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Original Article

The effect of the shoulder stability exercise using resistant vibration stimulus on forward head posture and muscle activity

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Abstract. [Purpose] The purpose of this study was to analyze shoulder stabilization using resistant vibration stimulus during bodyblade exercise followed by forward head posture improvement. [Subjects and Methods] Craniovertebral angle and cranial rotation angle were measured with 24 patients who were diagnosed with forward head posture. The experimental group conducted bodyblade exercise for 6 weeks and all patients received conventional physical therapy. The craniovertebral angle and cranial rotation angle were measured using a diagnostic imaging device to measure the change in forward head posture. Sternocleidomastoid, upper trapezius and serratus anterior muscle activity were measured using surface electromyography, voluntary contraction was converting into a percentage and mean value was calculated. [Results] The experimental group showed a significant increase in the comparison of the results of both groups before and after the intervention. The comparing group showed no significant difference. The experimental group showed the significant difference in mean value after the intervention in the comparison between the groups. [Conclusion] Resistant vibration stimulus by bodyblade controlled shoulder muscle activity causing scapular stabilization followed by neck position stability improvement. Rehabilitation program that activates whole kinetic chain of proximal and distal muscles such as bodyblade will show more effective improvement when choosing rehabilitation program for neck and shoulder disease clinically.
Key words: Bodyblade, Resistant active vibration stimulus, Forward head posture

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INTRODUCTION

Neck tends to be exposed to injury or stress biomechanically causing structural change because of its great mobility and low stability[1)]. Long-term continuous neck forward flexion which is abnormal asymmetric posture induces excessive forward flexion of lower cervical spine causing increased flexion moment and forward head posture (FHP)[2, 3)].

Thoracic kyphosis accompanies RSP due to biomechanical connections between the neck and back and body structural characteristics[4)]. For RSP, acromion protrudes forward causing scapular protraction, downward rotation and anterior tilt and scapula deviates from its normal position[4, 5)]. Abnormal scapular position and movement produce imbalance in muscle activity and tone of surrounding muscles of neck and shoulder girdle[6)], causing muscle balance disorder such as upper crossed syndrome and neck pain and disorder[7)]. Therefore, FHP and RSP are closely related[8)]. In other words, scapula stability exercise (SSE) that controls scapular position and movement can place thoracic cage to neutral position and return abnormal neck alignment due to head forward flexion to right position through muscle interactions in neck and shoulder. Treatment

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methods using SSE are currently being studied for neck stability, alignment and pain reduction[4, 9, 10].

A bodyblade is an effective tool for static and dynamic muscle strengthening of shoulder and a dynamic response treatment tool that produces force proportionately with the resistance of active vibration stimulus and is clinically used in many cases[11]. It produces 151N by 4.5 Hz proper vibration and resistant vibration stimulus that requires 270 muscle contractions a minute[12].

The exercise using a bodyblade is an open kinetic exercise but resistant vibration stimulus produces resistance from distal to proximal body segment causing proprioceptive sense facilitation by co-contraction and eccentric contraction that can be obtained from closed kinetic exercise followed by dynamic stabilization of muscles[13]. A bodyblade can be applied with various kinetic chain exercise patterns but most previous studies only analyzed direct and partial effect such as shoulder stability[14] and core muscle stabilization[12]. So far, there are few studies about the effect of actively induced resistant vibration stimulus.

Therefore, this study was to analyze the effect of SSE using a bodyblade on neck angle improvement in patients with FHP proving the effect of the resistant vibration stimulus on neck and shoulder disorder to provide effective and efficient treatment method and offer basic data for physical therapy.

SUBJECTS AND METHODS

This study was conducted with the patients who were diagnosed with forward head posture (FHP) and visiting or hospitalized in H hospital in Suncheon city, Jeollanam-do Province, South Korea from Nov 2015 to the end of Jan 2016. All patients were informed of purpose and method of the study prior to participation according to the ethical standard of the Declaration of Helsinki. The patients were randomly divided into the bodyblade exercise group (experimental group, n=12) and conventional physical therapy group (comparing group, n=12).

