J. Phys. Ther. Sci.
27: 2159–2162, 2015

Original Article

The effects of stretching exercise for upper trapezius on the asymmetric rate of bite force

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Abstract. [Purpose] The purpose of this study was to observe the effects of stretching the upper trapezius muscle on the asymmetric rate of bite force. [Subjects] Forty-seven female university students who had all their original teeth, had no disorders in the temporomandibular joints, and had never worn braces; participated in this study. [Methods] An occlusometer was used to measure biting forces. Subsequently, stretching exercises of the upper trapezius were performed. The subjects were divided into 3 groups at the start of the testing: the asymmetric rate of the first group was less than 10%; the asymmetric rate of the second group was between 10% and 20%; and the asymmetric rate of the third group was more than 20%. The stretching exercises were done on the dominant side of the upper trapezius. [Results] After the stretching exercises of the upper trapezius, the results showed that for the first group, whose asymmetric rate of biting force was less than 10%, there was a significant increase in asymmetric rate (from 5.1% to 10.3%). For the second group, whose asymmetric rate of biting force was measured to be between 10% and 20%, the asymmetric rate decreased from 14.7% to 14.3%, but the change was not statistically significant. For the third group, whose asymmetric rate of biting force was more than 20%, there was a significant decrease in asymmetric rate (from 27.8% to 12.6%). [Conclusion] We concluded that stretching exercises of the upper trapezius muscle had a direct effect on the asymmetric rate of biting force.
Key words: Asymmetric rate of biting force, Upper trapezius, Stretching exercise

(This article was submitted Feb. 19, 2015, and was accepted Apr. 3, 2015)

INTRODUCTION

Occlusion refers to contact between teeth in the maxillary and mandibular bones when the jaw is stable or when biting[1–3)]. The biting force refers to the force exerted by the masticatory muscles, particularly the masseter muscle, during occlusion[4)]. The temporomandibular joint also plays a role in the biting force. The temporomandibular joint provides a pivot for opening and closing the mouth, moves the chin left to right and back to front, and acts as a level for masticatory movement. There are several factors that could cause dysfunction of the temporomandibular joint, most commonly the displacement of cranial bones, the hyoid bone, cervical spine or occlusal problems, stress, oral parafunction habits, etc[5)]. These dysfunctions are referred to collectively as temporomandibular disorder, and they cause various symptoms including continual pain in the surrounding tissues of the temporomandibular joint and masticatory muscles. Temporomandibular disorder also decreases the range of motion of the jaw; and causes a crackling sound in the jaw when the joint is moved[6–8)]. For these reasons, treatment of temporomandibular disorder is necessary for the promotion of health because temporomandibular disorder weakens the biting force and causes masticational dysfunction. Generally, temporomandibular disorder can be treated by either conservative therapy or surgical therapy. Conservative therapy includes physical therapy, behavioral therapy, drug treatment, and the use of occlusal appliances. Surgical therapy includes orthographic surgery, arthroscopy, temporomandibular joint surgery, and temporomandibular joint arthrocentesis[9)]. Normally, the main treatment for temporomandibular disorders is direct treatment of the temporomandibular joint. However, Guzay[10)] suggested the Quadrant Theorem based on his observation of temporomandibular joint movement. His Quadrant Theorem states that temporomandibular joint movement centers on the first and second cervical vertebrae. From this theorem, we can see that cervical muscle activity affects temporomandibular joint movement. In connection with this, Ringqvist[11)] stated that the compressive stress that is formed between the first and second cervical vertebrae affects the biting force. Fonder[12)] stated that when there is imbalance in the

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Table 1. General characteristics of subjects

Asymmetric ratio	N	Age (years)	Weight (kg)	Height (cm)
Less than 10%	16	20.4±0.6[a]	58.6±11.3	161.1±4.9
10% to less than 20%	14	20.4±0.6	57.1±9.6	162.1±4.0
Above 20%	17	20.7±0.8	56.0±7.9	159.7±4.8

