International Journal of Industrial Ergonomics 41 (2011) 255–260

Contents lists available at ScienceDirect

International Journal of Industrial Ergonomics

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

Effects of different physical workload parameters on mental workload and performance

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

[a] Liberty Mutual Research Institute for Safety, 71 Frankland Road, Hopkinton, MA 01748, USA
[b] Industrial and Systems Engineering, Virginia Tech, Blacksburg, VA, USA

ARTICLE INFO

Article history:
Received 26 March 2010
Received in revised form
21 December 2010
Accepted 20 January 2011
Available online 18 February 2011

Keywords:
Workload assessment
Cognitive performance
Heart rate variability

ABSTRACT

The design and evaluation of an occupational task should include an assessment of mental workload, since excessive levels of mental workload can cause errors or delayed information processing. Physically demanding work that is performed concurrently with a cognitive task may impact mental workload by impairing mental processing or decreasing performance. The primary objective of this study was to determine whether there is a differential effect of various types of physical activity on both mental workload and cognitive performance. Objective and subjective assessment tools (heart rate variability and visual analog scale) were used as indicators of mental workload, while correct responses during an arithmetic task reflected levels of performance. Thirty participants (ages 18–24 years) performed a combination of tasks inducing both physical and mental workload. Type of physical effort, frequency of movement, and force exertion level were manipulated to alter the workload associated with the physical activity. Changes in subjective ratings generally corresponded to changes in both performance on the arithmetic task and objective mental workload assessment. Some discrepancies occurred at the highest physical force exertion level as participants perceived an increase in effort to maintain the same level of performance. Further research is needed to determine the force exertion threshold, beyond which the physical effort required interferes with mental workload and/or cognitive performance.

Relevance to industry: Technological advancements have increased the requirement for many workers to execute cognitive tasks concurrently with physical activity. When designing and evaluating such situations it is important to determine the interactive effects of these activities. A simple, uni-dimensional tool is suggested as a screening tool to identify situations requiring excessive or increased mental workload that many degrade performance or place additional stress on the individual.

1. Introduction

An assessment of mental workload is an important aspect in the design and evaluation of an occupational task. Efficient performance requires concentration on task-related information and suppression of extraneous stimuli to avoid information overload. Excessive levels of mental workload can cause errors or delayed information processing, particularly if the amount of information presented surpasses processing capacity (Ryu and Myung, 2005). Although the source of a considerable portion of the information obtained is directly related to a cognitive task, workers are often expected to perform physically demanding work concurrently, a situation that may require resource allotment. Examples include the public safety sector (e.g. police officers and firefighters), soldiers performing combat function, and occupations requiring extensive computer work. In such situations, there is a need to determine the impact that physical components may have on mental workload and to control factors that may increase the difficulty of tasks. Specifically, if considerable levels of both physical and mental activity are required, task (re)design might seek to avoid forms of physical activity that impair mental processing or decrease performance.

Past research in this area has focused predominantly on assessing the influence of physical demands on cognitive performance, but has yielded inconclusive results. Early work by Davey (1973) and Gupta et al. (1974) showed that cognitive performance increased immediately following low levels of physical activity, but that long-term exercise caused decrements in cognitive performance. More recent work supports the theory that physical workload increases the speed of information processing for simple cognitive tasks, such as detection, visual searches, and choice-responses (Eef Hogervorst et al., 1996; Tomporowski, 2003).

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

0169-8141/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.ergon.2011.01.008