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Comparison of trunk muscle reflex activation patterns between active and passive trunk flexion–extension loading conditions

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A B S T R A C T

The aim of the present study was to determine the effects of trunk flexion–extension loading on the neuromuscular reflexive latencies and amplitude responses of the trunk musculature. Eighteen male and female subjects (18–27 yrs) participated in active and passive trunk flexion extension, performed ~7 days apart. Subjects performed 60 trunk flexion–extension repetitions. Surface electromyography (EMG) was collected bilaterally from paraspinal and abdominal muscles. In the active condition, subjects volitionally moved their trunks, while in the passive condition the dynamometer controlled the movements. The trunk was perturbed before and immediately after 30 repetitions. Latency of muscle onset, latency of first peak, latency of maximum peak, and peak EMG amplitude were evaluated. No differences between conditions, sides, or perturbation session were apparent. Overall latencies were shorter in females ($p < .05$) and abdominal muscles compared to paraspinals ($p < .05$). Thoracic paraspinal muscle amplitudes were greater than all other muscles ($p < .05$). Based upon the present results, the neuromuscular system engages trunk flexor muscles prior to the paraspinals in order to provide possible stabilization of the trunk when flexor moments are generated. Overall, the results indicate no difference in response of the neuromuscular system to active or passive repetitive loading.

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1. Introduction

The ability of the neuromuscular system to effectively respond to external perturbations is of great concern, especially when considering the ramifications loading schemes present to the health of individuals. Work related physical exertions, due to manual material handling, influence the ability of the musculoskeletal system to coordinate movements (Granata & Sanford, 2000; Marras, 2000) and may significantly contribute to low back pain (Gallagher, Marras, Litsky, & Burr, 2005; Marras, Lavender, Ferguson, Splittstoesser, & Yang, 2010). Many factors have been presented to explain the etiology of low back pain and injury, such as muscle fatigue (Granata, Slota, & Wilson, 2004), muscle fiber type distribution (Mannion et al., 2000), and repetitive loading (de Looze et al., 1996).

Neuromuscular fatigue of the low back muscles does influence the ability of the system to control movement and respond accordingly to applied forces. Postural sense (Madigan, Davidson, & Nussbaum, 2006; Taimela, Kankaanpää, & Luoto, 1999; Wilson, Madigan, Davidson, & Nussbaum, 2006), neuromuscular coordination (Gorelick, Brown, & Groeller, 2003; Potvin & O'Brien, 1998), and reflexive responses (Hermann, Madigan, Davidson, & Granata, 2006) are modified due to the inability of the neuromuscular system to effectively receive, interpret and send information to the corresponding effectors (Taylor, Butler, & Gandevia, 2000; Taylor, Todd, & Gandevia, 2006). However, there is evidence to suggest that neuromuscular fatigue may not significantly alter the latency of the reflexive responses to perturbations (Mawston, McNair, & Boocock, 2007; Sanchez-Zuriaga, Adams, & Dolan, 2010). Additionally, neuromuscular fatigue of trunk flexor and extensor muscles is observed to increase the stiffness of the spine, possibly to compensate for the reduced ability of the system to respond when a load is introduced (Grondin & Potvin, 2009). In addition, when there is a greater activation of the muscle prior to introduction of a perturbation, the reflexive response amplitude gain decreases (Stokes, Gardner-Morse, Henry, & Badger, 2000; Vera-Garcia, Brown, Gray, & McGill, 2006).

Creep and tension–relaxation behaviors in human in vivo models are documented in the low back tissues (Granata, Rogers, & Moorehouse, 2005; McGill & Brown, 1992; Olson, Li, & Solomonow, 2009; Parkinson, Beach, & Callaghan, 2004; Rogers & Granata, 2006; Shin & Mirka, 2007). Granata et al. and Rogers and Granata report increased response gains from the paraspinal muscles after mechanical creep loading schemes, as well as reduction in the reflexive response of the muscles. Similarly, others have reported the modification of the paraspinal muscle response to either prolonged (Shin, D'Souza, & Liu, 2009; Solomonow, Baratta, Banks, Freudenberger, & Zhou, 2003) or repeated trunk flexion (Dickey, McNorton, & Potvin, 2003; Olson, Li, & Solomonow, 2004; Olson et al., 2009), with most results indicating an extended activation of the paraspinal muscles. Brief periods of static loading are observed to induce passive tissue creep in the lumbar region which is believed to significantly influence the response of the mechanoreceptors within the ligamentous tissues (Rogers & Granata, 2006; Shin, D'Souza, & Liu, 2009). In feline models, prolonged mechanical loading of the spinal ligaments is observed to significantly desensitize the embedded mechanoreceptors resulting in reduced neuromuscular responses (Sbriccoli et al., 2004; Solomonow, Zhou, Baratta, Lu, & Harris, 1999; Solomonow et al., 2000). Sanchez-Zuriaga et al. (2010) report significant reflex latency increases after a prolonged paraspinal creep, but no reflex latency changes when neuromuscular fatigue was induced. Although, reflex gain was reported to increase in some paraspinal muscles post-fatigue. There is also evidence to suggest the abdominal muscles provide additional support to the trunk to assist in increased trunk stability when flexor moments are applied (Cresswell, Oddsson, & Thorstensson, 1994; Hodges, 2001).

Based upon previous experiments, the relationship between neuromuscular response of the paraspinal muscles and creep/tension–relaxation loading has been inconclusive. Likewise, fatiguing of the paraspinal muscles provides a range of information when paraspinal muscle reflexes are induced. Data are currently scarce regarding the influence of repetitive passive movement (tension–relaxation) on neuromuscular reflex response, as compared to creep protocols in humans. Therefore, the purpose of this experiment is to compare passive trunk loading and active muscle contraction conditions while subjects perform similar trunk movements. It is hypothesized that the reflexive responses from the trunk muscles will be different between the loading schemes as differences between passive and active loading of the spine have been observed previously. As a second hypothesis, it was believed the activation pattern of the abdominal muscles would compensate for the re-