[a]Mean±SD

temporomandibular joint, the atlas and axis bones move into abnormal positions. This causes imbalance in the level of tension on the muscles that are attached to the atlas and axis. Yoshimatsu et al.[13] demonstrated the relationship between shoulder and cervical region symptoms and oral habits. Fonder[14] reported that, because 9 out of the 12 cranial nerves pass through the temporomandibular joint, problems arising in the temporomandibular joint can break the balance of 68 pairs of muscles surrounding the cervical region–quite a wide range of effects. In this regard, Lee[15] confirmed that temporomandibular disorders limit the motion of the upper cervical muscles; and increase the tender points of the trapezius and sternocleidomastoid muscles. Kim et al.[16] stated that the occlusion of an imbalanced temporomandibular joint could increase the tension of the muscles that surround the shoulders and cervical vertebrae, thereby causing pain. Hence, it is obvious that temporomandibular joint disorders have a close connection with the muscles of the cervical region. Nonetheless, much of the existing research has evaluated and treated the temporomandibular joint by focusing on the structure and tissues that surround the temporomandibular joint. For example, Iwatsuki et al.[17] examined the changes in biting force after the application of deep friction massage to the masticatory muscles of cerebrovascular accident subjects. Also Bae and Park[18] attempted to identify the influence of relaxation exercises for the masticator muscles on the limited ROM and pain in temporomandibular joint dysfunction (TMD). However, Heo[19] indicated the need for further research on the effect of scalene muscle stretching in the cervical region on the asymmetric rate of biting force; and also on the asymmetric rate of masticatory muscle activity. This would enable a therapeutic approach toward the treatment of cervical muscles, which can in turn affect the temporomandibular joint. Hence, this study was performed to further examine the effects of the cervical muscles on the function of the temporomandibular joint. This study was designed to examine the effects of stretching of the upper trapezius, as it affects the motion of the cervical muscles attached to the atlas and axis, and the function of the temporomandibular joint.

SUBJECTS AND METHODS

This study was performed with a one-group pretest-posttest design. The subjects were 50 female S-University students in Busan City, Republic of Korea who were in good health. They were thoroughly informed in advance regarding the proposed research. This study complied with the ethical standards of the Declaration of Helsinki, and written informed consent was received from each participant. The subjects had all their original teeth, had no temporomandibular disorders, and had never worn braces. Among the 50 original subjects, 3 had to withdraw due to personal circumstances, so in total, only 47 participated in the experiment. The left and right biting force of all 47 subjects were measured before the experiment. The subjects were subsequently divided into 3 groups according to the following asymmetric measurements: the asymmetric rate of the first group (16 persons) was less than 10%; the asymmetric rate of the second group (14 persons) was between 10% and 20%; and the asymmetric rate of the third group (17 persons) was more than 20%. The general characteristics of the subjects are shown in Table 1. A gnathodynamometer was used to measure biting force (TCT 2008, TCT Tech Co, Republic of Korea). The measurable range of the gnathodynamometer was 9.8–980N and the error range was less than 9.8 N. The thickness of the bite plate was 11 mm and a silicone cover was attached to protect the teeth. Sanitary gloves were used and were changed before every measurement. The gnathodynamometer displayed measurements in newtons (N). Before biting force measurements were taken, measures were taken to ensure that the subject was sitting in an optimal measurement pose, and measurements were taken twice (pre- and post-test measurements). Each measurement took 5 seconds and was taken three times. There was a 5 second break between measurements. The asymmetric rate was calculated by subtracting the nondominant side's biting force from the dominant side's biting force and the result was divided by the biting force of the dominant side, according to the following formula: asymmetric rate of biting force = (biting force of dominant side − biting force of nondominant side) ÷ biting force of dominant side × 100.

The experimenter trained the subjects in stretching exercises for the upper trapezius a sufficient number of times to ensure consistency. The starting position of the stretching exercise was the hook lying position. The experimenter fixed the subject's shoulder on the dominant side with his hand; and used his hand and abdomen to fix the subject's cervical vertebrae and neck. He then flexed the head and neck, flexed the shoulder on the dominant side to the opposite side laterally, and rotated the shoulders on the dominant side and ipsilateral site for upper trapezius stretching. In that position, the subject's shoulders were pushed toward the inferior direction, and the neck and head were pushed to the opposite side to stretch the upper trapezius. The stretching was done for 10 seconds each time. One set consisted of three stretches, and 3 sets were performed. After each stretch, the subject was given 10 seconds of rest, and between sets, there was a 1 minute rest period. The pre-test results were used for finding the dominant side by using the left and right asymmetric rate of biting force. Stretching exercise for upper trapezius on the dominant side was then performed. This research was per-

Table 2. The changes in asymmetric rate after stretching exercise for the upper trapezius on the dominant side (Unit: %)

Asymmetric ratio	Pre-stretching	Post-stretching
Less than 10%*	5.1±2.7[a]	10.3±8.1
10% to less than 20%	14.7±2.8	14.3±8.7
Above 20%*	27.8±5.3	12.6±8.8

[a]Mean±SD. * $p<0.05$ by paired t-test

formed to examine the effects of upper trapezius stretching exercise on the left and right asymmetric rate of biting force. Therefore, the changes in asymmetric rate of biting force were examined carefully. After measuring the left and right biting force 3 times, the mean value was used for analysis.

After examining the asymmetric rate from the results of the initial testing, the subjects were divided into 3 groups according to the following asymmetric measurements: the asymmetric rate of the first group (16 persons) was less than 10%; the asymmetric rate of the second group (14 persons) was between 10% and 20%; and the asymmetric rate of the third group (17 persons) was more than 20%. Subsequently, to examine the change in the results for asymmetric rate of biting force before and after the experiment, a paired t-test was performed. IBM SPSS Statistics for Windows (ver. 21.0) was used as the statistics program in this study, and the level of significance was $\alpha=0.05$.

