Analysis of Muscle Fatigue of Erect Spinae Caused by Treatment Table Height in Ultrasound Therapy

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Abstract. [Purpose] The objective of this study was to propose a work environment that could reduce musculoskeletal workload. Accordingly, spinal muscle fatigue caused by ultrasound therapy at various treatment table heights was examined and compared. [Subjects and Methods] Twenty-five healthy subjects participated in this experiment. The table height was set to 100%, 125%, and 150% of the stool height (45 cm). The electromyographic signals of the erector spinae at the thoracic (T10, T12) and lumbar (L2, L4) levels were collected by an electromyography (EMG) system during the performance of ultrasound therapy. The median frequencies were then calculated and compared. [Results] The lower the table height was, the smaller the median frequencies of thoracic and lumbar erector spinae on both sides were. The T10 and T12 levels on both sides and the left L2 region showed significant differences among the table heights. At every spinal level, the median frequency of the left erector spinae was lower than that of the right: T10, T12, L2, and L4 at 100%, L4 at 125%, and T10, T12, L2, and L4 at 150% showed significant differences. [Conclusion] During ultrasound therapy muscle fatigue increased at higher table heights and the muscle fatigue of the left erector spinae was greater than that of the right side. To reduce muscle fatigue, we recommend the table height work is raised to an appropriate height, and that is shared between left and right arms.

Key words: Ultrasound therapy, Workload, Muscle fatigue

INTRODUCTION

In their work with patients, 79.9% of physical therapists are exposed to work-related musculoskeletal disorders (WMSDs). Most pains occur in the shoulder, neck, spine, and the extremities. In particular, back pain is experienced by at least 82% of physical therapists1). Besides work overload, WMSDs can be also caused by using muscles for a long time with no rest or by too many repeated muscle contractions2). Long-term maintenance of the same posture or repeated performance of the same motion is highly correlated with pain. Musculoskeletal pain can also result when muscle contraction is continuously maintained or the muscle is repeatedly contracted without sufficient rest3).

In ultrasound therapy (UT), the upper extremities are moved repeatedly while a fixed posture of the trunk is maintained. On average, a physical therapist repeatedly performs UT several tens of times per day, for at least five minutes per session. Therefore, the performance of UT is likely to contribute to the development of musculoskeletal pain in the upper extremities and spine.

The continuous contraction of spinal muscles causes muscle fatigue, which may increase the prevalence of disc disease; therefore, efforts should be made to reduce the workload on the spine4). Table height is an important factor in determining workload5). Inappropriate table height is an important cause of spinal pain because it induces high muscle contraction and causes spinal pain6). Therefore, this study aimed to evaluate the muscle activities of the spine during the performance of UT and propose a table height that reduces the musculoskeletal burden.

SUBJECTS AND METHODS

The subjects of this study were 25 healthy adult males with no history of musculoskeletal or neurological diseases. The experimental process was sufficiently explained to each of the 25 subjects, who all gave their written prior consent. The mean age, mean height, and mean weight of the subjects were 20.8 ± 1.2 years, 165 ± 5.1 cm, and 61.9 ± 10.3 kg, respectively.

To evaluate the muscle fatigue caused by UT, electromyographic signals were collected at a sampling rate of 1,000 Hz by the LAX3204 electromyography system (LAXTHA, Korea). The median frequencies were calculated using Telescan software (LAXTHA, Korea) after processing with a 50–500 Hz band pass filter and a 60 Hz notch filter. The measured muscles were the erector spinae (ES) on both sides of the thoracic (T10, T12) and lumbar (L2, L4) spine. A stool 45 cm high with wheels and no back support was used. The height of the treatment table was set...
to 100%, 125%, and 150% of the stool height. The stool was positioned to give a distance of 1 cm between the knee and the treatment table when a subject sat on it. The ultrasound transducer used in this study was based on cylindricality device (Sonopuls 190, Enraf-Nonius, Germany). To reproduce the same transducer motion, an air disc (Dynair Balkissen, TOGU, Germany) 33 cm in diameter and 9 cm high was moved at a constant speed along a circular guideline indicated at 12 cm from the center of the air disc. The air disc was placed at the edge of the table. Subjects performed UT for one minute while holding the ultrasound transducer with their right hand. One-way ANOVA and Tukey’s post hoc test were conducted using SPSS 12.0 (SPSS, Chicago, USA) to analyze the significance of differences in the median frequency among the table heights. The significance level was 0.05.