FHP patients who have craniovertebral angle (CVA) of less than 52° and have cranial rotation angle, (CRA) of more than 143° were selected. Those who had congenital spinal deformity, spinal or shoulder surgery, nervous system problems, performed regular neck or shoulder exercise and could not perform natural head posture (NHP) during FHP measurement were excluded. Dominant arm of every patient was right side. Table 1 shows general characteristics of the patients.

Bodyblade (Classic, Mad Dogg Athletics, USA), an elastic pole exercise tool with 122 cm in length, 0.68 kg, 4.3 cm in width, was applied to the experimental group. When you grasp the rubber grip in the middle of the blade shaped pole and shake the pole, vibrations occurs with constant frequency and velocity at both ends of the pole. For training task, intensity, duration and frequency, two types of exercises that can improve FHP according to previous study were conducted[12]. For basic posture, the patients were standing in anatomic position with feet shoulder width and knee joint slightly flexed.

Exercise task (I); Grabbing the center of the pole with both hands with shoulder joint flexed to 180° in overhead position with the pole perpendicular to the floor and oscillation exercise in the sagittal plane. Exercise task (II); Grabbing the center of the pole with both hands with shoulder joint flexed to 90° with the pole parallel to the floor and oscillation exercise in the transverse plane. Also, the exercises were defined in a random order. The exercises were conducted 3 times a week for 6 weeks, which were 18 sessions in total. Foursets of each session, 3-minute exercise and 5-minute break, were conducted.

As conventional physical therapy, both groups received 20-minute hot pack, 15-minute transcutaneous electrical nerve stimulation (TENS) and 5-minute ultrasound therapy in the pain area; back of the neck and shoulder.

For FHP change measurement, CVA and CRA were measured. The patient relaxed and placed arms on the sides of the body while comfortably standing in the NHP and reached to self-balance posture (SBP). PROTEUS XR/A (GE Healthcare Co, USA) was used as diagnostic imaging device from the lateral side of the patient. CVA and CRA were measured with the seventh cervical vertebra, tragus and lateral canthus connected in a straight line. They were measured twice to calculate mean value. Smaller CVA and greater CRA increase FHP level[10, 15].

Delsys-Trigno Wireless EMG System (Trigno EMG Sensor, Delsys Inc., Boston, MA, USA) was used to measure surface electromyography (sEMG) which was used to analyze muscle activity change in neck and shoulder relating to FHP and RSP. For sEMG data, electrodes were attached halfway between mastoid and manubrium of sternum for sternocleidomastoid muscle (SCM), halfway between the seventh cervical vertebra and acromioclavicular joint for upper trapezius (UP), and to muscle at the back of the center line of axilla at the fifth or sixth rib height for serratus anterior (SA). The electrodes were attached to only dominant arm muscles (right-side).

Table 1. General characteristics of the subjects

	Experimental group (n=12)	Control group (n=12)
Gender (male/female)	1/11	4/8
Age (years)	21.0 ± 4.2[a]	25.4 ± 10.1
Height (cm)	163.8 ± 5.6	165.1 ± 7.2
Weight (kg)	61.3 ± 10.3	58.7 ± 8.0

[a]Mean ± SD.

Delsys EMG Works Acquisition was used to analyze the data. Sampling rate of EMG signals was set to 2,000 Hz and frequency bandwidth for noise rejection of EMG was set as 20–450 Hz. The collected EMG signals of each muscle were analyzed with root mean square (RMS).

For measuring posture for reference voluntary contraction (RVC), height adjustable bar was set in front of the patient. The patient maintained humerus and elbow joint straight in sitting position with forearms in neutral position and held 1 kg dumbbell in hands with back of hands side up. EMG signals were measured 3 times with shoulder joint flexed to 90° while wrist joint touching the bar for 15 seconds. EMG signals during 5 seconds in the middle of each trial were normalized as mean value to obtain RVC. All EMG data are expressed as percentages of the RVC (%RVC).

