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Effects of concurrent physical and mental demands for a short duration static task

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ABSTRACT

The purpose of this study was to quantify the effects of concurrent physical and mental demands on the upper extremity muscle activity during static exertions. Seventeen healthy participants performed isometric upper extremity exertions at five levels of physical intensity (5%, 25%, 45%, 65%, and 85% maximum voluntary contraction (MVC)) in the presence and absence of a mental task (Stroop color word test). Muscular responses were quantified using surface electromyography (EMG) and motor performance was measured through force fluctuations. Subjective assessments were obtained through the NASA-TLX tool and the Borg CR-10 Scale. In general, a decrease in mean anterior and posterior deltoid muscle activity and co-contraction index (CCI) of the shoulder was observed in the presence of the mental task. However, these changes were more prominent at higher physical exertion levels compared to the lower levels. Furthermore, the additional mental task resulted in decreased upper and lower arm muscle activity, specifically at the 45% MVC level. Motor performance improved at the middle exertion levels, but was adversely affected by the mental task at higher exertion levels. Decreased motor performance at higher loads may have been a result of decreased muscular effort to maintain the loads in a steady posture. Both mental and physical demand adversely affected the NASA-TLX ratings, however, ratings using the Borg CR-10 Scale were only sensitive to changes in physical demand.

Relevance to industry: Workplace tasks, such as jobs performed by healthcare workers, assembly line workers, and computer operators, have become more multidimensional in the recent years; with workers experiencing combined physical and mental demands in their daily jobs, yet their effect on muscular responses is not clearly understood. Results from this study suggest that certain physical exertion levels are more susceptible to interference by mental demands than others.

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1. Introduction

In 2008, work-related musculoskeletal disorders (WMSDs) accounted for 29% (317,440 cases) of injuries and illnesses forcing days away from work (BLS, 2008). The severity of injuries associated with WMSDs was determined to be greater than any other non-fatal injury, resulting in a median of 10 days away from work in 2008, two more days than the median for all days-away-from-work cases (BLS, 2008). Of these, injuries to the shoulder and the wrist resulted in 18 and 14 median days away from work, respectively. Also labeled as cumulative trauma disorder (CTD), repetitive strain injury (RSI), and work-related upper extremity disorder (WRUED), the total cost of these disorders in the United States was estimated at \$563 million (Webster and Snook, 1994) to \$6.5 billion in 1989 (Silverstein et al., 1998).

According to the World Health Organization, WMSDs are characterized as being multifactorial in origin (WHO, 1985), with physical work demands, psychosocial factors, and individual differences contributing significantly to the cause of the disorder. Physical risk factors such as repetitiveness and forceful exertions, and the combination of both, have shown the strongest association to WRUEDs (Kilbom, 1994). Sustained shoulder postures, greater than 60 degrees of flexion or abduction, have also shown to further influence the risk of shoulder injuries (Kilbom, 1994; Ohlsson et al., 1995). In addition to the physical demands, psychosocial factors have consistently been associated with WMSDs (Bongers et al., 1993; Buckle, 1997). While the etiology of WMSDs due to psychosocial factors is not clearly understood, strong associations between certain work-related psychosocial factors and low back and upper extremity WMSDs have been reported. Existing multivariable models of WMSDs have suggested potential direct/indirect causal pathways of physical, psychosocial and individual risk factors (and their interactions) with the development of WMSDs. Bongers et al. (1993) proposed an epidemiological model that hypothesizes

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