J. Phys. Ther. Sci.
27: 973–975, 2015

Original Article

Changes in the activity of the muscles surrounding the neck according to the angles of movement of the neck in adults in their 20s

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Abstract. [Purpose] The aim of this study was to examine changes in the muscle activity around the neck according to the neck movement angle during neck flexion and extension. [Subjects and Methods] Activities of the sternocleidomastoid muscle (SCM), splenius capitis and splenius cervicis muscles, upper trapezius muscle, and middle trapezius muscle during flexion and extension were assessed in 24 college students. [Results] SCM muscle activation significantly increased at every angle during flexion and extension. The activities of the splenius capitis and splenius cervicis muscles increased significantly during flexion. The activity of the upper trapezius muscle also increased significantly. [Conclusion] The results highlight the need for individuals not to adopt a neck flexion posture for extended periods.

Key words: Neck muscles, Electromyography, Muscle activation

(This article was submitted Nov. 21, 2014, and was accepted Dec. 25, 2014)

INTRODUCTION

Nowadays, people have various musculoskeletal diseases, due to a lack of exercise caused by busy lifestyles and increased computer use. The cervical vertebra has the largest range of motion and flexibility among the vertebrae, making it vulnerable to damage. Complaints of neck pain and functional and structural problems have increased in recent years due to excessive fatigue of the cervical vertebrae due to loads placed on them[1)].

The center of the shoulder joint should be vertically below both sides of the mastoid in a normally positioned head and neck. In this position, the head is balanced via constant contraction of the muscles located at the back of the neck. If excessive and repetitive activities cause constant neck imbalance, the head is supported by noncontractile structures, and pain may occur[2, 3)]. Individuals who spend a long time sitting may experience such imbalance, with the imbalance occurring mainly in the sagittal plane rather than in the coronal plane[4)].

The load that is applied to each muscle according to the neck position can be estimated by determining how much muscle activity changes around the neck as the angle of neck movement increases under conditions of overtension and excessive loads. This study aimed to determine the changes in the muscle activity around the neck according to the neck movement angle during neck flexion and extension.

SUBJECTS AND METHODS

The subjects of this study were conducted with 24 university students attending Y University in Gyeongsangnam-do, Korea. The mean age, height, and weight of the subjects were 20.5±0.5 years, 158.6±2.3 cm, and 53.5±9.3 kg, respectively. The selection criteria were as follows: subjects who had no significant disease that would have affected the study, no visual impairments, no auditory impairments of the vestibular organs, and no neurological problems. Subjects unable to comply with the experimental process were also excluded. All included subjects were given an explanation of the purpose of this study and provided their written informed consent prior to their participation in the study in accordance with the ethical principles of the Declaration of Helsinki.

A TELEMYO 2400 (Noraxon, USA) with Ag-Ag/Cl electrodes were used to determine the activities of the muscles surrounding the neck. A sampling rate of 1,000 Hz was used for the EMG signal acquisition, and the signals were full-wave rectified. MyoResearch-XP 1.07 (Noraxon, USA) software was used to perform band-pass filtering between 30–500 Hz, and the signals were also notch filtered

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at 60 Hz to remove noise. The muscle activity values were normalized to the maximum voluntary isometric contraction values of each muscle.

The muscle activity was measured three times in both neck flexion and extension, with the subjects sitting on a chair and adopting three neck positions of increasing angles the neutral position, an angle of 30°, and a full range of motion (ROM). To standardize the measured values of each muscle, the raw data were converted to the root mean square value. The mean value of the three repeated measurements was then used to compare the muscle activities. The electrodes were attached over the sternocleidomastoid muscle (SCM), splenius capitis and splenius cervicis muscles, upper trapezius muscle, and middle trapezius muscle[5]. All the data are expressed as the mean ± standard deviation.

SPSS for Windows (version 20.0) was used to analyze the data in this study. To determine the muscle activity according to the neck movement angles, repeated measures ANOVA was conducted, as well as a post hoc LSD test. Statistical significance was accepted at values of $p < 0.05$.

RESULTS

The activity of the SCM muscle increased significantly when the subjects performed flexion movement between the neutral position and the 30° flexed position, between the 30° flexed position and the full ROM position, and between the neutral position and the full ROM position ($p < 0.05$).

There was a significant increase in the activities of the splenius capitis and splenius cervicis muscles when the subjects performed flexion between the 30° flexed position and the full ROM position, and between the neutral position and the full ROM position ($p < 0.05$).

The activity of the upper trapezius muscle also increased significantly when the angle of flexion increased between the 30° flexed position and the full ROM position ($p < 0.05$, Table 1).

DISCUSSION

In this study, changes in the activities of the muscles surrounding the neck were determined according to the neck movement angle when adults in their 20s performed flexion and extension. The muscles examined in this study were the SCM, splenius capitis and splenius cervicis, upper trapezius, and middle trapezius.

In general, the SCM is used when the head is turned to the contralateral side or performs lateral bending on the ipsilateral side or when the head is in a forward slouched position. Such positions are closely related to neck and shoulder pain, which are common complaints in clinical practice[6, 7]. The splenius capitis and splenius cervicis play roles in stabilizing the neck during pulling motions, and damage to these muscles results in neck pain and headaches. Damage mostly occurs when these muscles perform flexion and extension[8]. The upper trapezius is used when the scapula is moved or during lateral bending of the head. Damage or overuse of these muscles results in neck pain, shoulder pain, and headaches. The splenius capitis and splenius cervicis are common sites of repetitive strain injury[9, 10]. The middle trapezius muscle is involved in nearly all movements of the scapula and in the stability of the scapula[11]. This muscle is often the focus of treatment for shoulder rehabilitation in clinical practice.

