Human Movement Science 40 (2015) 315–325

Contents lists available at ScienceDirect

Human Movement Science

journal homepage: www.elsevier.com/locate/humov

Changes in muscular activity and lumbosacral kinematics in response to handling objects of unknown mass magnitude

Walaa Elsayed [a], Ahmed Farrag [b,*], Mohsen El-Sayyad [b], William Marras [c]

[a] Faculty of Physical Therapy, Misr University for Science and Technology, Cairo, Egypt
[b] Basic Science Department, Faculty of Physical Therapy, Cairo University, Cairo, Egypt
[c] Department of Integrated Systems Engineering, The Ohio State University, Columbus, OH, USA

ARTICLE INFO

Article history:
Available online 5 February 2015

PsycINFO classification:
3610
4010
3670

Keywords:
Load knowledge
Lifting
Electromyography
Spine movement

ABSTRACT

The aim of this study was to evaluate the main and interaction effects of mass knowledge and mass magnitude on trunk muscular activity and lumbosacral kinematics. Eighteen participants performed symmetric box lifts of three different mass magnitudes (1.1 kg, 5 kg, 15 kg) under known and unknown mass knowledge conditions. Outcome measures were normalized peak electromyography of four trunk muscles in addition to three dimensional lumbosacral angles and acceleration. The results indicated that three out of four muscles exhibited significantly greater activity when handling unknown masses ($p < .05$). Meanwhile, only sagittal angular acceleration was significantly higher when handling unknown masses ($115.6 \pm 42.7°/s^2$) compared to known masses ($109.3 \pm 31.5°/s^2$). Similarly, the mass magnitude and mass knowledge interaction significantly impacted the same muscles along with the sagittal lumbosacral angle and angular acceleration ($p < .05$) with the greatest difference between knowledge conditions being consistently occurring under the 1.1 kg mass magnitude condition. Thus, under these conditions, it was concluded that mass magnitude has more impact than mass knowledge. However, handling objects of unknown mass magnitude could be hazardous, particularly when lifting light masses, in that they can

* Corresponding author at: Faculty of Physical Therapy, Cairo University, 7 Ahmed El Zayat Street, Bein El Sarayat, Giza 12612, Egypt.
E-mail addresses: whamdy@must.edu.eg (W. Elsayed), ahmedfarrag@cu.edu.eg (A. Farrag), dr_sayyad1@hotmail.com (M. El-Sayyad), marras.1@osu.edu (W. Marras).

http://dx.doi.org/10.1016/j.humov.2015.01.008

increase mechanical burden on the lumbosacral spine due to increased muscular exertion and acceleration.

1. Introduction

Manual materials handling such as lifting, pushing or carrying is a common activity for almost every human being. It can be performed either on a regular basis or irregularly depending upon the jobs demands. Lifting has been associated with an increased incidence of low back injuries (Coenen et al., 2014); it was shown to have a significant impact on trunk muscles activity (Ferguson, Marras, Burr, Davis, & Gupta, 2004). Unfortunately, handling objects without previous knowledge of their mass magnitude can be performed regularly in occupations such as luggage dispatching, refuse collection or mail distribution. In spite of a wealth of research exploring the different aspects of lifting maneuvers, very few studies were devoted to understanding the impact of mass knowledge on the musculoskeletal system.

Unexpected loading during manual materials handling can impact the trunk muscles that support the lifted objects as well as load the spinal tissues. Several studies tested how expectation during sudden loading influenced trunk muscle responses (Grondin & Potvin, 2009; Hwang, Lee, Park, & Kwon, 2008; Marras, Rangarajulu, & Lavender, 1987; Mawston, McNair, & Boocock, 2007). However, few studies investigated the impact of handling objects without prior knowledge of their mass, which can be a common daily occurrence.

Irrespective of which technique is preferred to handle an object, its proper execution requires precise neuromuscular coordination. This, in turn, requires a lifting strategy that considers and adapts to the magnitude and the size of the object mass (Kingma, Van Dieen, & Toussaint, 2005). Sometimes subjects can predict the needed strategy based on their previous experiences (Marras et al., 2006). However, other times this is not possible due to a lack of experience or when the load magnitude is unknown. When making inaccurate predictions about an object's mass magnitude, the trunk can adopt an inappropriate kinematic profile (Heiss, Shields, & Yack, 2002; Kotowski, Davis, & Shockley, 2007), which can be uncontrolled requiring stabilization (Butler, Andersson, Trafimow, Schipplein, & Andriacchi, 1993), achieved through trunk muscles co-contraction (Brown & McGill, 2010; Grondin & Potvin, 2009).

Handling objects of unknown mass can result in either mass overestimation or underestimation that can result in adverse effects. Subjects may lose their balance and suffer a fall or postural reactions required to regain balance could place the low back at risk of tissue damage (Commissaris & Toussaint, 1997; van der Burg, van Dieen, & Toussaint, 2000). Studies exploring trunk muscles response to lifting unknown masses are scarce. One study found that lifting an unknown mass increased back muscle activation by 10% compared to the known condition (de Looze et al., 2000). However, these authors used only two mass magnitudes (6.5 and 16.5 kg), which may have limited the options and made it easier for the subjects to expect the correct mass magnitude. Another study reported a sudden burst of abdominal muscle activity but only immediately after picking up a box of underestimated mass (van der Burg et al., 2000). Another recent study found a delayed increase in the trunk muscle activity when handling an object of underestimated mass. However, these authors used light masses (1 and 4 kg) and the subjects performed unilateral lifts in seated positions, which would limit the applicability of the results (Watanabe et al., 2013). Lack of knowledge about the center of mass of the lifted object did not appear to affect back muscles activities, although the position of center of mass impacted the Erector Spinae peak muscle activity (Meyers & Keir, 2003).

Trunk kinematics can also be influenced by mass knowledge as reported in a limited number of studies (Butler et al., 1993; Kotowski et al., 2007). These studies suggest that the effect of handling an unknown mass, although significant, was of too small a magnitude to be of clinical significance