RESULTS

For the first group, whose asymmetric rate of biting force was initially less than 10%, the asymmetric rate before the upper trapezius stretching was 5.1%; after the stretching, it had increased significantly to 10.3% ($p<0.05$). For the second group, whose biting force asymmetric rate was between 10% and 20%, the asymmetric rate before stretching upper trapezius was 14.7%; after the stretching it decreased to 14.3%, and the change was not statistically significant. For the third group, whose asymmetric rate of biting force was above 20%, the asymmetric rate before stretching was 27.8%; after the stretching, it decreased significantly to 12.6%, and the change was statistically significant ($p<0.05$) (Table 2).

DISCUSSION

Ciancahlini et al.[20] discovered that neck pain and symptoms of temporomandibular disorder are closely related. Eriksson et al.[21] discovered that head movements always accompany mandible movements; and that head movements precede mandible movements. Gangloff et al.[22] confirmed that while receiving treatment for temporomandibular disorder, patients experience a decrease in symptoms of cervical muscle pain and headache. Lee[15] confirmed that when temporomandibular disorder occurs, limitation of motion and tenderness of the sternocleidomastoid muscle and trapezius muscle tend to increase. Kaufman[23]; and Shin and Yang[24] reported that, while using temporomandibular joint orthodontic articulation, the rotational malalignment of the 1st and 2nd cervical vertebrae decreased, indicating that the temporomandibular joint affects cervical alignment. Hence this study also examined if the upper trapezius stretching that takes part in the movement of the 1st and 2nd cervical vertebrae can affect the biting force, which would suggest involvement of the temporomandibular joint.

An examination of the results demonstrated that in the group whose initial left and right biting force asymmetric rate was less than 10%, the asymmetric rate after stretching increased from 5.1% to 10.3%, which was an increase of 5.2%. For the group whose left and right biting force asymmetric rate was initially between 10% and 20%, the asymmetric rate after upper trapezius stretching decreased from 14.7% to 14.3% which was a decrease of 0.4%, but the change was not statistically significant. On the other hand, for the group whose initial left and right biting force asymmetric rate was more than 20%, the asymmetric rate after stretching the upper trapezius decreased significantly from 27.8% to 12.6%. These results showed that the upper trapezius stretching caused malpositioning of the 1st and 2nd cervical vertebrae and that the malpositioning can affect the function of the temporomandibular joint.

The results of this research can be explained by the research results of Ringvist[11] and Guzay[10]. Ringvist[11] stated that the compressive stress formed in the 1st and 2nd cervical vertebrae caused by abnormal muscle tension can cause an asymmetric rate of biting force. Guzay[10] mentioned that there was axis of movement of the temporomandibular joint at the 1st and 2nd cervical vertebrae while explaining the Quadrant Theorem. Therefore, temporomandibular function and muscle tension of the muscles in the cervical region are closely connected. In this regard, Fonder[14] stated that an imbalance in the nerves and muscles that control the function of temporomandibular joint is caused by abnormal position changes of the atlas and axis joint that lead to abnormal tension in the neck and shoulder. Moreover, Jung and Park[25] stated that since temporomandibular joint movement is connected to C1 and C2 when the cervical muscle tension increases, it interrupts the contraction of the masseter and temporal muscles that play important roles in occlusion. Hence, it can be said that biting force is affected by the tension of the upper trapezius, which takes part in the movement of the 1st and 2nd cervical vertebrae. Consequently, the results proved that biting force can be affected when the tension of the upper trapezius is controlled by performed stretching exercises. As a result, it was confirmed that upper trapezius stretching can affect a change in asymmetric rate of biting force. The present study found that when the asymmetric rate was less than 10%, stretching increased the asymmetric rate, which produced a negative effect, but that when the asymmetric rate was more than 20%, stretching the upper trapezius decreased the asymmetric rate, which produced a positive effect. Hence, when the asymmetric rate is small, use of a therapeutic approach for the masticatory muscle is more important than control of the tension of neck muscles, which might change the position of the 1st and 2nd cervical vertebrae and improve the function of the temporomandibular joint. But if the asymmetric rate is over 20%, improving the tone of the muscles of the cervical region and particularly the upper trapezius is recommended as a major

therapy for improving the function of the temporomandibular joint. However, the scope of this study has limited value with respect to verification of the connection between stretching the upper trapezius and its effects on the atlas and axis; and on the tone of the masseter and temporal muscles. Hence, the need remains for further research to verify the connection between stretching of the upper trapezius and cervical alignment and tone of the masticatory muscles.

ACKNOWLEDGEMENT

This work was supported by the Brain Busan 21 project.

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