Changes in muscle optical proprieties during prolonged bed-rest and subsequent rehabilitation in young subjects via a time domain NIRS tissue oximeter

Motto C.,[1] Marciano A.,[3] Crecchi M.,[3] Pilotto A. M.,[3] Porcelli S.,[3] Torricelli A.,[2] and Lacerenza M.[1]

[1]PIONIRS s.r.l., Milano, Italy; [2]Department of Physics, Politecnico di Milano, Milano 20133, Italy; [3]Dipartimento di Medicina Molecolare, Università di Pavia, Pavia, Italy lacerenza@pionirs.com

Introduction: Near-infrared spectroscopy (NIRS) is a noninvasive methodology classically utilized to determine the concentration of light-absorbing chromophores in biological tissues [1]. The robustness of the tissue oxygenation/deoxygenation estimates obtained by classical continuous wave NIRS equipment is affected by changes in cutaneous and subcutaneous tissue characteristics (i.e. melanin, adipose tissue), muscle fiber architecture, capillary distribution and mitochondrial function [2,3]. Time domain (TD) NIRS oximetry, providing direct estimation of absorbance (μ_a), and reduced scattering (μ'_s), is becoming a more reliable tool to track changes in the matching between oxygen delivery and utilization occurring within the muscle [3,4]. Prolonged muscle disuse, classically simulated by bed-rest study, induces prominent changes in skeletal muscle structure, microvasculature and muscle oxidative capacity [5]. However, no data are present to describe the effects of bed-rest on optical characteristics of skeletal muscle. In this study TD-NIRS was used to monitor changes in muscle oximetry during prolonged bed-rest and subsequent rehabilitation in young subjects.

Methods: Nine (n=9) young participants (23 ± 4 years) underwent 21 days of bed-rest and subsequent 3 weeks of endurance-based rehabilitation. A TD-NIRS commercial tissue oximeter (NIRSBOX, PIONIRS srl, Italy) was employed to monitor the evolution of optical parameter (μ_a, μ'_s, DPF) and retrieve HHbMb, HbMbO2, HbMbtot and SmO2. Data (10-s duration, with an acquisition frequency of 10 Hz) were acquired on the vastus lateralis muscle of each subject in five consecutive sessions: pre-bed rest, after 9 days and after 20 days of bed rest, immediately post-bed rest, and post-rehabilitation. Statistical analysis was performed using one-way ANOVA for repeated measurement, with paired t-tests post-hoc comparison to identify significant differences (Holm-Bonferroni's corrected p-value < 0.05) between measurement points.

Results: After bed rest, a 15% increase of μ'_s values were registered, from pre-bed rest values of 11.5 ± 0.8 cm-1 (685 nm) and 10.6 ± 0.6 cm-1 (830 nm). Pre-bed rest values of DPF (5.1 ± 0.8 (685 nm) and 4.8 ± 0.7 (830 nm)) increased of 14% after 20 days of bed rest. Trends towards baseline conditions post-bed rest and after the retraining period were recorded. Related variations in skeletal muscle tissue oximetry estimates were also observed.

Conclusions: Bed rest significantly affected optical parameter (μ_a, μ'_s, DPF) of muscle tissue. TD-NIRS measurements should be taken into consideration to track changes in the tissue oxygenation/deoxygenation estimates after interventions affecting muscle optical characteristics.

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