RESULTS

The median frequencies of the erector spinae (ES) in the T10 and T12 levels on both sides and at the left L2 level were the lowest at 100% and the highest at 150%. The post-hoc test showed a significant difference between 100% and 150%. The median frequencies of ES at the right L2 level and the L4 level on both sides were also the lowest at 100% and the highest at 150%. However, there were no significant differences among the median frequencies at 100%, 125%, and 150% (Table 1). At 100% and 150%, the median frequency of the left ES was significantly lower than that of the right ES at every spinal level. At 125%, the median frequency of the left ES was also lower than that of the right ES at every spinal level, but only the difference at the L4 level was significant (Table 2).

DISCUSSION

The back muscles of the trunk perform appropriate postural adjustments in the voluntary movement of the trunk or body segment. The proprioceptive senses generated from repeated movements of the hand are conveyed to the α-motor neurons of the ES, and the back muscle is activated in response to the hand movements7. UT work consists of the repeated movements of the upper extremities and hands. In this study, the median frequencies of ES at both sides were observed at all levels. UT work repeated for one minute seems to have caused a load on the back muscle. In particular, the muscle fatigue of the left ES was a little higher, which seems to because of its role in stabilization when the right upper extremity is used. Therefore, unilateral muscle fatigue could be prevented if UT work were performed al-
alternately by for the left and right upper extremities. UT is low-intensity work characterized by repeated movements of the upper extremities in a specific posture. Although it is generally assumed that WMSDs are accompanied by high-intensity muscle contractions, they can also be generated by low-intensity muscle contractions. Sustained muscle contraction at 8% of the maximal voluntary contraction is sufficient to cause pain\(^9\). Because sustained muscle contraction decreases the tension generating ability of the muscle, additional motor units must be activated. The metabolic waste thus generated is not removed by normal blood circulation because the increased muscle contraction resulting from the increased motor unit activation interferes with blood circulation. Cumulative metabolic wastes can cause muscle pain creating a pain-spasm cycle\(^9, 10\). A survey revealed discomfort of the shoulder and back muscles is caused by upper extremity work\(^10\). A decrease in the median frequency of the ES caused by UT work was observed in this study. In particular, the lower the table height was, the lower the median frequency became. Consequently, we believe repetitive performance of UT at a low table height contributes to WMSDs by increasing muscle fatigue of ES. Maintaining a correct posture is essential for reducing musculoskeletal pain and fatigue. Poor working posture can cause musculoskeletal or nervous diseases by accumulating stress in the body. Furthermore, even physiologically normal people can experience pain and fatigue caused by musculoskeletal burden if they perform repetitive movements\(^12\).

Table height is a critical factor in the maintenance of a correct posture in UT work. In this study, therefore, a wheeled stool 45 cm in height was used to reproduce the clinical setting. The table height was set to 100%, 125%, and 150% of the height of the stool, 45 cm, 56.2 cm, and 67.5 cm, respectively. This study conducted a quantitative analysis with an electromyographic system. The results show that the median frequencies of the ES on both sides at the T10 and T2 levels significantly decreased at lower table heights. These results suggest that performing UT at inappropriate table heights increases the fatigue of the thoracic back muscles. Although the differences were not statistically significant, the median frequencies of ES at the L2 and L4 levels also decreased at the lower table heights, also suggesting fatigue of the lumbar muscles. We believe the reason for these changes in median frequency with table height is the increasing moment applied to the spinal segment at the lower table height. Therefore, the height of the treatment table should be raised appropriately in order to prevent fatigue of ES caused by repetitive performance of UT.

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