THE EFFECTS OF SUBMAXIMAL SHOULDER MOMENT, TASK PRECISION AND MENTAL DEMAND ON MUSCLE ACTIVITY DURING GRIP EXERTIONS

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INTRODUCTION

Over 100,000 new cases of musculoskeletal disorders (MSDs) reported annually in the U.S. resulted from overexertion or repetitive motion of the upper extremity [1] and cost the health care and insurance systems hundreds of millions of dollars [2]. Despite the prevalence and cost associated with upper extremity MSDs, the underlying mechanisms for these injuries are still not well understood. In the workplace, external forces have been relatively well evaluated, but internal muscular loads are not as easily assessed. Further complicating matters is that, in addition to external forces, laboratory studies have identified several other factors that increase muscle activity in the upper extremity, including the nature of loading, increased task precision and mental demands. Failure to account for these factors by assessing external loads alone in the workplace will likely underestimate muscle load. For example, the addition of a submaximal grip or mental load to maximal shoulder exertions have been shown to interfere with the ability to produce maximal shoulder moment without necessarily reducing muscle activity; this effect was greatest when all tasks were combined [3]. The purpose of this study was to determine the influence of task precision, mental demands and shoulder exertions on forearm and shoulder muscle activity during a grip exertion task.

METHODS

Participants (8 males, 8 females) were recruited from the university community and visited the lab on two occasions. On the first visit, participants were oriented to the protocol and had their maximal grip and shoulder strengths determined. The experimental protocol was conducted during the second visit. In total, there were 4 grip conditions, 3 shoulder loads and 2 mental loading levels. Each of the 24 conditions was repeated 3 times in a randomized block design. Participants were seated with the right arm abducted to 90°. They then exerted grip forces of 0, 30 and 100% MVC while simply maintaining shoulder posture or exerting a 40% MVC shoulder moment. To create the 40% MVC shoulder moment, participants either pushed upwards against a force transducer (*force-controlled*) positioned just proximal to the elbow or supported an equivalent weight (*posture-controlled*) hung from the same location. The 30% MVC grip force was maintain under two levels of precision: high precision required the grip force to be maintained within ±5% and low precision within ±10%. The increased mental loading condition was achieved by the simultaneous use of the Stroop test [3]. All forces and linear envelope EMG (3 Hz analog) were collected at 100 Hz. Surface EMG was recorded from 8 muscles on the right upper extremity: trapezius (TR), anterior deltoid (AD), middle deltoid (MD), posterior deltoid (PD), flexor carpi radialis (FCR), flexor digitorum superficialis (FDS), extensor carpi ulnaris (ECU), and extensor digitorum communis (EDC). Each trial lasted 10 s and participants received a minimum rest of 1 minute between trials and 5 minutes between blocks.

RESULTS AND DISCUSSION

Preliminary analysis (n=3) indicated that maintaining 90° arm abduction while holding the grip dynamometer required shoulder moment of 20-30% MVC. Middle deltoid activity was approximately 30% MVE for these contractions, as previously found [4]. Force- and posture-controlled shoulder exertions at 40% MVC increased trapezius and deltoid activity by 20-25% MVE beyond that required to support the arm alone. Interestingly, for both 40% MVC moments (force- and posture-controlled), forearm extensor muscle activity increased by 2-3% MVE without an increase in grip force (Fig. 1). The need for greater precision in grip force also appeared to increase forearm muscle activity slightly. Based on these preliminary data, there appears to be a slight reduction in deltoid activity between the force- and posture-controlled moments with 0 and 30% MVC grip. The ability to generate a maximal grip exertion was compromised during simultaneous force-controlled shoulder exertions but not in any other condition. This 10-15% MVC reduction in grip force was paralleled by a similar decrease in forearm muscle activity. The findings of this study will improve our knowledge of the interactions of physical and cognitive demands in the workplace and their role in upper extremity MSDs.

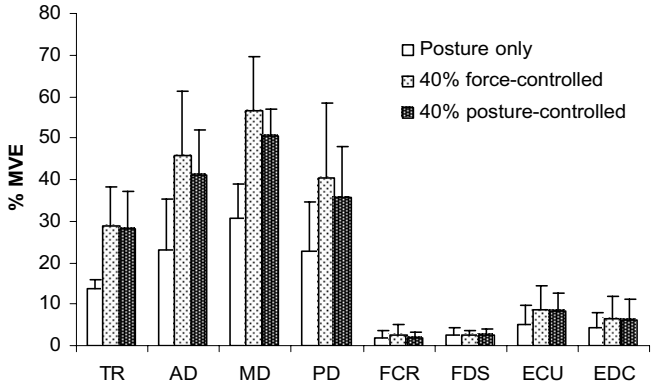

Figure 1: Muscle activity at 90° shoulder abduction with and without a 40% shoulder moment (no grip force).

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