EFFECTS OF PROLONGED STANDING ON OXYGEN SATURATION IN THE SOLEUS AND ERECTOR SPINAE MUSCLES OF THE LOWER BACK USING NEAR INFRARED SPECTROSCOPY

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INTRODUCTION

Occupations, such as supermarket cashiers, health care employees, and assembly line workers, require workers to stand for prolonged periods of time. This has been associated with injury and health problems including lower extremity discomfort, low back pain, swelling of the lower limbs, and lower extremity venous blood restriction [1]. It is important to understand the reasons for the onset of fatigue and discomfort during prolonged standing in order to minimize these health problems. Psychophysical metrics, such as questionnaires that rate perceived levels of discomfort and fatigue can yield important insights, however are limited. Quantitative measures, such as electromyography (EMG), leg volume, underfoot center of pressure, and skin temperature, have also been used, but the findings are equivocal [1]. Therefore, new methods of exploring fatigue and discomfort due to long-term standing are needed.

Near infrared spectroscopy (NIRS) is a non-invasive technique that measures changes in absorption of near infrared light by oxyhemoglobin and deoxyhemoglobin to determine the change of oxygen saturation (SO₂) in a muscle over a period of time. A muscle experiences a decrease in SO₂ when it fatigues during a maximal voluntary contraction (MVC) followed by an increase in SO₂ immediately afterwards [2].

The goal of this pilot study was to compare perceived discomfort in selected regions of the lower extremity to changes in muscle SO₂ of the respective regions during prolonged standing on a hard surface. Based on previous findings, our hypothesis was that SO₂ will decrease in selected muscles of the lower extremity as participants experience lower extremity discomfort and fatigue during prolonged standing.

METHODS

Four healthy subjects (age: 23.2 ± 3.4 y; weight: 79.5 ± 19.0 kg) completed the testing protocol. Subjects were asked to stand still on a hard surface while keeping both feet on the ground for a duration of six hours with two minute sitting breaks after each hour. All subjects were given the same type of shoes and socks to wear throughout the testing session. A questionnaire was administered at the beginning of the session and every subsequent half hour of standing, which asked subjects to rate their perceived level of discomfort using a CR10 Borg scale. They rated their perceived level of discomfort in their upper and lower back, hips, upper legs, knees, lower legs, ankles, and feet ranging from 0 (no discomfort) – 10 (extreme discomfort) in a nonlinear fashion. Ratings of 11, “~”, and “.” were also an option to represent maximal discomfort [3].

NIRS was used to record SO₂ in the lateral portion of the soleus muscle and erector spinae muscle in the L3-L5 region of the lower back. The change in SO₂ (ΔSO₂) was calculated after each hour, defined as the average SO₂ of the final five minutes of the hour minus the average SO₂ during five minutes of initial baseline standing. Perceived discomfort ratings in the feet and lower back at the end of each hour were respectively compared to the ΔSO₂ in the soleus and erector spinae muscles after each hour.

RESULTS AND DISCUSSION

The perceived level of discomfort for the feet and
lower back were transformed to a linear Borg scale ranging from 6-23 with six corresponding to no discomfort at all [3]. Results of the ΔSO₂ in the soleus and perceived discomfort rating in the feet are plotted to show trends over each hour spent standing and across subjects (Fig. 1).

As expected, the perceived discomfort level in the feet and lower back gradually increased over the six hours spent standing on the hard surface for all subjects. Unexpectedly, the ΔSO₂ in the soleus suggested increases over time spent standing for subjects S02, S03, and S04 while subject S01 experienced little or no change. The ΔSO₂ in the erector spinae muscle showed more variation over time and across subjects. Subjects S02 and S03 showed large increases after the first hour whereas subjects S01 and S04 showed varying trends of increases and decreases of ΔSO₂ across each hour.

The unexpected increase in SO₂ over time in the soleus and lower back erector spinae muscles could be due to the slow contractions experienced during long term standing. Previous research has related muscle fatigue during MVCs to decreased SO₂; however, during prolonged standing, the soleus and erector spinae muscles are never fully exerted. Instead, they undergo low intensity contractions that occur over a longer period of time. These contractions may cause a small influx of oxygenated hemoglobin to the muscles which increases SO₂.

Results of the ΔSO₂ in the erector spinae muscle in the L3-L5 region and perceived discomfort rating in the lower back are plotted to show trends over each hour spent standing and across subjects (Fig. 2).

The unexpected increase in SO₂ over time in the soleus and lower back erector spinae muscles could be due to the slow contractions experienced during long term standing. Previous research has related muscle fatigue during MVCs to decreased SO₂; however, during prolonged standing, the soleus and erector spinae muscles are never fully exerted. Instead, they undergo low intensity contractions that occur over a longer period of time. These contractions may cause a small influx of oxygenated hemoglobin to the muscles which increases SO₂.

**REFERENCES**


**ACKNOWLEDGEMENTS**

Thank you to Dr. Patrick J. Sparto and the Medical Virtual Reality Center for the use of laboratory space and to Nancy Beluk and the Magnetic Resonance Research Center for help with equipment.