Available online at www.sciencedirect.com
ScienceDirect
Journal of Sport and Health Science 5 (2016) 52–60
www.jshs.org.cn

Original article

A history of low back pain affects pelvis and trunk coordination during a sustained manual materials handling task

Joseph F. Seay [a,*], Shane G. Sauer [a], Tejash Patel [b], Tanja C. Roy [a]

[a] *Military Performance Division, U.S. Army Research Institute of Environmental Medicine, Natick, MA 01760, USA*
[b] *Biophysics and Biomedical Modelling Division, U.S. Army Research Institute of Environmental Medicine, Natick, MA 01760, USA*

Received 1 March 2015; revised 20 July 2015; accepted 20 November 2015
Available online 11 January 2016

Abstract

Purpose: The purpose of this study was to compare the coordination between the trunk and the pelvis during a sustained asymmetric repetitive lifting task between a group with a history of low back pain (LBP; HBP) and a group with no history of LBP (NBP).
Methods: Volunteers lifted a 11-kg box from ankle height in front to a shelf 45° off-center at waist height, and lowered it to the start position at 12 cycles/min for 10 min. Lifting side was alternated during the trial. Continuous relative phase was used to calculate coordination between the pelvis and trunk rotation at the beginning (Min 1), middle (Min 5), and end of the bout (Min 9).
Results: While there were no main effects for group, a significant interaction between time and group indicated that, in the frontal plane, the NBP group coordination was more anti-phase toward the end of the bout, with no such differences for the HBP group. Analysis of sagittal-axial (bend and twist) coordination revealed the HBP group coordination was more in-phase at the end of the bout over the entire cycle and for the lifting phase alone, with no such differences for the NBP group.
Conclusion: Differences between groups demonstrate residual consequences of LBP in an occupational scenario, even though the HBP group was pain-free for >6 months prior to data collection. More in-phase coordination in the HBP group may represent a coordination pattern analogous to "guarded gait" which has been observed in other studies, and may lend insight as to why these individuals are at increased risk for re-injury.

Keywords: Lifting; Lowering; Occupational biomechanics; Relative phase; Relative phase variability

1. Introduction

Low back pain (LBP) has long ago reached epidemic proportions in the US, with four out of five people experiencing LBP at least once in their lives.[1,2] LBP is also the most common reason for seeking medical care for civilians[3] and military alike.[4,5] In military cohorts, back pain-related medical issues were among the top three leading causes for lost duty days for U.S. soldiers as recently as 2011.[5,6] Issues related to back pain have also ranked among the highest risk factors for permanent disability within 5 years of onset at 20%.[7]

Symptoms resolve for most individuals who experience LBP, and these individuals return to pre-injury work and activity levels pain-free within 8 weeks.[8] While the majority of healthcare resources are spent on those individuals for whom LBP lasts longer,[1] the others who return to occupational and recreational activity with a history of LBP (HBP) are more likely to experience recurring episodes of LBP. Within 1 year after initial LBP episode, epidemiological studies report recurring episodes at rates ranging from 24% to 50%.[9,10]

Research estimates that only 6%–15% of reported LBP episodes are first-time episodes;[11] with over 85% of annual LBP cases being recurrences. It is not surprising that HBP places individuals at increased risk for future episodes. This notion is supported by other studies which report 24%–50% of those who suffer initial LBP episodes have a recurring episode of LBP within 1 year,[9] and that chance of recurrence increases with age.[9] In collegiate athletes, one study reported that athletes with HBP were three to six times more likely to suffer a bout of LBP during their collegiate career than activity-matched athletes who never had LBP.[12] In the U.S. military, a high disability rate due to LBP, combined with a 19% disability rate leads to an estimate that approximately 80% of soldiers return to full duty

Peer review under responsibility of Shanghai University of Sport.
* Corresponding author.
E-mail address: joseph.f.seay.civ@mail.mil (J.F. Seay).

http://dx.doi.org/10.1016/j.jshs.2016.01.011
2095-2546/

after LBP, and that approximately 24% of the U.S. Army can be categorized as HBP.[6,7,13]

The athletic literature has demonstrated that there are functional consequences to having HBP. Collegiate athletes with HBP, who had returned to full activity levels within their sport for quite some time, ran significantly slower on the shuttle run when compared to sport-matched controls with no history,[14] suggesting that their performance-related residual effects were associated with HBP. Also differences have been observed in walking and running mechanics between those with and without LBP. When comparing runners with mild to moderate LBP *vs.* runners with HBP *vs.* runners who have never experienced LBP (NBP), research has documented increases in knee stiffness,[15] more in-phase pelvis–trunk coordination,[16] and decreases in coordination variability.[17] These disparities are consistent with the "guarded gait" typically associated with more severe LBP.

