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RELATIONSHIP BETWEEN HANDGRIP SUSTAINED SUBMAXIMAL EXERCISE AND PREFRONTAL CORTEX OXYGENATION

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1. INTRODUCTION

Fatigue might be defined as an exercise-induced loss of power- or force-generating capacity.[1] It has not been fully clarified what the effect is of fatiguing skeletal muscle exercise on brain, and in particular on ipsi- and contralateral prefrontal cortex (PFC). A recent functional magnetic resonance imaging (fMRI) study[2] demonstrated that during sustained muscle contractions there is a progressive involvement of the ipsilateral and contralateral PFC, whose activation may be involved in processing fatigue-related feed-back and/or adjusting the descending command for the ongoing task.[3]

Functional near infrared spectroscopy (fNIRS) has been used to monitor brain oxygenation changes over the motor cortex in a wide variety of exercise modalities: finger opposition,[4] finger tapping,[5] finger flexion/extension,[6] palm squeezing,[7] plantar flexion,[8] and walking.[9] Prefrontal cortex oxygenation response upon exhaustive cycling exercise was also investigated.[10-12]

The aim of this study was to assess bilateral PFC oxygenation during a sustained submaximal handgrip isometric exercise by two-channel fNIRS.

2. METHODS

Twelve right handed volunteers (age: 28.5±4.1 yrs) participated in this study. Subjects were physically active although none were engaged in daily, intensive or

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specific training programs. All subjects gave their informed consent prior to participation after a full oral and written explanation of the experiments.

All subjects performed the motor task consisting of 4-min continuous isometric contraction at 30% of their maximal voluntary contraction (MVC) while their forehead was monitored by fNIRS (Fig. 1). The study was performed in a quiet room. For oxy- and deoxyhemoglobin (O_2Hb and HHb) measurements, a 2-channel NIRS oximeter (NIRO-300, Hamamatsu, Japan) was employed. The two sets of emission and detection NIRO-300 probes were attached bilaterally to the forehead of the subjects. In each set, the emission and detection probe were kept at a constant geometry and distance (5 cm apart) by a rubber shell that in turn was attached by a double-sided adhesive sheet. The detection probes were placed in correspondence of Fp1 and Fp2 of the 10-20 system for the EEG electrode placement with the emission probes being lateral by 5 cm on both sides approximately at F7 and F8, respectively. The anterior part of the prefrontal area, including Brodmann areas 9 and 10, may be the main area of contribution to the NIRS measurements. NIRS data were collected at the frequency of 6 Hz and transferred on-line to a computer for storage and subsequent analysis. The quantification of O_2Hb and HHb concentration changes, expressed in $\Delta\mu M$, was obtained by including an age-dependent constant differential pathlength factor $(4.99 + 0.067 * age^{0.814})$.[8]

Handgrip force was measured by a system consisting of a handgrip device and a digital handgrip analyzer (MIE, Medical Research, UK) (Fig. 1). The system in turn was connected to a computer for data acquisition and analysis (Mie Cas software). The pliers were fixed in vertical position to a rigid support (Fig.1). The grip span was 2 cm, and the exact point where the subject had to grasp was marked, in order to standardize the testing conditions. Subjects exerted handgrip contractions to match the output force to the target figure on a digital display. The sampling rate for force data was 33 Hz. MVC handgrip force was measured before the experiment itself (one day before) in each subject. The MVC value was calculated by averaging the measures over 5 trials. Heart rate (HR) was measured by a pulse oximeter (Nellcor N-200, USA).

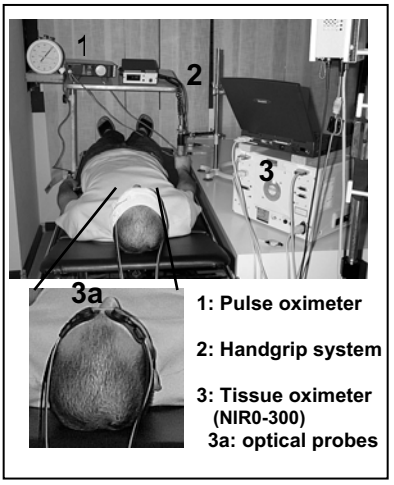

Figure 1. Experimental set-up