The Kolmogorov-Smirnov test was performed with the measured values to verify normalization. To compare the results of both groups before and after the experiment, a paired t-test was conducted. To compare the differences between both groups before and after the experiment, an independent t-test was conducted. The significance level was set at $\alpha=0.05$ and SPSS ver. 18.0 software was used for statistical processing.

RESULTS

Table 2 shows muscle activity changes by sEMG and FHP angle changes in the experimental group and comparing group. In the comparison of the results of both groups before and after the experiment, for the mean value changes of %RVC in the experimental group, there was a significant decrease in sternocleidomastoid muscle and upper trapezius muscle and there was a significant increase in serratus anterior muscle ($p<0.05$). For the mean value changes of FHP angles, there was a significant increase in CVA and there was a significant decrease in CRV. But there was no significant result in the comparing group.

In the comparison between the differences between both groups before and after the experiment, there was a significant difference in the mean values of the experimental group after the intervention ($p<0.05$).

DISCUSSION

The purpose of this study was to conduct 6-week bodyblade exercise, which uses resistant vibration stimulus to control neck and shoulder muscle activity and stabilize shoulder, with forward head posture (FHP) patients and measure changes in CVA and CRA to analyze FHP improvement.

Weon et al. reported that FHP excessively increases muscle activity of UP[16]. Thigpen et al. showed that, in comparison with ideal posture, FHP causes SA muscle activity decrease and trapezius overwork during upper extremity evaluation[6]. SCM, superficial neck muscle, muscle activity should be minimized for FHP improvement[10]. Muscle activity was measured using sEMG after bodyblade exercise and there was a significant decrease in SCM and UP and there was a significant increase in SA in this study. This result occurred because vibration stimulus less than 50 Hz produced during bodyblade exercise induced tonic vibration reflex on muscle and tendon activating proprioception feedback[10, 17]. Lister et al. showed that bodyblade training increases sense of position, movement and shoulder joint stability and decreases pain and physical symptoms from shoulder joint instability[4].

Thigpen et al. showed that posture change due to FHP changes scapular movement and muscle activity when raising hand over head[6, 10]. For FHP evaluation method, Harman et al. used CVA and CRA as test inspector and analyzed FHP changes. This study also used CVA and CRA in standing position to measure FHP[18]. CVA significantly increased as 56.8 ± 2.5° and CRA significantly decreased as 142.9 ± 4.2° after bodyblade intervention. Generally, CVA scale shows that CVA less than 50° accompanies pain and CRV more than 145° is considered as abnormal range[19].

As a result of this study, resistant vibration stimulus by bodyblade controlled shoulder muscle activity and stabilized scapula followed by neck stability. This result occurred because of α-motor neuron mobilization increase during vibration

Table 2. Comparison of changes in muscle activity and FHP angle between the groups

Variable	Experimental group		Control group	
	Pre-test	Post-test	Pre-test	Post-test
sEMG (%RVC)				
SCM	46.5 ± 5.8[a]	36.83 ± 6.1*†	49.3 ± 4.6	46.7 ± 4.6
UT	5.2 ± 0.9	3.6 ± 0.5*†	4.8 ± 0.8	4.5 ± 0.7
SA	10.5 ± 1.3	16.5 ± 2.0*†	11.0 ± 0.8	11.1 ± 0.8
FHP (°)				
CVA	48.2 ± 3.0	56.8 ± 2.5*†	49.5 ± 1.4	50.7 ± 2.9
CRV	150.7 ± 5.3	142.9 ± 4.2*†	147.7 ± 4.6	147.2 ± 5.2

[a]Mean ± SD. sEMG: surface electromyography; FHP: forward head posture; SAM: sternocleidomastoid; UT: upper trapezius; SA: serratus anterior; CVA: craniovertebral angle; CRA: cranial rotation angle
*Significant differences between pre- and post-tests ($p<0.05$)
†Significant differences between the SFE and the ASI groups ($p<0.05$)

stimulus, neuromuscle control, global muscle strengthening and proprioception feedback[20]. Rehabilitation program such as bodyblade exercise which activates whole kinetic chain of proximal and distal muscles will show more effective improvement and should be considered when clinically choosing neck and shoulder disease rehabilitation program in the future.

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