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The effects of a fatiguing lifting task on postural sway among males and females

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ABSTRACT

Lifting and falls comprise a large proportion of work related injuries. Repetitive lifting to the point of fatigue can affect postural sway, which is associated with fall risk. To investigate the effects of lifting and fatigue on postural sway in males and females, 35 participants (18 male, 17 female) were asked to lift a weighted box in sets of 25 lifts at 5 different incremental weights (10, 15, 20, 25, and 30 kg) until fatigue. Before and after each lifting set, participants performed a single leg balance test on a force platform to assess postural sway by means of center of pressure mean velocity. Analysis of pre-fatigue to post-fatigue postural sway measurements indicated that there were no significant differences in mean velocity when males and females were grouped together. However, when analyzed as separate groups, mean postural sway center of pressure velocity increased for males but did not for females, indicating that males and females use different strategies to maintain balance when fatigued.

1. Introduction

In 2014, the leading causes of nonfatal work-related injuries or illnesses were overexertion in lifting (33%) and slips, trips, and falls (27%) (Bureau of Labor Statistics, 2015). Repetitive lifting can endanger the body due to the impact of muscular fatigue on soft tissues, reduced force generation capacity of the muscles, and changes in the biomechanics and kinematics of lifting (Dolan & Adams, 1998; Marras & Granata, 1997; Sparto, Parnianpour, Reinsel, & Simon, 1997). Repetitive lifting to fatigue has also been shown to decrease postural stability (Sparto et al., 1997).

Postural sway can be defined as body movement resulting from the corrective mechanisms associated with maintenance of upright posture, wherein increased sway reflects an increased effort to maintain balance (Hasan, Goldner, Lichtenstein, Wood, & Shiavi, 1990). Studies which utilized muscular fatiguing tasks have also shown an increase in postural sway as a consequence of fatigue in the lower extremities (Adlerton, Moritz, & Moe-Nilssen, 2003; Bisson, McEwen, Lajoie, & Bilodeau, 2011; Cetin, Bayramoglu, Aytar, Surenkok, & Yemisci, 2008; Gribble & Hertel, 2004; Lundin, Feuerbach, & Grabiner, 1993; Springer & Pincivero, 2009; Yaggie & McGregor, 2002), upper extremities (Nussbaum, 2003), back (Cetin et al., 2008; Davidson, Madigan, & Nussbaum, 2004; Madigan, Davidson, & Nussbaum, 2006), and whole body (Springer & Pincivero, 2009). In similar research, muscular fatigue has been quantified by: electromyography (EMG) measures of instantaneous median frequency (Bonato et al., 2003; Dedering,

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Németh, & Harms-Ringdahl, 1999; Dolan & Adams, 1998) and mean power frequency (Kankaanpää, Taimela, Webber, Airaksinen, & Hänninen, 1997; Potvin & Norman, 1993); a 50–86% decrease in performance of a maximal voluntary contraction (Cetin et al., 2008; Davidson et al., 2004; Madigan et al., 2006); an inability to maintain a set cadence (e.g. lifting rate, step rate, repetitions per minute) (Springer & Pincivero, 2009); volitional fatigue (i.e. participant indicates that he is no longer physically capable of continuing) (Nussbaum, 2003; Springer & Pincivero, 2009); and psychophysical scales (e.g. Borg Category Ratio 10 or the Visual Analogue Scale) (Adlerton et al., 2003; Bonato et al., 2003; Dedering et al., 1999). Research has shown that the Borg Category Ratio 10 and the Visual Analogue Scale subjective fatigue scales significantly correlate with EMG assessments of fatigue, (Bonato et al., 2003; Dedering et al., 1999; Öberg, Sandsjö, & Kadeefors, 1994) and are suitable tools to measure fatigue in the absence of objective measures (Adlerton et al., 2003; Borg, Borg, Larsson, Letzter, & Sundblad, 2010).