In the ergonomic literature, studies have implied that participating in manual materials handling tasks is among the work-related factors associated with LBP.[18–21] There is also an increased risk of occupational LBP with any job task which involves the motion combinations of bending and twisting from the waist (trunk sagittal lean and rotation).[3,22,23] Such factors are also a consideration in the military, where one report indicates that slightly more than 2/3 of U.S. soldier occupational tasks involve lifting and lowering between the ground and waist height.[24] However, few studies have explored differences in lifting mechanics between individuals with and without HBP; insight into these differences could elucidate adaptations due to LBP. A recent study has reported differences in lifting mechanics between soldiers with and without HBP; specifically, individuals with HBP maintained more consistent mechanics (range of motion and angular velocity) during a 10-min lift/lower task than those with NBP.[25]

Dynamical systems measures, such as continuous relative phase (CRP) analysis, have been able to provide information on how segments interact relative to each other. Relative phase has been utilized in the past to incorporate angular position and angular velocity information over an entire motion cycle which compliments kinematic analyses.[26] Data analyzed using relative phase angle (CRPΘ) and CRPΘ variability have demonstrated differences in lower limb[27,28] and pelvis–trunk coordination[17,29] between individuals with and without LBP. Additionally, these measures can be adapted to analyze segmental interactions which incorporate asymmetric motions, such as trunk bend and twist (sagittal bend and axial rotation) during running.[30] Using such techniques to analyze interactions between the pelvis and trunk during a manual materials handling paradigm will allow for additional insights into the "bend and twist" motions associated with occupational LBP.

The purpose of this study was to compare the coordination and coordination variability profiles of the trunk and the pelvis during a sustained asymmetric repetitive lifting task between an HBP and an NBP group during a repeated box lift/lower paradigm. We chose a 10-min asymmetric lift/lower paradigm in order to simulate a typical time-modulated occupational scenario. We chose a box mass of 11 kg and cadence of 12 lift/lower cycles/min in order to provide sufficient physical stress to elicit any time-related differences between the groups and to ensure that all participants were performing the same amount of work at the same rate, while maintaining the safety of our participants with HBP. We hypothesized that the HBP group would demonstrate different coordination mechanics over time as compared to the NBP group. Specifically, we expected the HBP group to display more in-phase coordination (CRPΘ; values closer to 0), which would represent "guarded mechanics" often associated with LBP during gait. Consistent with previous coordination findings,[29] we also hypothesized that the HBP group would demonstrate decreased coordination variability, demonstrating a decreased ability to adapt after the resolution of LBP and/or over time.

2. Materials and methods

2.1. Participants

Twenty healthy male soldiers gave informed consent to participate in this study. Ethical approval was granted by the U.S. Army Research Institute of Environmental Medicine's institutional review board. The investigators adhered to the policies for protection of human subjects as prescribed DoD Instruction 3216.02 and the research was conducted in adherence with the provisions of 32 CFR Part 219. Participants were asked about their history with LBP. LBP was defined as pain, soreness, or tightness that prevented a person from performing their usual duty or training regimen for more than 3 days. Because we were interested in non-specific LBP, participants were excluded from participation if they reported that their LBP was the result of traumatic injury, or if they were medically diagnosed with a slipped or bulging inter-vertebral disc. Those who had never experienced a bout of LBP were placed in the NBP group ($n = 11$; 176.8 ± 5.2 cm; 81.6 ± 14.0 kg; 26 ± 6 years). If a participant had experienced a bout of LBP that lasted less than 6 weeks and have had no symptoms for at least 6 months, then they were placed in the history of back pain group ($n = 9$; 176.4 ± 5.1 cm; 81.0 ± 11.4 kg; 24 ± 5 years). Participants were also excluded from participation if they reported any current or prior musculoskeletal injuries or medical conditions that would either interfere with their completion of the testing or that would predispose them to injury during the testing.

2.2. Equipment

A detailed description of the methods used in this study has been published previously.[25] A custom 3-shelf station was constructed for this experiment. Two platforms were affixed to the left and right of a central vertical channel, angled at 45°. Within the central channel a small step was built atop an adjustable floor (Fig. 1). Foam blocks could be inserted to adjust the floor height so that the two platforms would be at waist height of the participant standing on the flooring. The low central platform shielded the participant's feet, while creating an ankle height shelf for an 11-kg box with handles to be placed directly in front of the participant. The box was lifted and lowered from shelf to shelf at a fixed cadence maintained using a metronome (KDM-2; KORG USA Inc., Melville, NY, USA).