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Interactive effects of mental and postural demands on subjective assessment of mental workload and postural stability

Angela DiDomenico [a,*], Maury A. Nussbaum [b]

[a] *Liberty Mutual Research Institute for Safety, 71 Frankland Road, Hopkinton, MA 01748, USA*
[b] *Virginia Tech, Blacksburg, VA 24061, USA*

Abstract

Attentional resources are required to maintain an upright posture while completing concurrent mental tasks, with allocation dependent on the nature and complexity of the individual tasks. If available resources are exceeded, either mental or balance performance may be compromised. In this study, the effects of several levels of mental and postural demands were determined using subjective assessment of mental workload and postural stability. Mental activity performed, visual condition, and postural stance were the independent variables. Each of 18 conditions, comprised of a mental task and sustained upright stance, lasted for one minute. Perceived mental workload and postural stability were obtained using a visual analog scale and postural stability scale, respectively. Increases in the difficulty of the standing task did not significantly affect cognitive performance, although larger subjective ratings of mental workload indicated that individuals perceived an increase in difficulty associated with the mental task. Perceptions of postural stability, however, did reflect changes in objective postural sway measures caused by alterations in mental demands. The results overall suggest that a state of heightened arousal, caused by physical/environmental changes or mental demands, may lead to changes in the effectiveness of the visual analog scale, whereas the postural stability scale can still provide a reasonable indication of postural sway.

Keywords: Mental workload; Postural sway; Postural stability; Subjective assessment

* Corresponding author. Tel.: +1 508 497 0274; fax: +1 508 435 0482.
E-mail address: angela.didomenico@libertymutual.com (A. DiDomenico).

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1. Introduction

As highlighted by the National Institute for Occupational Safety and Health (NIOSH), falls from heights are a concern among multiple divisions of industry (NIOSH, 2000). Workers in many occupational settings are exposed to fall hazards on a daily basis. Using the National Traumatic Occupational Fatalities (NTOF) surveillance system, NIOSH (2000) found falls from elevations to be the fourth leading cause of occupational fatality in the United States between 1980 and 1994. In the same period, 10% of all occupational fatalities occurred from falls. The NTOF system is based on information gathered from death certificates; therefore, these statistics are likely underestimates of the actual values due to limitations in ascertaining appropriate and complete data from death certificates (NIOSH, 2000). Despite these limitations, approximately 80% of work-related fatalities are identified on death certificates, providing a reasonable estimate of the relative severity of falls in the workplace (Stout and Bell, 1991). Improved fall prevention is necessary to move towards a reduction of fatalities and injuries related to falls (Bagchee et al., 1998).

There is an important need for methods to evaluate existing and new prevention strategies, and more generally to determine factors that lead to falls. Since many occupational falls appear to be related to loss of balance or impairment of balance control, a better understanding of postural stability can facilitate fall prevention (Bagchee et al., 1998; Hsiao and Simeonov, 2001). This includes identifying factors that adversely affect postural stability and developing interventions that promote improved stability.

Presently, body sway measures derived from a force plate during quiet stance have been used as numeric indicators of postural stability. This interpretation has been substantiated by reports that increased lateral spontaneous-sway was associated with incidents of falling (Maki et al., 1994). Lichtenstein et al. (1988, 1989) also found that elderly individuals with a history of falling had a greater sway area than those who had not fallen.

Balance control is a complex motor skill that involves integration of sensory inputs and the planning and execution of flexible movement patterns (Ferdjallah et al., 2002). Integration of information from sensory systems provides the individual with information about their orientation in space to allow for compensatory reflexive movements in order to maintain postural control (Cobb, 1999). Sensory inputs are not solely responsible for maintaining postural control, however. Postural stability also depends on the integrity of the musculature, effectiveness of processing within the central nervous system, and intact neural pathways for motor control (Horak et al., 1989). Stable control of posture can be automatic for healthy individuals, but it is often challenging for individuals lacking balance due to fatigue, pathology, injury or age (Ferdjallah et al., 2002).

Recent research using a dual task paradigm suggests that sensorimotor processing, essential to postural control, requires attentional resources. Several researchers have documented that even highly practiced postural tasks require some cognitive processing, and that the degree of processing varies with the complexity of the postural task (Brown et al., 1999). Attention-demanding secondary tasks, therefore, compete with the postural control system for neural resources (Dault et al., 2001b; Yardley et al., 2001). Allocation of attention and resources during the performance of concurrent tasks is complex, but in part controlled by the individual (Kahneman, 1973). The allocation policy employed depends on many factors, including the nature of both the mental and postural task, the goal of the individual and the instructions provided (Dault et al., 2001a).