There is evidence that the risk of falls is related to postural sway among older adults, however comparable research on working age adults, particularly females, is limited (Brauer, Burns, & Galley, 2000; Lichtenstein, Shields, Shiavi, & Burger, 1988; Maki, Holliday, & Topper, 1994; Piirtola & Era, 2006). Furthermore, there is little literature on the effect of a fatigue-inducing repetitive lifting work-related task on postural sway. In one study, Sparto et al. (1997) found that young male participants had a significant increase in the excursion of the center of pressure (COP) in the anterior-posterior direction after lifting an isoinertial load equal to 25% of their maximum lifting capacity at their maximum rate (participant average = 39 lifts/min) to fatigue. However, in a work setting employees may have little control over the frequency, duration, and weight of materials they are lifting.

There are tools and guidelines that can aid work sites in setting maximum weight limits and optimal conditions for lifting tasks, including the Revised NIOSH Lifting Equation (Waters, Putz-Anderson, Garg, & Fine, 1993), the ACGIH TLV for Lifting (American Conference of Governmental Industrial Hygienists, 2009), the Ohio BWC Lifting Tables (Ferguson, Marras, & Burr, 2005) and the Danish Working Environment Authority's (WEA) Manual Handling: Regulation Practices in Denmark and Comparable Countries working environment guidelines (The Danish Working Environment Authority, 2008). According to the Danish WEA (2008) for optimal conditions the maximum weight limit for a load in the hands 30 cm anterior to the torso is 30 kg for both males and females (Fig. 1). Non-optimal conditions include: the load is too large, unstable, or difficult to grasp; the lifting task involves twisting or stooping of the trunk, raised arms, and/or high frequency ($\geq$120 lifts/h) or duration ($>$ 7.5 h/week) lifts; or occurs in a confined space. Under similar conditions the maximum weight limit using the Revised NIOSH Lifting Equation is 23 kg (Waters et al., 1993). Compared to similar guidelines, the Danish permit the most weight (i.e., 30 kg) to be repetitively lifted, and thereby potentially allow more rapid onset of fatigue.

Because of the relationship between fatigue and workplace injuries is not well understood, research of worker limitations due to work tasks involving repetitive heavy lifting and fatiguing tasks could help decrease work place injuries. Therefore, the first objective of this study was to examine how fatigue affects postural sway in males and females as a group. Additionally, because the American workforce is comprised of 51.7% of females and is projected to grow (Bureau of Labor Statistics, 2016), there is a need for knowledge on the effects of a fatigue-inducing repetitive lifting work-related task on postural sway in females. This need led to the second objective, to examine how fatigue affects postural sway in males and females separately. The results of this study could provide insight on how fatigue due to repetitive heavy lifting could affect balance in a work environment.

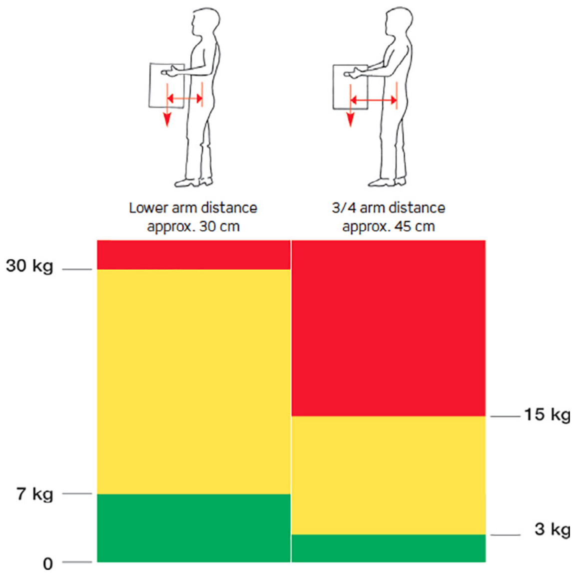

Fig. 1. Danish WEA table for safe lifting zone. For green zone, there are not aggravating factors present. For yellow zone there is at least 1 primary aggravating factor present, and an evaluation of frequency and duration is needed. For red zone, an intervention is required. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)