THE EFFECTS OF SHOULDER ABDUCTION ANGLE AND WRIST ANGLE ON UPPER EXTREMITY MUSCLE ACTIVITY IN UNILATERAL RIGHT-HANDED PUSH/PULL TASKS

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INTRODUCTION

High arm elevation and non-neutral wrist postures are independently associated with increased worker discomfort and muscle activity [1, 2]. Further, increased shoulder abduction angles increase activity of muscles surrounding the shoulder complex [3], which can accelerate muscular fatigue, especially in awkward postures [4]. However, potential interactions between these factors and their relative implications for strength and injury to the upper extremity remain unclear. This study intended to quantify upper extremity activity across a range of shoulder and wrist postures and describe how demands between these joints were modulated while performing pushes and pulls.

METHODS

20 participants (21.6 ± 1.5 yrs, 1.68 ± 0.12 m, 72.5 ± 16.5 kg) completed 72 seated right-handed isometric exertions in two force directions (push, pull) using combinations of shoulder angle (0, 45, 90, 120°), and wrist angle (flexion, neutral, extension). An absolute force of 30N was held for 7 seconds at each posture combination, with off-axis forces maintained below 5 N. All posture and force direction combinations were performed in a randomized order. Surface electromyography (EMG) was collected for 16 muscles (8 muscles surrounding the shoulder, 2 of the upper arm, and 6 of the forearm) using a Noraxon Telemyo 2400 T G2), linear enveloped and normalized to muscle-specific maximal excitations (denoted as %MVE). Hand force was collected with an AMTI 6-DOF force transducer rigidly fixed to a MOTOMAN HP-50 robotic arm. Force was sampled synchronously with EMG at 1500 Hz using VICON Nexus 1.7.1 software. A 2-way repeated measures ANOVA (4 shoulder postures * 3 wrist postures) was completed to determine the effects of shoulder angle and wrist position on mean normalized muscle activity.

RESULTS AND DISCUSSION

Muscular activity changes were closely related to changes in local joint orientations and force direction, with the largest changes in activity outputs appearing in forearm musculature as wrist positions deviated from neutral postures. In push exertions, forearm extensor activity was greatest in flexed wrist postures, ranging from 11-20% MVE (p<0.01). During pulls, extensor activity was greatest in extended wrist postures, exceeding 25%...
MVE in some cases (Figure 1A, p<0.01). Muscle activity for the forearm flexors was greatest in flexed wrist postures during pull exertions (Figure 1B, p<0.05). Increased shoulder abduction angle resulted in increased muscular activity of muscles surrounding the shoulder (Figure 2, p<0.01). Push exertions had variable effects on the anterior and posterior deltoid with increasing shoulder abduction angle, while middle deltoid increased with increasing abduction angle (p<0.0016).

Non-neutral wrist postures produced large increases in forearm activity for both force directions, with increases as much as 300% when compared to neutral positions in some instances. Activity levels for both forearm flexors and extensors exceeded recommended levels for intermittent forearm activity [5], even at low abduction angles. These activity levels were exacerbated as the wrist deviated from neutral in pull exertions for both forearm flexors and extensors, and for forearm extensors in pushing exertions (Figure 1). This suggests that the wrist may be prone to injury and strength limitations in these postures.

The large increases seen in shoulder musculature as abduction increased is likely due to moment arm changes and the increased difficulty to stabilize the glenohumeral joint during maintain body posture in these non-neutral positions [6]. Overall shoulder muscular activity increased by over 25 %MVE with increased shoulder abduction. Specific shoulder muscle activity levels varied markedly with force exertion direction. Exertions with increased humeral elevation relative to body position increase total muscle activity in both pushing and pulling exertions [7], and these elevated postures are a known risk factor in shoulder muscle fatigue, discomfort and shoulder pathology [8].

CONCLUSIONS
Overall joint demands switch with task conditions, with dependencies on local joint postures and force direction. Deviated wrist postures should be avoided as much as possible, as substantial changes in muscular activity occurred in these positions. Secondly, efforts should be focused to minimize shoulder abduction to decrease muscular activity and injury risk. There was limited evidence to suggest that shoulder posture influenced wrist activity levels or that wrist posture influenced shoulder muscle activity levels.

Figure 2. Normalized EMG of anterior deltoid (A) and middle deltoid (B) during pushes and pulls across shoulder angles and wrist postures for neutral wrist positions only. Other wrist postures are not shown as no effect was found. Significant differences within directions are denoted by different letters.

REFERENCES