Description of proposed research

Research abstract

Research Problem: Low back pain affect many millions of people worldwide and is a primary cause of disability impairing health and normal activities of daily living.

Significance: Novel device that can be used at home by an individual has been developed to potentially decrease low back pain compression and pain.

Objective: Objectives would be to investigate the acute and chronic effects of the novel trunk decompression device on individuals with chronic low back pain.

Methods: After an acute session of the trunk decompression device, participants would be monitored with ultrasonography for changes in lumbar vertebral disc distance. Participants would also be measured for changes in lower back range of motion, neuromuscular efficiency (the extent of muscle electromyographic activity to sustain a relative load), muscle activation during a lifting task, back extension endurance (Beiring Sorensen test), and pain pressure threshold. Similar measures would be implemented after a 4-week training program in individuals suffering from chronic low back pain.

Background and review of relevant prior work

Low back pain (LBP) stands as the primary cause of global musculoskeletal disability. It results in separation from work and is the most common cause of disability among individuals under the age of 45 (US Department of Health and Human Services 1994). Back pain is the most expensive industrial health/injury problem (Snook and Stover 1987). Many methods for diagnosing and addressing LBP have emerged, resulting in a significant rise in healthcare expenditures. Paradoxically, this surge has coincided with an increase in disability and the persistence of the condition (O'Sullivan et al., 2016). Chronic pain conditions, especially musculoskeletal disorders impose a huge burden on human society and the healthcare systems (Pincus et al., 2010). For example, hundreds of millions of people suffer from disorders like low back or neck pain (Hurwitz et al., 2018). Despite improvement in understanding of the contributing factors to the development of these conditions, there has been only a moderate improvement in their successful treatment (Van der Windt et al., 2008).

The neuromuscular adaptations to these conditions are listed as the changes in muscle activity, kinematics, muscle properties, sensorimotor control, and performance (Devecchi et al., 2021). The importance of these neuromuscular adaptations to the musculoskeletal disorders has resulted in extensive investigations as changes in these features may contribute to pain resistance or recurrence (van Dieen et al., 2017). In this regard,

adaptations in muscle activity, kinematics and sensorimotor control have been reported in the affected populations (van Dieen et al., 2019). These adaptations may extend beyond the duration of painful episodes of the disorders and could lead to potential long- term consequences (Hodges, 2011). It is common for chronic low back pain to have decreased stabilizing muscle coordination and function (Biering-Sørensen, 1984; Enthoven et al., 2003). Reduced back endurance has been demonstrated to be a predictor of both long-term back-related disability (Enthoven et al., 2003) and the occurrence of first-time chronic low back pain (Biering-Sørensen, 1984). Trunk muscle fatigue can exacerbate neuromuscular deficiencies, which can lead to back pain, unstable lumbar spine, and brief uncontrolled intervertebral movements (Granata & Gottipati, 2008).

Studies of individuals with and without low back pain for example, have shown differences in voluntary muscle activation (van Dieen et al., 2003), muscle reflexes (Radebold et al., 2000), kinematics (Larid et al., 2014), cortical sensory inputs from (Flor et al., 1997) and motor outputs to (Tsao et al., 2011) the trunk. For example, both an increase and a decrease of trunk muscle activation in individuals with low back pain has been shown in the literature (van Dieen et al., 2003). With healthy conditions, the central nervous system is assumed to use an optimal control pattern to achieve the task goal at a minimal energetic cost (Van Dieen et al., 2017). Efferent motor commands and the resultant feedback of the motor actions provide the information on performance and associated costs, allowing the individual to adapt the motor commands to achieve the task goal with minimal costs (in terms of neural drive, or mechanical costs of muscle force production) (Van Dieen et al., 2017). However, numerous studies have reported that the central nervous system (CNS) can undergo plastic (semi-permanent) reorganization following musculoskeletal disorders (Roy et al., 2017).

Although different exercises have been commonly used as a treatment in reducing pain and disability like low back pain, the effect size is not large (Saragiotto et al., 2016) and interventions have shown at best only moderate effects (Chou and Hoffmann, 2007). A better understanding of the nature and the mechanisms behind the adaptations to the disorders are crucial for more effective treatments (van Dieen et al., 2017). Various devices and methods have attempted to relieve back pain, but none have proven significantly effective and consistent in pain reduction. Therefore, it is essential to develop a non-invasive, portable, cost-effective, and user-friendly solution that can be used conveniently at home.

General objective:

The objective of the research is to examine acute and chronic (4 weeks of training) changes in structural (i.e., lumbar vertebral disc height), kinetic (forces), kinematic (i.e. range of

motion), ergonomic (e.g., lifting task), low back muscle activation (EMG) and sensory perception (i.e., visual analogue scales for pain and pain pressure thresholds).

Specific objectives of the internship or subproject.

a) muscle activation (neuromuscular efficiency: EMG / load) as well as pain pressure thresholds during a lifting task of a relative load and an isometric back extension endurance to task failure and range of motion with shoulders experiencing chronic pain.

b) the variability between synergistic muscles (e.g., hamstrings versus lumbar erector spinae) during a functional lifting task and a back extension endurance test (Beiring Sorensen test).

Methodology

Individuals suffering from idiopathic chronic low back pain would be recruited to participate in an acute exercise session and thereafter a 4-week training program. A novel trunk decompression device involving applying pressure with the device on the upper thighs while supine and hips flexed has been reported anecdotally to reduce pain symptoms and associated movement dysfunctions.

Pre- and post-testing in the acute session would include morphological, physiological and practical measures. Participants would also be measured for changes in lower back range of motion (e.g., sit and reach), neuromuscular efficiency (the extent of muscle electromyographic (EMG) activity to sustain a relative load of 20% of body mass), with an isometric hold and during a lifting task, back extension endurance (Beiring Sorensen test), while assessing pain subjectively with a visual analogue scale and quantitatively by a pain pressure threshold ergometer. The flexion relaxation response (EMG reduction or quiescence at full trunk flexion, which can contribute to low back injuries) is altered with LBP and thus would also be monitored. LBP-induced trunk muscles tightness or stiffness can affect proper standing and seated posture and would be monitored. Similar measures would be implemented after a 4-week training program in individuals suffering from chronic low back pain.