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The effects of caregiver experience on low back loads during floor and overhead lift maneuvering activities

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ABSTRACT

This study investigated the effects of caregiver experience on peak external forces and moments generated at the L5/S1 joint of the low back when maneuvering loaded floor-based and overhead-mounted patient lifting devices. Twenty caregivers were divided into more-experienced and less-experienced groups based on the product of two factors: their years of lifting experience and the frequency of lifting the caregivers had done in the past. Ground reaction forces and moments as well as motion capture data were recorded while caregivers performed five different maneuvering tasks with both lifts in each of three conditions (caregiver subjects worked alone, as the primary caregiver in a pair, and as the secondary caregiver in a pair). Six outcome measures (net external forces and moments at the L5/S1 joint) were recorded. Multivariate analyses of variance of all net external forces and moments were done separately for the floor and overhead lifts. A significant effect of experience level was found for the floor lift ($p = 0.006$) but not for the overhead lift ($p = 0.163$). A follow-up univariate analysis of floor lift activities found significant differences between more-experienced and less-experienced caregivers for Turn, Push and Legs Up activities.

Relevance to industry: Previous work has shown that overhead lifts reduce the loads on caregivers compared to floor lifts. The findings of this study further underscore the need to purchase overhead lifts to protect less-experienced caregivers (including informal family caregivers) who are at increased risk of back injury when maneuvering floor lifts.

1. Introduction

Caregivers (including nurses, nursing aides, healthcare workers, etc.) have the highest incidence rates for nonfatal occupational injury and illness involving days away from work according to the Bureau of Labor Statistics (BLS, 2008). These injuries are largely due to patient handling tasks (Edlich et al., 2004; Engkvist, 2004; Leighton and Reilly, 1995; Nelson et al., 2007; Waters, 2007b). The use of mechanical patient lift devices (lifts) can reduce the risk of caregiver injury during patient transfers (Collins et al., 2004; Evanoff et al., 2003, 2004; Trinkoff et al., 2003; Zhuang et al., 2000, 1999). However, there are important differences between the two main types of lift devices – floor lifts (devices that roll on a set of wheels on the floor) and overhead lifts (lifts that are suspended from a track attached to the ceiling). Some qualitative research has shown that overhead lifts are preferred to floor lifts based on psychophysical measurement (Alamgir et al., 2009; Engst et al., 2005; Holliday et al., 1994; Zhuang et al., 2000). Unfortunately, psychophysical measurements may over-estimate the capabilities of the body's tissues particularly when dealing with infrequent heavy lifting activities as is the case with patient handling (Waters, 2007a). Also, thresholds of discomfort can be lower for novice workers than for experienced workers (Parakkat et al., 2007). For these reasons, biomechanical studies may be better for comparing overhead and floor lifts.

The two most relevant biomechanical studies that investigated this issue both chose to use novices (individuals with little to no experience with patient lifting) as test subjects (Marras et al., 2009; Rice et al., 2009). Rice et al. (2009) measured horizontal hand forces generated by a single participant to maneuver lifts while varying

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the weight of the patient. A total of 18 surrogate patients ranging in weight from 51 kg to 146 kg were pushed, pulled and turned in both floor and overhead lifts. The authors found that the floor lift required significantly higher forces to maneuver. Marras et al. (2009) performed a similar comparison but using more sophisticated measurements. The authors examined the activities of maneuvering floor and overhead lifts using an EMG-assisted biomechanical model to estimate the compression and shear forces along the lumbar spine of 10 participants. Marras et al. found the loading due to floor lifts to be higher than the loading for overhead lift, which agrees with Rice et al.

However, these findings from novice subjects may not provide an accurate representation of loading patterns in experienced caregivers. For instance, there are two biomechanical studies that show more-experienced caregivers have different muscle activation patterns than novices (Hodder et al., 2010; Keir and MacDonell, 2004). Both studies found significant differences between experienced and inexperienced subjects. Keir and MacDonnell found mixed results in their pilot study of patient lifting activities with three experienced subjects producing lower mean erector spinae activity but higher shoulder activity than four novice subjects. Hodder et al. had similar findings in their study of 12 novice and 10 experienced nurses who were asked to perform a series of manual patient handling tasks. However there are no studies that compare the low back loading between caregivers with different levels of experience.

