



Original Article

Effect of neck flexion restriction on sternocleidomastoid and abdominal muscle activity during curl-up exercises

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Abstract. [Purpose] The purpose of this study was to investigate the effect of neck flexion restriction on sternocleidomastoid (SCM), rectus abdominis (RA), and external oblique (EO) muscle activity during a traditional curl-up exercise and a curl-up with neck flexion restriction. [Subjects] In total, 13 healthy male subjects volunteered for this study. [Methods] All subjects performed a traditional curl-up exercise and a curl-up exercise in which neck flexion was restricted by the subject's hand. Surface electromyography (EMG) signals were recorded from the SCM, RA, and EO during the curl-up. [Results] There was significantly lower EMG activity of the SCM during the curl-up exercise with neck flexion restriction compared to the traditional curl-up exercise. Conversely, the activity of the RA and EO muscles was significantly higher in the curl-up exercise with neck flexion restriction than in the traditional curl-up exercise. [Conclusion] Neck flexion restriction is recommended to prevent excessive activation of superficial cervical flexors during the curl-up exercise.

Key words: Abdominal muscle, Neck flexion restriction, Curl-up exercise

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INTRODUCTION

Abdominal muscle strengthening exercises are frequently used for the promotion of health and prevention of musculoskeletal disease, as well as for rehabilitation of lower back pain^{1,2)}. Strengthening the abdominal muscles helps to stabilize the trunk and lessen the stress on the lumbar spine³⁾. The curl-up exercise has been shown to produce reasonable levels of activity in the rectus abdominis (RA) muscle while minimizing the resultant load on the spine⁴⁾.

However, the curl-up exercise may activate the superficial cervical flexors, such as the sternocleidomastoid (SCM), because the head and shoulders are raised off the floor during the neck flexion. Superficial cervical flexors are the dominant muscle group during neck flexion movement⁵⁾. A neck flexion position that causes neck pain could be a contributing factor to increased back pain, because the vertebral regions are connected to each other⁶⁾. According to Lee et al.⁷⁾ the activity of the SCM muscle increases as the neck flexion angle increases. Muscle activity of the superficial neck flexor is significantly increased in cervical pain during the neck stabilizing task; increased activity of the SCM could be compensatory for poor segmental stability of the deep muscles. Therefore, an intervention to decrease SCM activity with neck flexion restriction during the curl-up exercise is required.

Research has focused primarily on increased abdominal activity during curl-up exercises using an unstable surface⁸⁾ and different positions of the upper and lower limbs⁹⁾ to identify the most effective position to increase abdominal strength. The question of whether neck flexion restriction can alter the muscle activity of the RA, external oblique (EO), and SCM muscles

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during a curl-up has not been investigated. Thus, the purpose of this study was to assess the effect of neck flexion restriction on SCM and abdominal muscle activity during the traditional curl-up exercise and the curl-up exercise with neck flexion restriction.

SUBJECTS AND METHODS

In total, 13 healthy male subjects were recruited from Inje University, Gyeongsangnam-do, Republic of Korea. The mean age of the subjects was 23.7 ± 0.4 years, and their mean height and weight were 173.2 ± 5.25 cm and 66.5 ± 5.7 kg, respectively. Subjects were excluded if they had a history of abdominal or low-back pain within 6 weeks prior to the study and an inability to correctly perform all the exercises in a pain-free manner. Prior to participation, all subjects read and signed an informed consent form that was approved by the Institutional Research Review Committee of Inje University.

Surface electromyographic (EMG) signals were collected with a Trigno wireless EMG system (Delsys, Inc., Boston, MA, USA). EMG data were collected from the SCM, RA, and EO muscles on the dominant side. The electrode placements were as follows: SCM, half the distance between the mastoid process and the sternal notch; RA, 2 cm lateral to the umbilicus; and EO, the inferior edge of the eighth rib superolateral to the costal margin¹⁰. Root mean square values were calculated for all raw data. To normalize the data, the maximum voluntary isometric contraction (MVIC) of each muscle was measured using the maneuver suggested by Kendall et al¹¹. All EMG data are expressed as %RVC.

