

# Effects of Below-knee Assembly Work at Different Reach Distances on Upper-extremity Muscle Activity

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**Abstract.** [Purpose] We investigated upper-extremity muscle activity during below-knee assembly work performed by healthy adults at three different reach distances evaluate the physical risk factors associated with neck and shoulder disorders of reach distances. [Subjects] Sixteen young male workers were recruited. [Methods] Activities of the right upper trapezius, anterior deltoid, and biceps brachii muscles were measured during below-knee assembly work at the three different reach distances. [Results] The normalized EMG data of the upper trapezius, anterior deltoid, and biceps brachii muscles generally increased significantly as the reach distance at which the assembly work was performed increased. [Conclusion] Below-knee workers should engage in work that involves shorter (nearer) reach distances.

**Key words:** Below knee work, Electromyography, Shoulder pain

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## INTRODUCTION

Many industrial workers have to work in awkward and stooped working positions. Stooped working positions require sustained trunk flexion, which can be a risk factor of work-related musculoskeletal disorders<sup>1,2)</sup>. Postures that are used when working at below-knee heights, such as stooping, occur more commonly on building sites than in other work environments<sup>3)</sup>. Stooped postures in working situations are often related to neck and shoulder pain<sup>4)</sup>. Work-related musculoskeletal disorders such as overuse disorders account for a significant proportion of work injuries. Certain risk factors also increase upper-extremity muscle injuries, including repetitive work and assembly work<sup>5,6)</sup>. Many workplace shoulder musculoskeletal disorders are caused by assembly work<sup>7)</sup>. Work-related musculoskeletal disorders are painful disorders of muscles and tendons that can be induced by work activities that are repetitive or that involve awkward postures<sup>6)</sup>. However, few studies have evaluated the effects of different below-knee assembly work reach distances. The purpose of this study was to evaluate the effect of reach distances on the upper extremity disorders of below-knee workers.

## SUBJECTS AND METHODS

Sixteen young, male, right-hand-dominant workers with a mean age of  $21.3 \pm 1.7$  years, height of  $172.7 \pm 6.4$  cm, and weight of  $66.1 \pm 9.6$  kg were recruited. The subjects were not accustomed to below-knee assembly work. They had no past history of orthopedic disorders affecting the neck or shoulder region and no history of neurological disorders. Each subject provided his informed consent before participation in this study. This study was approved by the Inje University Faculty of Health Sciences Human Ethics Committee. Muscle activity was measured using the MP150 system (BIOPAC Systems, Santa Barbara, CA, USA) with a pair of Ag/AgCl electrodes measuring 2 cm in diameter. The upper trapezius, anterior deltoid, and biceps brachii muscles are often the source of pain in the upper extremity<sup>4)</sup>. Three surface electrodes were placed on the muscles of the dominant (right) side: slightly lateral to and halfway between the cervical spine at C-7 and the acromion for the upper trapezius; on the anterior aspect of the arm, approximately 4 cm below the clavicle for the anterior deltoid; and for the biceps brachii, the subjects were asked to flex the forearm in the supinated position, and two active electrodes were placed 2 cm apart, parallel to the muscle fibers at the center of the muscle mass<sup>8)</sup>. The reference electrode was attached to the lateral epicondyle of the humerus. The sampling rate of the EMG signal was 1,000 Hz, and signals were band-pass filtered between 20 and 450 Hz. The root mean square values were calculated. EMG data were normalized using the maximum voluntary isometric contraction (MVIC) value of each muscle. MVIC was measured using the manual muscle test as described by Kendall et al<sup>9)</sup>. All subjects per-

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formed below-knee assembly work (nut-and-bolt assembly) for 3 min using the same workstation. Working postures for the task required sustained knee and trunk flexion. The experimental protocol specified three below-knee assembly work conditions: a height of 30 cm and a reach distance of 30 cm (RD30); a height of 30 cm and a reach distance of 45 cm (RD45); and a height of 30 cm and a reach distance of 60 cm (RD60). The test order was randomized. The activities of the right upper trapezius, anterior deltoid, and biceps brachii muscles were measured for each below-knee assembly work condition. The EMG signal was collected for 3 min, and the first and last 10 s were discarded. During data collection, the participants were barefoot. Statistical analysis was performed using one-way repeated-measures analysis of variance (ANOVA). The Bonferroni correction was used to identify specific differences among multiple pair-wise comparisons. All significance levels were chosen as  $p < 0.05$ , and SPSS software (ver. 20.0; IBM, Armonk, NY, USA) was used for statistical analyses.

## RESULTS

The upper trapezius muscle activity of RD60 ( $21.9 \pm 7.0$ ) was significantly higher than those of RD45 ( $13.3 \pm 5.8$ ) and RD30 ( $6.3 \pm 2.9$ ), and that of RD45 was higher than that of RD30 ( $p < 0.05$ ). The anterior deltoid muscle activity of RD60 ( $29.4 \pm 8.8$ ) was significantly higher than those of RD45 ( $20.4 \pm 7.1$ ) and RD30 ( $12.2 \pm 5.6$ ), and that of RD45 was significantly higher than that of RD30 ( $p < 0.05$ ). The biceps brachii muscle activity of RD60 ( $12.7 \pm 7.0$ ) was significantly higher than those of RD45 ( $9.0 \pm 5.5$ ) and RD30 ( $6.2 \pm 4.2$ ), and that of RD45 was higher than that of RD30 ( $p < 0.05$ ).

## DISCUSSION

These results show that the activities of the upper trapezius, anterior deltoid, and biceps brachii muscles increased significantly in below-knee assembly work at far distances. Anton et al.<sup>10</sup> found that activities of the anterior deltoid and biceps brachii muscle increased more when overhead work was performed under a far-reach condition than under close-reach condition. Chopp et al.<sup>11</sup> showed that moving the task closer to the worker decreased muscle activity. Haslegrave et al.<sup>12</sup> found working with the arms away from the body (a far reach or held out to the side) increased the potential for shoulder injury. Our present results are consistent with previous reports indicating that moving the task closer to a worker decreases upper-extremity muscle activity. Below-knee assembly work constitutes a risk factor for musculoskeletal disorders.

This study had some limitations. One is the small num-

ber of participants. Additionally, the participants were not accustomed to below-knee assembly work, and fatigue was intentionally minimized. Further studies should include subjects who are accustomed to below-knee assembly work. The present results indicate that, among the positions tested, muscle demands during below-knee assembly work are lowest at a height of 30 cm above the floor and a reach distance of 30 cm. The present results indicate that below-knee workers should consider the reach distance. A greater reach distance appears to be a strong risk factor in below-knee assembly work as it increases the potential for shoulder injury.

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