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Changes of Masticatory Muscle Tone and Stiffness According to Head Posture

Background: Although previous researches have developed interventions for neck problems, headache, and temporomandibular disorder in patients with forward head posture (FHP), changes in masticatory muscle tone or stiffness as FHP worsening have not been investigated.
Objective: To examine changes in masticatory muscle tone and stiffness through craniovertebral angle (CVA).
Design: Cross sectional study
Methods: The subjects were 21 healthy males with normal head posture. Three CVA were established for posture measurement in which the bilateral anterior temporal and masseter muscles were measured during the subjects maintained a series of postures.
Results: The Right masseter muscle significantly increased in stiffness with advancing FHP ($p < 0.05$). No significant changes were observed in the muscle tone or stiffness of any other masticatory muscles, and no significant differences were found in bilateral masticatory muscle tone or stiffness in each measurement posture.
Conclusions: This study suggests that the increased stiffness of the right masseter muscle as the FHP worsened requires consideration in physical therapy assessment and intervention.

Key words: *Masticatory muscle; Muscle Tone; Stiffness; Forward head posture*

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INTRODUCTION

Poor head position due to forward head posture (FHP) can cause neck pain [1], temporomandibular dysfunction syndrome [2], reduced forced vital capacity and forced expiratory volume [3], a reduction in cervical movement, and thoracic kyphosis [4]. Furthermore, FHP is characterized by lower craniovertebral angle (CVA) and neck extensor muscle strength than in normal head posture (NHP) [5]. There is no difference in the resting-state thickness of the neck extensor muscles in either condition, but the semispinalis capitis muscle in isometric neck extension in FHP is less thick than in NHP [5]. Abnormal posture can lead to a shortening of the neck extensor and semispinalis capitis muscles due to a change in neck muscle length [6]. Typically, problems of alignment in the musculoskeletal system have a negative effect on the stiffness of the functionally connected muscles in a resting state [7].

The anterior temporalis and masseter muscles selected for measurement in this study are representative masticatory muscles. Their muscle activity increases during voluntary clenching, and this activity and the bite force of these muscles change depending on head posture [8]. Approximately 80% of tension-type headache patients also have tenderness in various muscles including pericranial, cervical, masseter, upper trapezius, and temporalis. The tenderness of the masseter and temporalis muscles has some correlation (39%) with chronic tension headache [9].

The human upright posture requires static and dynamic balance mechanisms that engage with proprioceptive, vestibular, and visual stimuli [10]. The alignment of the neck is particularly important for posture control [6]. Upright posture is achieved by afferent

nerve stimulation [11], and correct posture can be maintained through visual feedback. However, changes in neck posture affect the activity of the masticatory muscle [8], and this can interfere with breathing and weaken the accessory respiratory muscles [3]. In contrast, some studies have suggested that there is no correlation between head posture and painful cervical spine or craniomandibular disorders [12].

This investigation of the effects of FHP on muscle tone and stiffness constitutes a new approach to research of the negative effects of FHP on the human body. At present, there are no studies on the tension and stiffness in the masticatory muscles due to poor head posture. Instead, existing FHP studies tend to focus on improving cervical alignment and reducing pain. An approach that differs from these previous studies will produce novel and interesting results. As such, this analysis of changes in the resting muscle tone and stiffness of the masticatory muscles according to neck posture is expected to provide new basic data for a therapeutic approaches to managing FHP.

METHODS

Subjects

A total of 21 healthy subjects were selected for this study. Participants with no FHP when the CVA was measured were included. The purpose and intent of the study were explained to each subject who then signed an informed consent form. Furthermore, only males in their 20s were selected to ensure homogeneity of the sample. The age, height, and weight, and CVA of the subjects were 23.00±2.30 years, 173.62±5.07cm, and 69.86±7.15kg, 54.50±22.5° respectively. The chewing habit of the subjects were left side (n=2), right side (n=5) and bilateral side (n=14).

Measurement Methods

Craniovertebral angles

To measure the subjects' craniovertebral angle (CVA), the application, ON Protractor was downloaded from the Android Play Store to a V30 smartphone (LG Electronics, South Korea). The photography and radiography of this application are proven methods with high validity in CVA measurement [13]. The CVAs were recorded based on sagittal craniocervical posture. To begin, each subject sat on a chair with no backrest and assumed 90° flexion of the hip and knee joints for alignment of the lower extremities, with both hands on the thighs, a natural head posture, and gazing to the front. A marker was attached at the spinous process of seventh cervical spine of each subject and the CVA was measured using the ON protractor application. The smartphone was mounted horizontally on a tripod at head height to the subject. The CVAs of the subjects' NHP was in the 49° to 59° range [14]. Subjects whose resting CVA was outside this range were excluded.

After the initial measurement, participants' head posture was adjusted by setting their CVA at 41 to 42° for CVA 1 and at 32 to 33° for CVA 2. Each posture was maintained by setting the angles on the smartphone application and continuously monitoring the head position of the subjects. The CVA was measured twice in the resting condition of the masticatory muscles at each CVA condition.

Muscle tone and stiffness

The tone and stiffness of the subjects' masticatory muscles, including anterior temporal muscles and masseter muscles in both sides were measured using a Myoton PRO® device (Myoton AS, Estonia). According to the measurement positions set in a previous study of the electromyography of masticatory muscles [15], the highest point of each muscle belly was marked with a water-based pen. For the measurement, the Myoton device was positioned vertically at each marked point for each posture. The mandible of the subjects was placed centrally with no contact between the upper and lower teeth.

