Passive Knee Exoskeleton Reduces Quadriceps Muscle Activation During Downhill Skiing: A Pilot Study

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***Abstract*— This work examines the effects of the AGAINER Ski Exoskeleton, designed to assist the upper leg muscles during downhill skiing. Thigh muscle activity was analyzed during controlled (squat) and realistic (ski) conditions. Promising results were observed on quadriceps activity reduction.**

I. Introduction

The AGAINER Ski Exoskeleton (SIA SKIPPI, Riga, Latvia) is a passive knee exoskeleton with adjustable gas springs [1]. It is intended to relieve leg muscles by providing an extension moment at the knee, assisting the user in sustaining a squat-like position during downhill skiing. The purpose of this pilot study was to investigate the exoskeleton's effect on thigh muscles; we hypothesized that the exoskeleton's extension moment would reduce quadriceps muscle activity.

II. Methods

A. Squat Trials

Data were collected from one healthy subject wearing the exoskeleton and a pair of ski boots. The subject performed five squats under each the following conditions: without the exoskeleton (No Exo), with the exoskeleton deactivated (Exo OFF), and with the exoskeleton at three pressure/assistance levels (Exo 10, Exo 15, Exo 20; pressure measured in bar). Unilateral electromyography (EMG) data were collected from the rectus femoris (RF), vastus lateralis (VL), biceps femoris (BF), and semitendinosus (ST) muscle groups.

B. Downhill Ski Trials

EMG data were also collected from one healthy subject downhill skiing through an evenly-spaced slalom-style course. The course required three turns on each the right and left side. Ski trials were performed by the subject under three conditions: No Exo, Exo OFF, and Exo 15.

C. Data Analysis

Across all trials, the EMG data were high-pass filtered (20 Hz, fourth-order), full-wave rectified, and then low-pass filtered (6 Hz, second-order). The EMG data for each muscle were subsequently averaged across trials and normalized by the average EMG value of the No Exo condition.

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III. Results

During the squat trials, RF and VL activity decreased with assistance level, whereas BF and ST increased while wearing the exoskeleton (Fig. 1, top). During the ski trials, RF and VL activity decreased by approximately 40% with the exoskeleton, whereas BF activity increased and ST activity decreased slightly (Fig. 1, bottom).

IV. Discussion

In general, the exoskeleton decreased quadriceps activity while increasing or having no effect on hamstrings activity. Additionally, quadriceps activity decreased with increasing exoskeleton pressure, and also decreased when the exoskeleton was worn but deactivated. Limitations of this work include the small number of trials, subjects, and testing conditions, and will be addressed in future work.

References

[1] "Againer-ski," http://againer-ski.com/, accessed: 2019-04-08.

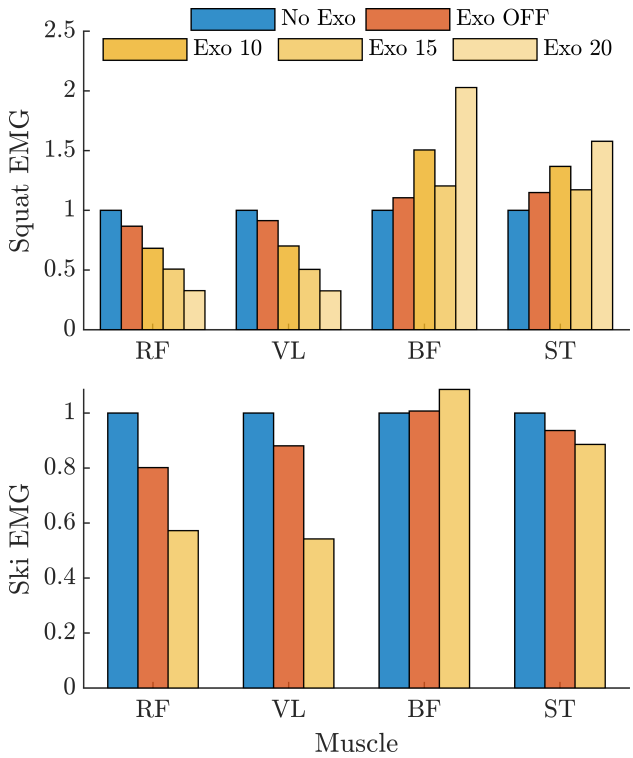

Fig. 1. AGAINER Ski Exoskeleton reduces average EMG in the quadriceps, but not hamstrings, during (top) squat and (bottom) ski trials.