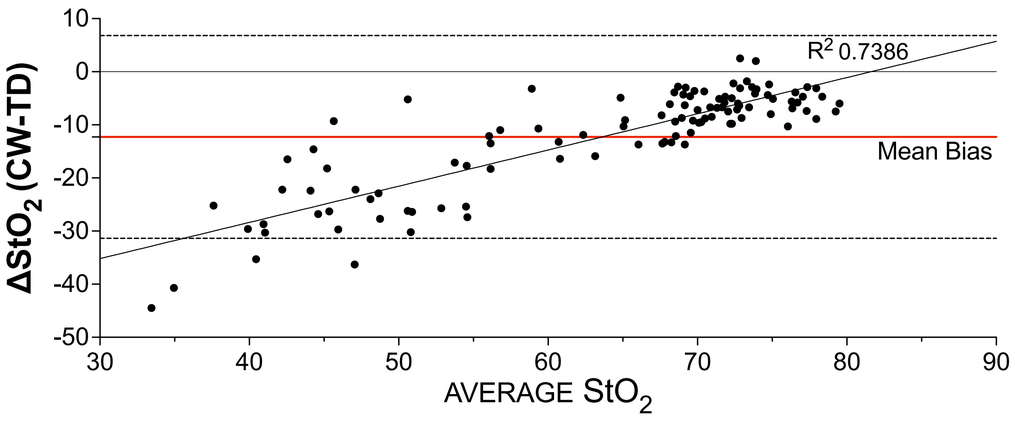


Figure 2. Bland-Altman plot illustrating a **consistent (around 10%) bias between devices**, which increases as StO_2 values decrease.

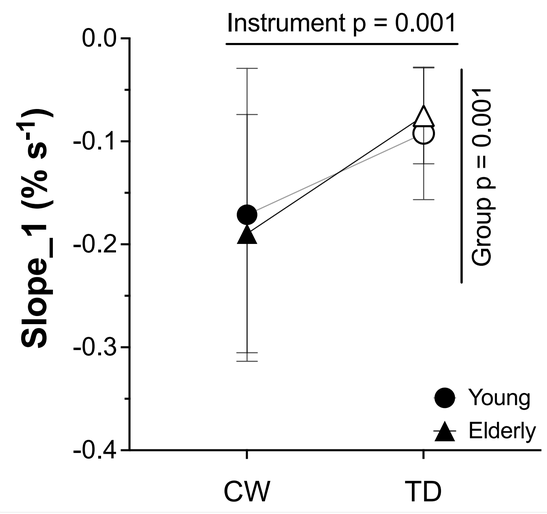


Figure 3. Slope_1 values across different devices and age groups analysed with 2WAY ANOVA. **Resting muscle oxygen consumption were different among devices.**

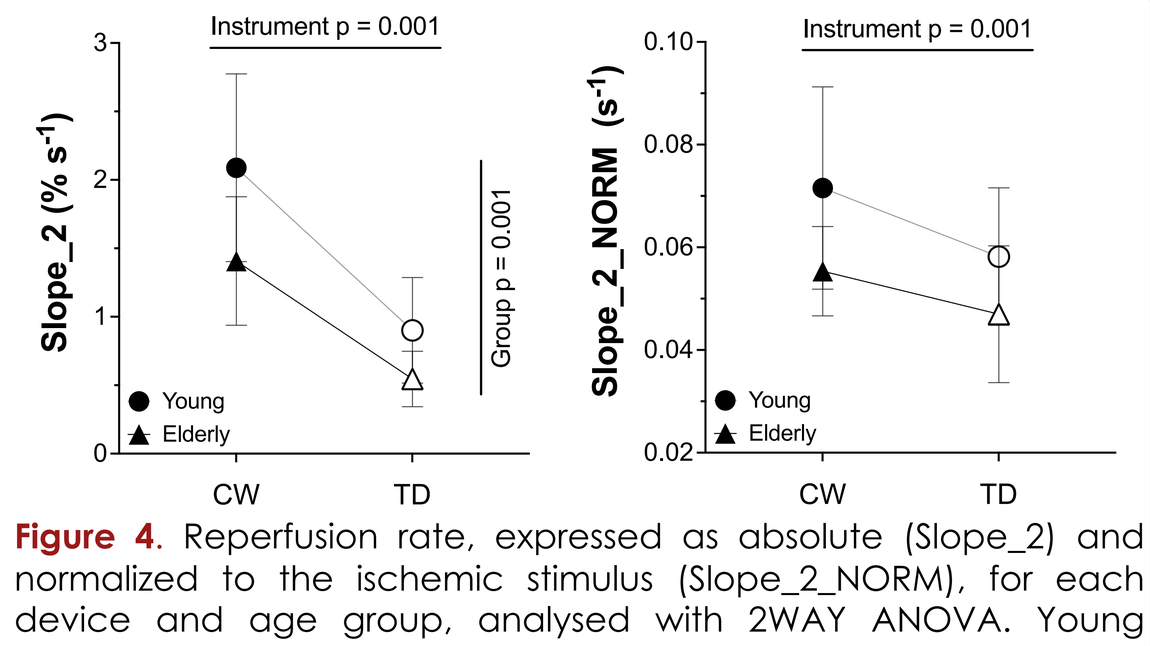


Figure 4. Reperfusion rate, expressed as absolute (Slope_2) and normalized to the ischemic stimulus (Slope_2_NORM), for each device and age group, analysed with 2WAY ANOVA. Young showed higher values compared to elderly. **The estimation of vascular responsiveness was affected by different decives.**

CONCLUSIONS

Significant differences across devices and age groups were observed, confirming previous findings where frequency-domain NIRS data were compared to those calculated assuming constant scattering in young participants [4]. Thus, **caution is needed when comparing NIRS-derived values from different devices and establishing device-specific reference frameworks is crucial** to reliably differentiate physiological from pathological values, particularly when different populations are investigated.

LIMITATIONS

Different quadriceps sites were utilized, but there is no evidence about differences in VL and VM muscle responses from rest to exercise [5,6].

REFERENCES: *[1]Grassi, 2016, J Biomed Opt [2]Barstow, 2019, J Appl Physiol [3]Soares, 2020, Micr Res [4]Hammer, 2019, J Appl Physiol [5]Okushima, 2015, J Appl Physiol [6]Chin, 2011, J Appl Physiol*

UNIVERSITÀ DI PAVIA

PIONIRS