

Effects of Different Overhead Work Conditions on the Neck and Shoulder Muscles

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Abstract. [Purpose] This study investigated the upper trapezius muscle and sternocleidomastoid muscle activities during overhead work performed under three different conditions. [Subjects] Ten young overhead workers (five males, five females), aged 22–32 years, were recruited. [Methods] We measured the right side upper trapezius muscle activity and right side sternocleidomastoid muscle activity of all subjects while they performed overhead work under the following conditions: 1) one hand doing overhead work and a fixed neutral neck posture; 2) one hand doing overhead work with maximal neck extension; and 3) two hands doing overhead work with maximal neck extension. [Results] In Condition 3 there was a significant increase in the upper trapezius muscle activity compared to Condition 1; There was also a significant increase in the sternocleidomastoid muscle activity compared to Condition 1 and Condition 2. [Conclusion] Overhead workers should only be asked to do one-handed work that requires a neutral neck posture. A neutral neck posture and a device, such as a monitor or mirror, would reduce the risk of muscle strain from overhead work.

Key words: Overhead work, Cervical flexion-relaxation ratio, Electromyography

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INTRODUCTION

A common concern in the modern workplace is shoulder musculoskeletal disorders from overhead work¹⁾. Overhead work is associated with the upper extremity disorders and discomfort^{1–3)}. Overhead workers have an increased risk of musculoskeletal injury³⁾. Long-term overhead working postures result in strain and fatigue of shoulder muscles⁴⁾ because arm elevation is associated with shoulder muscular fatigue⁵⁾. Herberts et al.⁶⁾ found that localized muscle fatigue accumulates in the supraspinatus and trapezius muscles during maintenance of an overhead posture.

Upper arm flexion is associated with the trapezius muscle, and numerous studies have been carried out on upper arm flexion posture in overhead work and the associated neck and shoulder muscle activity and pain. However, few studies have examined neck and shoulder muscle activity and changes in neck posture and hand conditions during overhead work. The main aim of this study was to examine the physical risk factors associated with neck disorders during overhead work performed under three different conditions. The contribution of neck muscles was evaluated biomechanically by examining electromyogram (EMG) activities of the major anterior and posterior neck muscles during overhead work performed under the three conditions.

SUBJECTS AND METHODS

Ten young overhead workers (five males, five females), aged 22–32 years and with a mean height and weight of 168.1 ± 5.7 cm and 61.5 ± 9.0 kg, respectively, participated in this study. All of the subjects were healthy and had been free of neck and back pain for a minimum of 1 year before the study; they had no upper limb or cervical spine pathologies and no rheumatological or neurological conditions. Ethical approval for this study was obtained from the Inje University Faculty of Health Sciences Human Ethics Committee. The subjects provided their informed consent prior to participation.

The EMG signals were pre-amplified by a pre-amplifier placed close to the electrodes, and signals were then sent to the data acquisition unit of an MP150 system (Biopack System, Santa Barbara, CA, USA), which amplified and sampled the EMG inputs at 1000 Hz. The EMG data were analyzed using a program created by AcqKnowledge software (version 3.9.1) and expressed relative to the maximum voluntary contraction (MVC). The sternocleidomastoid muscle electrodes were placed along a line drawn from the sterna notch to the mastoid process, at 1/3 the length of the line from the mastoid process. The upper trapezius muscle electrodes were placed on the upper back, with the two active electrodes placed at the upper crest of the shoulder, halfway between the spine (C-7) and the acromion of the shoulder. All subjects performed overhead work for 3 min-

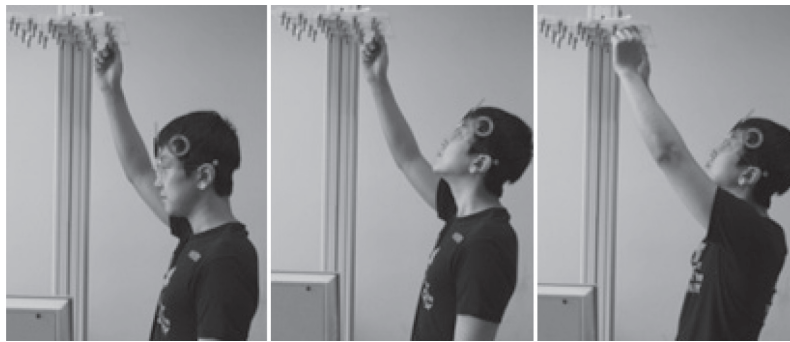


Fig. 1. Three overhead work conditions (1, 2, 3)

