BIOMECHANICALLY-ASSISTIVE GARMENT OFFLOADS LOW BACK DURING LEANING AND LIFTING

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INTRODUCTION

Low back pain is the leading cause of limited physical activity, affecting 80-85% of adults in their lifetime [1]. Development of low back pain can result from elevated, prolonged and/or repetitive forces on the spine, which commonly occur during daily activities such as leaning and lifting. Wearable assistive devices (e.g., exoskeletons) are emerging as a potential means of mitigating low back injury risks and associated pain, by offloading the lumbar spine. The majority of these exoskeletal devices have bulky form-factors (designed for use in industrial settings), but are impractical for daily use at home or in other business, social or clinical settings. An appealing, low-profile alternative may be to adapt clothing by embedding structures that assist movement biomechanics. These structures could be entirely passive (springs), quasi-passive (clutchable springs), or active (actuated); where both quasi-passive and active might be controlled via feedback from wearable sensors. The purpose of this initial study was to investigate the degree to which a biomechanically-assistive garment could passively offload lumbar muscles and discs during leaning and lifting.

METHODS

We developed a biomechanically-assistive garment prototype that passively assists lumbar extension during leaning and lifting, and is sufficiently low-profile to be worn as (or under) clothing. We then tested 7 healthy subjects performing leaning and lifting tasks with vs. without the prototype to assess its effect on lumbar muscle activity, which was used as an indicator of biological tissue loading. The prototype consists of an upper-body interface (shirt), a lower-body interface (shorts), and elastic bands which run along the back, connecting the upper and lower interfaces (Fig. 1A). As the user leans forward, the elastic bands stretch, providing a lumbar extension moment, which reduces moments required by the muscles. Because the elastic bands act with larger moment arms about the spine (than muscles), they provide equivalent extensor moments with smaller force magnitudes, resulting in reduced compressive forces on the spine. Subjects performed 10 trials: (3 leaning angles + 2 lifting weights) x (2 conditions, i.e., with and without the prototype), while we recorded kinematics, force and electromyography (EMG) data. Each subject gave informed consent prior to participation. Subjects leaned forward to a pre-determined angle (30°, 60°, 90°) for 30 seconds while holding a 4.5 kg weight to their sternum. Subjects then lifted a weight (12.7 or 24 kg) using a squat posture. Mean and peak EMG were the main outcomes for the leaning and lifting trials, respectively. Intersubject means and standard deviations were computed. T-tests were performed to assess significance (alpha = 0.05).

RESULTS AND DISCUSSION

Wearing the prototype during leaning and lifting tasks reduced erector spinae EMG activity (Fig. 1B). Mean EMG was reduced by 15% ± 19% ($p=0.07$), 27% ± 10% ($p=0.001$) and 43% ± 33% ($p=0.02$) for the 30°, 60° and 90° leaning conditions, respectively (Fig. 1C). Peak EMG was reduced by 10% ± 22% ($p=0.12$) and 11% ± 22% ($p=0.07$) for the 12.7 kg and 24 kg lifting trials, respectively.

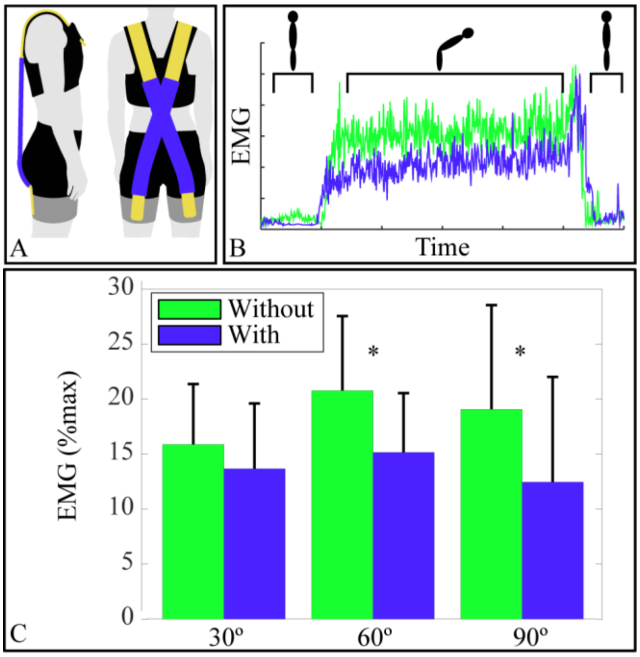

Figure 1: (A) Wearable prototype. (B) Representative EMG vs. time plot for leaning. (C) Mean erector spinae EMG was reduced during leaning With (blue) vs. Without (green) the biomechanically-assistive garment prototype.

These EMG reductions suggest that the prototype reduced lumbar muscle forces. Since these muscle forces constitute the majority of compressive force on the lumbar spine [2], these findings suggest that lumbar disc loading may also be reduced. These results demonstrate the feasibility of biomechanically-assistive garments to reduce lumbar muscle and disc loading, which may help mitigate overuse and/or overloading risks that can lead to low back injury and pain. Future prototypes will integrate quasi-passive structures and wearable sensors in order to control the magnitude and timing of assistance.

CONCLUSIONS

We found that passive, biomechanically-assistive garments are capable of offloading low back muscles, and potentially discs, during leaning and lifting, which may reduce force-induced injury risks.

ACKNOWLEDGEMENTS

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