Data analysis

All data in this study were analyzed using a statistical processing application (SPSS 23.0, IBM, USA). The changes in tone and stiffness of the masticatory muscles according to the changes in head posture were analyzed by conducting a Friedman test, and differences in the tone and stiffness of the left and right masticatory muscles in each position were examined by performing the Wilcoxon Rank sum test. The significance level of every test was set as $\alpha = .05$.

RESULTS

Change of muscle tone and stiffness on the superficial back line muscles in each group

The muscle tone and stiffness of the masticatory muscles increased as the CVA decreased and FHP

increased, but the changes were mostly insignificant. Only stiffness of the right masseter muscle significantly increased as the CVA decreased ($p < .05$). The muscle tone and stiffness of the bilateral masticatory muscles showed no significant differences between the measurement postures.

Table 1. Change of masticatory muscle tone and stiffness (N=21)

Region / Variable	Side	Normal head posture	Forward head posture	
		Normal CVA (°)	CVA 1 (°)	CVA 2 (°)
Anterior temporal muscle	Left	26.41±2.50	26.61±3.17	26.62±3.01
Muscle tone (Hz)	Right	26.37±3.05	26.43±2.31	26.48±2.50
Anterior temporal muscle	Left	710.81±46.56	719.69±34.73	723.57±46.36
Stiffness (N/m)	Right	708.33±48.16	711.64±38.09	713.79±37.21
Masseter muscle	Left	15.13±0.98	15.62±1.56	15.93±2.40
Muscle tone (Hz)	Right	15.18±1.12	15.38±1.23	15.49±1.66
Masseter muscle	Left	321.10±49.69	336.40±69.06	339.24±79.87
Stiffness (N/m)	Right	322.50±61.95	332.64±53.96	335.12±75.82*

Values are means ± SD, $p<.05$
CVA: craniovertebral angle

DISCUSSION

A forward head posture causes musculoskeletal disorders. This study was no significant difference in tone or stiffness of the left and right masticatory muscles. This result presents new tone and stiffness values of the masticatory muscles in healthy people with normal CVA.

In general, a smaller CVA indicates worse FHP [16], and as the CVA decreases, the strength of the neck extensor muscles shows a decreasing tendency [5]. In this study, as the CVA decreased, the tone and stiffness of the masticatory muscles generally increased, but only stiffness in the right masseter muscle increased significantly.

Several reasons can be considered for there being no change in the tone and stiffness of the left and right anterior temporal muscles, right anterior temporal muscle, and the left masseter muscle in from a resting state according to the changing CVA. First, temporary posture changes in healthy people may not cause particular changes in the tone and stiffness of the masticatory muscles. Second, there was no abnormal face length in the study's subjects, such as in Down syndrome patients whose facial size is associated with masticatory muscle tone [17]. Third, the subjects were healthy people with no missing tooth teeth or temporal mandibular joint disorders.

Elsewhere, a tendency towards greater tone in the masseter muscle can be found in individuals with temporal mandibular joint disorders [18]. Furthermore, tenderness of the masticatory muscles has been associated with a 'long face' craniofacial morphology in children [19]. Jung et al. [20] found that changes in head posture had no significant effect on masticatory muscle activity or occlusal contact. Yang et al. [21] also argued that masticatory muscle activity was not affected by changes in head posture but was affected by bite force during clenching. In addition, major factors influencing changes in masticatory muscle activity include occlusal change [22] and the forward biting position of the mandible [8].

However, the present study is somewhat limited because it measured the tone and stiffness of masticatory muscles in resting conditions at different CVAs in healthy subjects. It should be considered that the results may have been different if the study had been conducted in FHP patients with pathological deformations of the cervical spine curve from poor head posture. Previous studies have shown that poor head posture is seen in patients with neck pain [1] and that CVA is negatively correlated with neck pain [23]. People older than 70 show a tendency of increased FHP; according to age, average CVAs are 49.97±6.94°, 41.06±8.82°, and 32.67±9.52° for 70–74 years, 75–79 years, and 90–96 years, respectively. Thus, CVA gradually decreases with age [9]. Similarly, unilateral chewing is positively correlated with age, and is

associated with a smaller forward head angle than bilateral chewing [23]. A follow-up study will be conducted with elderly subjects to consider the correlations between CVA, age, and chewing pattern. The forward head posture is associated with changes in the muscle activity of masticatory muscles and dental occlusion alterations [24].

The activity of masticatory muscles increases during clenching. Specifically, the activity of the temporalis and masseter muscles when clenching at 70% in an upward head posture is higher than in NHP [8]. This study therefore contains the limitations that subjects' chewing patterns were not considered and differences in tone and stiffness of the masticatory muscles by age were not examined.

Nevertheless, this study is significant because it presents masticatory muscle tone and stiffness in an upright head position from a new perspective. The results of this study suggest that stiffness of the right masseter muscle needs to be managed when the CVA decreases.

CONCLUSION

In the present study, as FHP worsens, stiffness of the right masseter muscle tends to increase. This finding represents new data for FHP assessment and approaches to physical therapy. Appropriate efforts should therefore be made for therapeutic approaches to avoid unnecessarily increased stiffness of this particular muscle in physical therapy for FHP patients.

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