Assessing the Effects of a Passive Back Support Exoskeleton on Gross Lumbar Proprioception & Neuromuscular Control

Shawn M. Beaudette, Emma J. Ratke, Jayson Woodall, Aurora Battis
Department of Kinesiology, Faculty of Applied Health Sciences, Brock University, St. Catharines ON, CAN
Email: sbeaudette@brocku.ca

Summary

Passive back support exoskeletons can reduce the activation of paraspinal musculature during forward flexion. The preliminary results of this work suggest that these devices can alter both the (1) proprioceptive acuity at mid-range lumbar flexion, and (2) the neuromuscular control of the paraspinals during maximum forward flexion tasks. These findings add to the growing body of literature relating to the use of passive back-supporting exoskeletons.

Introduction

Passive back support exoskeletons (BSEs) are an emerging assistive technology which have been designed to offload the lumbar spine, thereby potentially preventing low back injuries in occupational settings [1]. Evidence suggests that BSEs can reduce paraspinal muscle activation, perceived fatiguability, and can improve worker productivity [2]. It is likely that reductions in paraspinal muscle activation are generated through an increase in the passive rotational stiffness of the lumbar spine, with such changes affecting both the timing and magnitude of paraspinal muscle activation during forward flexion [3]. At present it is unclear whether the increase in lumbar passive rotational stiffness generated through a BSE can affect both (1) the timing of paraspinal muscle activation during forward lumbar flexion (i.e., the flexion relaxation phenomenon; FRP) or (2) measures of lumbar proprioception, which are affected, in part, by the activation of the surrounding musculature (i.e., fusimotor drive). Therefore, the purpose of the present study was to explore the effects of a commercially available BSE on the timing of paraspinal muscle activation during forward flexion, and measures of lumbar proprioception.

Methods

A cross-sectional, repeated measures design was used with a current convenience sample of 9 (5 male) participants (mean age 22.4 ± 0.31y, height 175.9 ± 1.13cm, mass 76.0 ± 1.84kg), who completed forward flexion active re-positioning tasks and full spine flexion tasks across five conditions - with and without a BSE (HeroWear, Apex2). Participants were outfitted with body-worn IMU (XSens, Awinda; fs=60Hz) and EMG (Noraxon, Ultium; fs=2000Hz) equipment to measure lumbar flexion/extension kinematics and time varying activation of the lumbar erector spinae musculature (L3) bilaterally. Raw data were processed to resolve outcomes related to proprioception (i.e., neutral and mid-range targeting error), and FRP (i.e., the lumbar flexion angle associated with eccentric and concentric erector spinae onset/offset events). Preliminary results have been assessed using one-way ANOVA, and Tukey-Kramer post hoc analyses with effect sizes interpreted using a partial eta-squared test statistic (η_p^2).

Results and Discussion

Preliminary findings pertaining to the effect of a BSE on lumbar proprioception and FRP are presented in Figure 1. At present, no statistically significant effects exist regarding either outcome class, although some effects are beginning to emerge. Specifically, (1) mid-range proprioception appears to be improved when the BSE is active ($\eta_p^2 = 0.2268$), and (2) the paraspinal musculature appears to remain inactive for a larger component of a full-flexion movement (i.e., earlier eccentric offset, later concentric onset; $\eta_p^2 = 0.1358$).

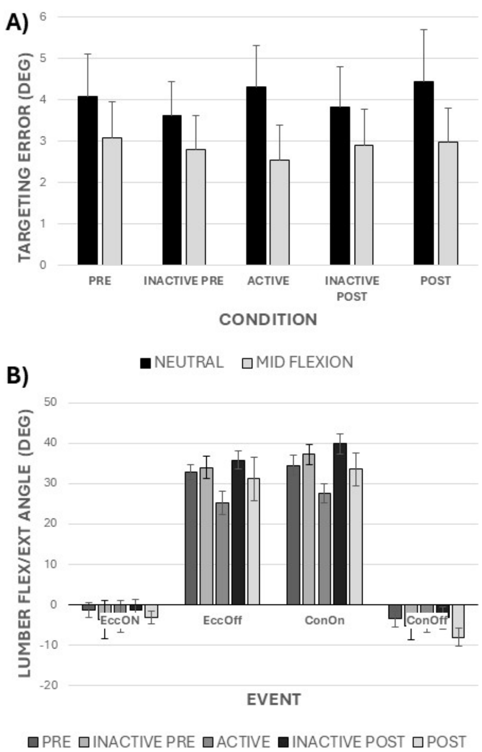

Figure 1: Preliminary proprioception (A) and FRP (B) results.

Conclusions

Although further sampling is ongoing, these preliminary data suggest that commercially available BSEs can affect both lumbar proprioception as well as the neuromuscular control of maximum lumbar flexion tasks.

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References

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