Table 1. Comparison of normalized EMG data of the two muscles during overhead work under 3 conditions

| Muscles | mean \pm SD (%MVC) | | |
|---------------------|----------------------|-----------------|------------------|
| | Condition 1 | Condition 2 | Condition 3 |
| Upper trapezius | 61.8 \pm 38.6 | 65.7 \pm 53.7 | 74.7 \pm 46.4* |
| Sternocleidomastoid | 9.4 \pm 6.5 | 14.4 \pm 7.9* | 26.1 \pm 15.0* |

utes using the same workstation. The experimental protocol specified three overhead work conditions: 1) one hand doing overhead work and a fixed neutral neck posture; 2) one hand doing overhead work with maximal neck extension; 3) two hands doing overhead work with maximal neck extension (Fig. 1). Initial neck posture was set by the cervical range of motion. The test order was randomized. Overhead work was performed at a height 25 cm above the head of each subject. The right side upper trapezius muscle and sternocleidomastoid muscle activities were measured in each condition of overhead work. The EMG signal was collected for 3 minutes, and the first and last 10 seconds were discarded. During data collection, the participants were barefoot and their feet were positioned 20 cm apart.

Statistical analysis was performed using a one-factor repeated measures analysis of variance (ANOVA) model. Bonferroni correction was performed to identify specific differences between multiple pairwise comparisons. All significance levels were $p < 0.05$, and SPSS version 18.0 (SPSS, Chicago, IL, USA) was used for the statistical analyses.

RESULTS

EMG data collected from the right side upper trapezius and sternocleidomastoid muscles were averaged. The normalized EMG data of the upper trapezius and sternocleidomastoid muscles differed significantly among the three conditions. In Condition 3, there was a significant increase in upper trapezius muscle activity compared to Condition 1 ($p < 0.05$); there was also a significant increase in sternocleidomastoid muscle activity compared to Condition 1 and Condition 2 ($p < 0.05$) (Table 1).

DISCUSSION

This study investigated the upper trapezius muscle and sternocleidomastoid muscle activities during three conditions of overhead work performed by healthy adult participants. Condition 3 showed a significant increase in upper trapezius muscle activity compared to Condition 1. Arm elevation angle is associated with trapezius activity⁷⁾ and the direction of arm elevation influences upper trapezius activity⁸⁾. Condition 3 showed a significant increase in sternocleidomastoid muscle activity compared to Condition 1 and Condition 2. Nimbarte et al.⁹⁾ found that the sternocleidomastoid muscle was most active with an extended neck posture during lifting. Overhead work requiring arm elevation and head extension and related shoulder-neck disorders was studied among farmers¹⁰⁾. The development of intramuscular pressure of the infraspinatus and supraspinatus muscles is influenced by arm posture and primarily by the elevation angle¹¹⁾. Sood et al.¹²⁾ found that there is an effect on muscle activity when the working height moves from low to high. Chopp et al.¹³⁾ found that normalized electromyographic activity was greater for fixed configurations, particularly when pulling in a backward direction compared to pushing down or forward; pulling backwards at angles of -15° and 0° showed the highest muscular demand. Research has shown that moving the task closer to the worker decreases muscle activity¹⁴⁾. Overhead work is an increased risk factor of musculoskeletal injury. The present results indicate that muscle demands during overhead work are lowest when one hand is used and a neutral neck posture is maintained. Overhead workers should demand work that involves one hand with a neutral neck posture. A neutral neck posture and a device, such as a monitor or mirror, should be used to reduce the risk of muscle injury in overhead work. Two-handed overhead work is a greater risk than one-handed overhead work, and

an extended neck posture during overhead work is a greater risk than a neutral neck posture. Performing overhead tasks using a neutral neck posture and one hand would result in decreased upper extremity muscle demand.

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