All subjects performed two types of curl-up exercise. First, subjects performed a traditional curl-up exercise. The subject was instructed to lay supine with both arms down by their side, knees flexed to approximately 90°, hips flexed to approximately 45°, and feet placed flat on the floor. Subjects elevated their trunk by lifting their head and shoulders until the scapulae were lifted above the floor. A target bar was placed at the chest to provide feedback when the scapulae were off the floor. Second, subjects performed a traditional curl-up exercise with neck flexion restriction. The subject began in a supine hook-lying position and was asked to move to the chin tuck position. Then, the subject was instructed to “Lightly touch your right hands on your mandible” to provide a tactile cue for neck flexion restriction during curl-up. The subject was asked to touch the target bar during each curl-up exercise and to hold the position for 5 s. All test trials were repeated three times, with a 1-min rest between trials to avoid fatigue. The mean value of these measurements was used for data analysis.

To compare the differences in normalized EMG muscle activity of the SCM, RA, and EO muscles, between the traditional curl-up and curl-up with neck flexion restriction exercises, a paired-t test was used. All data were analyzed using the SPSS for Windows software package (ver. 18.0; SPSS Inc., Chicago, IL, USA); a p value < 0.05 was considered to indicate statistical significance.

RESULTS

There was significantly lower EMG activity of the SCM during the curl-up exercise with neck flexion restriction than the traditional curl-up exercise ($p < 0.05$). Conversely, the activity of the RA and EO muscles was significantly higher during the curl-up exercise with neck flexion restriction compared to the traditional curl-up exercise ($p < 0.05$; Table 1).

DISCUSSION

The results of this study showed that the curl-up exercise with neck flexion restriction decreased the activity of the SCM muscle and increased the activity of the abdominal muscles significantly. This may have important clinical implications for abdominal muscle strengthening in patients with neck pain.

In this study, we showed that during the curl-up exercise in which neck flexion was restricted by the subject’s hand, the muscle activity of the SCM was decreased compared to the traditional curl-up exercise. Recently, a self-monitored method using tactile stimulation through the subject’s own finger touching has been shown to be a useful clinical method to enhance abdominal muscle training and to prevent compensatory movement¹². Superficial cervical flexors (SCM and anterior scalenes) contribute to forward translator motion in the cervical region⁵. Considering the significantly decreased SCM activity in this study, having subjects touch their hands on the mandible could be a good strategy to prevent forward translation in

Table 1. Electromyography activity (% maximum voluntary isometric contraction) in the sternocleidomastoid, rectus abdominis, and external oblique muscles during the traditional curl-up and curl-up with neck flexion restriction exercises

Muscle	Traditional curl-up	Curl-up with neck flexion restriction
Sternocleidomastoid	32.2 ± 4.5*	22.1 ± 6.1
Rectus abdominis	46.5 ± 12.3	56.2 ± 11.1*
External oblique	38.8 ± 15.5	50.4 ± 17.8*

*p<0.05

the cervical region.

Previous studies focused on decreased SCM and increased abdominal activity during the curl-up exercise^{13, 14}. Yoon et al.¹⁴ reported that the muscle activity of SCM during curl-up with craniocervical flexion (CCF) was significantly lower than during the traditional curl-up exercise, but the abdominal muscle activity did not differ between the two tasks. However, we found that decreased SCM activity could influence increased abdominal muscle activity during curl-up with neck flexion restriction. It is possible that neck flexion restriction by the subject's hand (SCM: 22.1%MVIC) could be used to greatly reduce cervical curve flexion relative to CCF (right SCM: 39.5, left SCM: 38.2%MVIC) due to decreased SCM activity. Thus, reduced cervical flexion during the curl-up exercise with neck flexion restriction could increase abdominal muscle activity because of the lengthened lever arm of the trunk.

This study had several limitations. First, only healthy young men participated in this study. Therefore, the findings cannot be generalized to other populations. Second, we estimated the neck flexion angle according to SCM activity. Further studies are needed to assess not only the activity of the abdominal muscle, but also kinematic data in the cervical region.

This study provides empirical evidence that the curl-up exercise in which neck flexion is restricted by the hand is more useful for enhancing abdominal muscle activity compared to the traditional curl-up exercise. This suggests that it may be used as an alternative abdominal strengthening exercise for the management of patients with neck disability. Therefore, the curl-up exercise with neck flexion restriction is recommended to prevent excessive activation of the superficial cervical flexors during the curl-up exercise.

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