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Full Length Article

Tactile cues can change movement: An example using tape to redistribute flexion from the lumbar spine to the hips and knees during lifting

Brendan L. Pinto, Shawn M. Beaudette, Stephen H.M. Brown*

Human Health and Nutritional Sciences, University of Guelph, Guelph, ON, Canada

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ABSTRACT

Given the appropriate cues, kinematic factors associated with low back injury risk and pain, such as spine flexion, can be avoided. Recent research has demonstrated the potential for tactile sensory information to change movement. In this study an athletic strapping tape was applied bilaterally along the lumbar extensor muscles to provide continuous tactile feedback information during a repeated lifting and lowering task. The presence of the tape resulted in a statistically significant reduction in lumbar spine flexion when compared to a baseline condition in which no tape was present. This reduction was further increased with the explicit instruction to pay attention to the sensations elicited by the tape. In both cases, the reduction in lumbar spine flexion was compensated for by increases in hip and knee flexion. When the tape was then removed and participants were instructed to continue lifting as if it was still present, the reduction in lumbar flexion and increases in hip and knee flexion were retained. Thus this study provides evidence that tactile cues can provide vital feedback information that can cue human lumbar spine movement to reduce kinematic factors associated with injury risk and pain.

1. Introduction

Kinematic factors such as spinal flexion have been related to low back injury risk and pain (Hoogendoorn et al., 2000; Marras et al., 1995). Specifically, repeated or maximal loaded flexion can be destructive to the tissues of the spine (Adams & Hutton, 1985; Callaghan & Mcgill, 2001; Gallagher, Marras, Litsky, & Burr, 2005; Gunning, Callaghan, & Mcgill, 2001; Parkinson & Callaghan, 2009; Thoreson et al., 2017; Wade, Robertson, Thambyah, & Broom, 2014). Additionally, lifting objects with high magnitudes of trunk flexion can increase the risk of developing lower back pain (Ngo, Yazdani, Carlan, & Wells, 2017), and high magnitudes of trunk flexion have been identified as a significant risk factor for the development of occupational low back disorders (Fathallah, Marras, & Parnianpour, 1998). Further, lumbar flexion can contribute to increased injury risk during lifting movements because lumbar anterior shear forces are increased in flexion (Potvin, McGill, & Norman, 1991), and the erector spinae muscles are less effective at resisting/combating such forces in this position (Harriss & Brown, 2015; McGill, Hughson, & Parks, 2000). Moreover, the sagittal plane moment arms of the erector spinae muscles decrease as the trunk flexes (Jorgensen, Marras, Gupta, & Waters, 2003), such that these muscles need to generate higher relative forces to meet moment demands. Low back pain patients commonly report initial aggravation and re-aggravation of pain during flexion movements (O'Sullivan, 2000). Purposely avoiding lumbar flexion in those who are flexion intolerant has the potential to provide immediate pain relief (Ikeda & McGill, 2012). Given appropriate cues

* Corresponding author at: Department of Human Health and Nutritional Sciences, University of Guelph, 50 Stone Rd East, Guelph, ON N1G 2W1, Canada.
E-mail address: shmbrown@uoguelph.ca (S.H.M. Brown).

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and feedback, an individual's motions can be changed to avoid kinematic risk factors, such as spine flexion (Frost, Beach, Callaghan, & Mcgill, 2015).