The question of whether low back loading changes with experience level is of particular importance because experienced caregivers tend to be older and risk of back injury increases with age (Jager and Luttmann, 1996). This increased risk of injury may be partially offset by the effect of increased experience and this may explain why we see lower rates of injury in older workers despite their higher susceptibility (Rong, 2008; Yassi et al., 1995). There are however some studies that had the opposite finding that older caregivers had higher prevalence of back injuries than younger workers (Karahan et al., 2009; Moscato et al., 2010). This latter case is more worrisome particularly in the case of inexperienced older workers in the workforce. Similarly, informal caregivers who look after family or friends at home are at particular risk as they often are both inexperienced and older. Fourteen percent of these informal workers report being in physical discomfort or pain (Canadian Home Care Association, 2003). The case of informal caregivers is the most troubling because these workers do not have access to the tools, training or support that their paid counterparts have at hand.

The studies that do recruit trained subjects either do not report how many years of experience their caregivers had (Santaguida et al., 2005; Zhuang et al., 1999) or report that the subjects are not considered true caregivers (Keir and MacDonell, 2004). Santaguida et al. (2005) and Zhuang et al. (1999) did not report the experience level of the caregivers, though they did report the mean ages of their subjects which were 27.3 and 45.8 years respectively. Caregiver mean age may give us a hint of their levels of experience. Santaguida et al. compared the loads at the L5/S1 joint resulting from three types of floor lifts and two different overhead lifts and found the loads from floor lifts to be higher than from overhead lifts. Zhuang et al. (1999) estimated the hand and L5/S1 forces required to push, pull and turn floor, overhead as well as stand-up lifts. They found that the floor lifts required the most force to move followed by the stand-up lifts and overhead lifts in that order. The three experienced participants of Keir and MacDonell's were "experienced with all transfer methods…but were not employed as healthcare professionals…" (p. 298). In their study Keir and MacDonell (2004) compared muscle activity patterns and found higher activity for floor lifts than with overhead lifts.

The motivation for this analysis came from observations during a related study on one and two caregiver lift use (Dutta et al., submitted). During data collection for this study, we noted that caregivers who had more experience moved very differently than those who had less experience. Our objective was to examine the data collected for the related lift use study to determine if there were differences in low back loading between more-experienced and less-experienced caregivers while maneuvering floor and overhead lift devices.

2. Methods

In our study, we estimated the net external forces and moments that result from moving a patient from a bed to a wheelchair and back to a bed using floor and overhead lifts in a simulated clinical environment. Previous biomechanical studies of lift maneuvering activities have used methods of varying complexity to estimate low back loading since there is no gold standard (Davis and Jorgensen, 2005; Kingma et al., 2001). We based our methods on those used by Santaguida et al. (2005) because these offered a reasonable compromise between simplicity of instrumentation to allow for data collection in the clinical environment and accuracy of force measurement. Santaguida et al. collected ground reaction forces from a pair of forceplates and kinematic data from a motion capture system and calculated compression and shear at the L5/S1 joint using a single equivalent muscle model. We improved on these methods by collecting ground reaction forces using recently developed ForceShoes rather than forceplates to allow the caregiver to move more naturally. We also chose to compare loading at the low back by calculating external forces and moments rather than internal compression and shear values. We limited our comparison to external loads because of the inaccuracies with single equivalent muscle models that do not account for co-contraction of trunk muscles (Granata and Marras, 1999). However, without an accurate estimate of co-contraction it is possible this investigation obscured experience related differences between our two groups.

2.1. Caregiver participants

A total of 21 female caregivers were recruited through advertisements at Toronto Rehabilitation Institute. Caregivers had an average (SD) age of 38.9 (10.8) years with all subjects between ages of 19 and 60. Our caregivers had an average (SD) of 8.7 (9.5) years of experience in patient lift/transfer activities using mechanical lift devices with all having at least one year of such experience. The average (SD) number of lifts they performed per shift was 8.5 (9.2). These 21 caregivers were ranked according to how much experience they had with patient lifting. A caregiver's experience level was calculated by multiplying the number of years of experience she had with the average number of patient lifts performed per shift. Based on this ranking, the 10 caregivers with the highest experience level were placed in the *more-experienced* category while the 10 caregivers with the lowest experience level were placed in the *less-experienced* category. The data from the 21st caregiver was removed from our data set because we determined she would be unrepresentative in either group with 6.5 years of experience. Table 1 summarizes experience and average number of lifts performed per shift for our two groups of caregivers. Matlab 7.9.0 (Mathworks, Natick, MA) was used to perform *t*-tests to show that the masses and heights of the caregiver subjects were not significantly different between our two groups ($p = 0.58$ and $p = 0.54$ for mass and height, respectively).

Exclusion criteria included pregnancy; musculoskeletal or neuromuscular injury of upper limbs, lower limbs, or back within