In the present study, the activity of the SCM muscle increased significantly whenever the angles of movement increased between the neutral position and the 30° flexed position, between the 30° flexed position and the full ROM position, and between the neutral position and the full ROM position. These results are consistent with those of other studies, which reported that the activity of the SCM muscle increases as the neck angle increases[12, 13]. The activity of the splenius capitis and splenius cervicis muscles also increased significantly when the neck performed flexion between the 30° flexed position and the full ROM position, and between the neutral position and the full ROM position. The increase is due to the response of the splenius capitis and splenius cervicis muscles to tension (i.e., a pulling force). This tension occurs when the neck performs flexion rather than extension. When this occurs, the splenius capitis and splenius cervicis muscles contract and flex to stabilize the neck[8]. The activity of the upper trapezius muscle increased only between the

Table 1. Comparison of muscle activity according to neck movement angle

Muscle	Action	Neutral	30-degree angle	Full ROM
SCM (%MVIC)	Flexion	3.34±2.2	4.56±3.4	5.65±4.1[abc]
	Extension		8.94±6.2	17.55±18.4[abc]
Splenius capitis & Splenius cervicis (%MVIC)	Flexion	9.64±7.5	13.22±10.1	13.06±9.5[ac]
	Extension		12.15±14.7	13.08±10.7
Upper Trapezius (%MVIC)	Flexion	4.33±5.0	4.39±5.2	4.62±5.4[b]
	Extension		4.38±5.1	4.94±4.7
Middle Trapezius (%MVIC)	Flexion	11.70±12.1	13.21±11.7	12.31±9.1
	Extension		10.50±7.5	10.60±6.4

All values, Mean±SD; MVIC: maximum voluntary isometric contraction; SCM: sternocleidomastoid muscle.
Superscripts indicate significant differences, $p<0.05$:
[a]: between neutral and 30° flexion; [b]: between 30° flexion and full ROM; [c]: between neutral and full ROM

30° flexed position and the full ROM position. Because this muscle is relatively larger, stronger, and more resilient than the other muscles measured in this study, it was not activated at the smaller neck movement angle. However, when the tension (pulling force) increased, this muscle was activated, as reported by other studies[14, 15]. In conclusion, the muscle activity measured in this study increased when flexion movements were performed under conditions of increased loads. However, no increase was found when the subjects performed extension movements. The results highlight the need for individuals not to adopt a neck flexion posture for extended periods.

The limitations of this study were the small number of subjects and the limited age range of the study group. A future study will include more subjects of various ages.

REFERENCES

1) Jull G, Barrett C, Magee R, et al.: Further clinical clarification of the muscle dysfunction in cervical headache. Cephalalgia, 1999, 19: 179–185. [Medline] [CrossRef]
2) Kisner C, Colby LA: Therapeutic Exercise: Foundations and Techniques. FA Davis, 2012.
3) Jeon J, Ju S, Jeong H: The effect of cervical stabilizing exercises in the standing position and the supine position on deep neck muscle strength and endurance. J Phys Ther Sci, 2012, 24: 423–425. [CrossRef]
4) Mekhora K, Liston C, Nanthavanij S, et al.: The effect of ergonomic intervention on discomfort in computer users with tension neck syndrome. Int J Ind Ergon, 2000, 26: 367–379. [CrossRef]
5) Criswell E: Cram's Introduction to Surface Electromyography, Jones & Bartlett Publishers, 2010.
6) Barton PM, Hayes KC: Neck flexor muscle strength, efficiency, and relaxation times in normal subjects and subjects with unilateral neck pain and headache. Arch Phys Med Rehabil, 1996, 77: 680–687. [Medline] [CrossRef]
7) Jull G, Kristjansson E, Dall'Alba P: Impairment in the cervical flexors: a comparison of whiplash and insidious onset neck pain patients. Man Ther, 2004, 9: 89–94. [Medline] [CrossRef]
8) Shedivy DI, Kleinman KM: Lack of correlation between frontalis EMG and either neck EMG or verbal ratings of tension. Psychophysiology, 1977, 14: 182–186. [Medline] [CrossRef]
9) Pepper E, Wilson V, Taylor W, et al.: Repetitive strain injury and electromyography: applications in physical therapy. Phys Ther Prod, 1994, 5: 17–22.
10) Hägg GM, Aström A: Load pattern and pressure pain threshold in the upper trapezius muscle and psychosocial factors in medical secretaries with and without shoulder/neck disorders. Int Arch Occup Environ Health, 1997, 69: 423–432. [Medline] [CrossRef]
11) Wegner S, Jull G, O'Leary S, et al.: The effect of a scapular postural correction strategy on trapezius activity in patients with neck pain. Man Ther, 2010, 15: 562–566. [Medline] [CrossRef]
12) Forsberg CM, Hellsing E, Linder-Aronson S, et al.: EMG activity in neck and masticatory muscles in relation to extension and flexion of the head. Eur J Orthod, 1985, 7: 177–184. [Medline] [CrossRef]
13) Morimoto K, Sakamoto M, Fukuhara T, et al.: Electromyographic study of neck muscle activity according to head position in rugby tackles. J Phys Ther Sci, 2013, 25: 563–566. [Medline] [CrossRef]
14) Mathiassen SE, Winkel J, Hägg GM: Normalization of surface EMG amplitude from the upper trapezius muscle in ergonomic studies—a review. J Electromyogr Kinesiol, 1995, 5: 197–226. [Medline] [CrossRef]
15) Harms-Ringdahl K, Ekholm J, Schüldt K, et al.: Load moments and myoelectric activity when the cervical spine is held in full flexion and extension. Ergonomics, 1986, 29: 1539–1552. [Medline] [CrossRef]