Common methods of cueing a change in motion include visual and verbal feedback. However, in the case of the trunk visual cues can be challenging as individuals are not able to directly watch their back as they move, and for those who lack kinesthetic awareness verbal instruction may not be optimal. Recent research has demonstrated the potential for tactile sensory information to change how people move. For example, tactile vibration has been shown to directly influence trunk posture (Martin, Lee, & Sienko, 2015). Further, vibro-tactile cues can elicit an individual to change their direction of movement (Ross & Blasch, 2000), and can be used to cue movement changes during physical activity (Spelmezan, Jacobs, Hilgers, & Borchers, 2009). However, these cues do not necessarily elicit a specific movement/response (Spelmezan et al., 2009), but instead act as a reminder or alert, the result of which is dependent on interpretation of the cue. Tactile cues also have the advantage of shorter reaction times compared to visual and auditory cues (Godlove, Whaite, & Batista, 2014; Murata, Kuroda, & Karwowski, 2017; Scott & Gray, 2008), and the addition of a tactile cue to a visual cue has been shown to improve reaction times (Prewett et al., 2006). As spine posture changes, structural properties of the skin, including skin hardness, thickness, also change (Beaudette, Zwambag, Bent, & Brown, 2017). These structural changes affect skin stretch sensitivity, tactile acuity and touch sensitivity (Beaudette, Smith, Bent, & Brown, 2017). Using a tactile cue that provides continuous feedback about skin deformation of the lower back may help provide feedback to elicit specific changes in movement, such as reductions in lumbar spine flexion. One method of doing this would be to restrict the skin from stretching, which may cue attention to the area of restriction during motion. This hypothesis was recently successfully confirmed with the use of a liquid bandage during an experimental spine flexion task where the hips were restricted and visual, auditory and somatosensory information were attenuated (Beaudette, Pinto, & Brown, 2018).

The purpose of this investigation was to assess the effectiveness of a tactile cue (tape), applied to the lower back, in changing flexion motion of the lumbar spine during a repeated lifting/lowering task. Leukotape P was used as it provides rigidity similar to that of regular tape as opposed to the more recently popular elastic tapes that are designed to stretch with the skin. We aimed to use this rigidity to limit the skin from stretching and provide a continuous cue regarding skin stretch. It was hypothesized that participants would be able to respond to the tape on the lower back and reduce lumbar spine flexion. Further, it was expected that when given explicit verbal instruction to be attentive to the tape, participants would reduce their lumbar spine flexion further, and that this would be retained once the tape was removed. Finally, it was hypothesized that the reduction in spine flexion would be redistributed to result in increases in hip and knee flexion.

2. Methods

2.1. Participants

Healthy volunteers included 11 individuals (4 females) (mean ± SD age 23 ± 1.1 years; mass 70.1 ± 11.6 kg; height 174.2 ± 7.4 cm). Exclusion criteria were any lower back pain or injury within the last year, or allergies to adhesives or gels. A health screening questionnaire was completed by each participant that included questions about previous pain, injuries, musculoskeletal disorders and physical activity. These matters were additionally verbally discussed with participants. All procedures were approved by the local Research Ethics board.

2.2. Procedure

Participants performed repeated lifting and lowering trials under four conditions (Table 1): 1) baseline control; 2) with Leukotape (BSN Medical, Laval, QC, CAN) applied to the skin overlaying the left and right lumbar extensor muscles, from the 12th thoracic to the 1st sacral vertebra (Fig. 1) (Tape only condition); 3) with Leukotape applied and instruction to pay attention to the tape (Intention condition); 4) with Leukotape removed (Retention condition). Conditions were presented in this same order for all participants, with a minimum of 5 min of rest between each condition to mitigate the effects of fatigue. Preceding the first condition, a 5 s quiet standing trial was performed. Trials involved continuously lifting and lowering a 40.6 × 27.3 × 17.8 cm box containing 3 kg of mass, from the ground to standing, for 35 repetitions at a self-controlled pace. The mass was placed 15.2 cm away from the participant's toes and this location was marked with tape to ensure consistency between trials. The mass was selected to create a noticeable demand but avoid fatigue over the course of the 35 repetitions. Participants were instructed to lift as they normally would and were given practice lifts

Table 1
Description of the four repeated lift/lower conditions.

Condition	Description
Baseline	Repeated lifting and lowering with the instruction to lift/lower normally.
Tape	Repeated lifting and lowering with Leukotape applied, with no additional instruction.
Intention	Repeated lifting and lowering with Leukotape applied and the additional instruction to pay attention to the tape: "When the tape stretches don't let yourself bend your back further. When the tape crunches don't let your back extend further. Find a way to do the task while preventing the tape from stretching or crunching".
Retention	Repeated lifting and lowering with no tape, and the instruction: "pretend the tape is still affixed and try to pay attention to it as you did in the previous trial".