J. Phys. Ther. Sci. 29: 332–335, 2017

The Journal of Physical Therapy Science

Review Article

Analysis of mechanical properties of cervical muscles in patients with cervicogenic headache

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Abstract. [Purpose] This study aimed to compare and analyze the mechanical properties of the upper cervical muscles in patients with cervicogenic headache to identify efficient methods of treatment and diagnosis. [Subjects and Methods] A total of 40 subjects including 20 healthy individuals and 20 patients with cervicogenic headache were selected. A MyotonPRO device was used to measure the tone (Hz), stiffness (N/m), and elasticity (log decrement) of the suboccipital muscles and upper trapezius of the subjects. [Results] There was no significant difference between the 2 groups in the elasticity of the suboccipital muscles and upper trapezius. However, there was a statistically significant difference in tone and stiffness. [Conclusion] This study showed that the tone and stiffness of the suboccipital muscles and upper trapezius in patients with cervicogenic headache had increased compared to healthy subjects.

Key words: Cervicogenic headache, MyotonPRO, Mechanical properties

(This article was submitted Oct. 19, 2016, and was accepted Nov. 11, 2016)

INTRODUCTION

Headache is a common disorder with a lifetime prevalence rate of 96% and time-specific prevalence rate of 16%[1)]. In 2004, the International Headache Society (IHS) recognized the term cervicogenic headache in the classification of headache disorders and suggested new diagnostic criteria. Headache is classified as primary headache, in which the headache itself is the disorder, and secondary headache, which is caused by other conditions; cervicogenic headache is classified as a secondary headache[2)]. The pain originates in the neck, and develops in the cephalic and/or facial regions. The headache is unilateral and includes cervical pain and dysfunction[3)]. The source of the pain is not in the head but in the neck. Cervicogenic headache originates in the upper cervical region, and the headache mechanism involves nociceptive structures such as the upper cervical spinal nerves, ganglia, disks, facet joints, muscles, and ligaments[4)]. Nearly 70% of those who periodically experience headache are reported to have symptoms in the cervical spine region along with the headache, and probably had been advised to undergo treatment of the cervical spine[5)].

Many researchers have investigated cervicogenic headache with various aims and methods. Watson et al.[6)] evaluated the differences in cervical position and muscle strength between patients with cervicogenic headache and healthy subjects by evaluating and analyzing forward head posture and isometric strength of cervical muscles. Zwart[7)] analyzed the differences in cervical mobility among patients with cervicogenic headache, those with migraine, and those with tension headache. Zito et al.[5)] aimed to establish more precise diagnostic criteria for cervicogenic headache. They analyzed the differences among patients with cervicogenic headache, those with migraine, and healthy subjects by performing different clinical measurements, including cervical mobility, cervical posture, pressure-pain threshold of each cervical segment, and muscle elasticity. Lee et al.[8)] analyzed the differences in cerebral blood flow between patients with cervicogenic headache and healthy subjects, while

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Table 1. General characteristics of the subjects

	Mean ± standard deviation	
	Control group	Experimental group
Gender (male/female)	8/12	7/13
Age (years)	31 ± 6.1	33 ± 5.5
Body mass index (kg/m^2)	21.6 ± 2.1	21.8 ± 2.5

Control group: patients with cervicogenic headache
Experimental group: healthy subjects

Dunning et al.[9] applied exercise therapy and thrust manipulation joint mobilization in patients with cervicogenic headache and analyzed the differences between the groups.

Even though many studies aimed to establish diagnostic criteria and investigate treatment efficacy in patients with cervicogenic headache, they mainly used subjective reports and manual examinations as tools of measurement; no reports used objective tools for analysis. The MyotonPRO (Myoton AS, Tallinn, Estonia) is a recently introduced device that can objectively measure the mechanical properties of muscles[10]. Bailey et al.[11] studied the inter-rater reliability of the MyotonPRO by analyzing muscle tone, stiffness, and elasticity of the left, right, and upper biceps brachii muscles in elderly subjects. The results showed a high inter-rater reliability for all variables. Kim et al.[12] investigated the changes in the characteristics of the back muscles in subjects after many hours of driving. They used MyotonPRO as an objective measurement tool to analyze the changes in the characteristics of back muscles before and after prolonged driving.

Because cervicogenic headache originates in the upper cervical muscles, analysis of the characteristics of these muscles in patients with cervicogenic headache would aid in diagnosis and treatment. However, there is a lack of literature analyzing the characteristics of the muscles in patients with cervicogenic headache, and no published reports used an objective tool. Therefore, this study aimed to analyze the biomechanical properties of the upper cervical muscles in patients with cervicogenic headache to identify efficient methods of diagnosis and treatment.

SUBJECTS AND METHODS

This study was approved by bioethics committee of Sehan university center (IRB) (Approval number: 2016-09) on July 1, 2016. This study was conducted from August 1, 2016 to August 31, 2016. A total of 40 subjects including both male and female aged between 22 and 40 were studied. The 40 subjects selected included 20 patients with cervicogenic headache and 20 healthy controls. Subjects were a written agreement. The experimental group was composed of patients who had been diagnosed with cervicogenic headache according to the diagnostic criteria of the IHS; the duration of illness was between 4 months and 2 years. The healthy subjects were limited to those with no history of headache or treatment for cervical injury or pain[5] (Table 1). The MyotonPRO (Myoton AS, Tallinn, Estonia) device was used to measure the tone (Hz), stiffness (N/m), and elasticity (log decrement) of the left and right suboccipital muscles and upper trapezius in the experimental and control groups, and the mean values were analyzed. The measurement procedure involved pressing the device against the skin, with a force of 0.18 N and instantly applying an impulse of 0.4 N for duration of 15 ms. The skin surface oscillation induced by the MyotonPRO was measured to verify the value of the mechanical variability[11]. Measurement of the suboccipital muscles was performed with the subjects lying face down on a bed with a hole for the face. Measurements were obtained by palpating the spinous process of C2 and the muscle at the midpoint of the occiput[13]. Measurement of the upper trapezius was performed with subjects seated on a chair. The subjects leaned back and rested their arms on an armrest during measurement, and all subjects sat on the same chair. The trapezius muscle belly located midway from the acromion to the spinous process of C7 was palpated and measured[14].

An independent t-test was used to investigate the differences in the mechanical properties of the suboccipital muscles and upper trapezius in the experimental and control groups. The level of statistical significance was set as α=0.05, and Windows SPSS ver. 19.0 statistical program was used for statistical processing and analysis.

RESULTS

Comparison of the characteristics of the suboccipital muscles and upper trapezius in the experimental and control groups showed statistically significant differences for tone and stiffness ($p<0.01$) (Tables 2 and 3). However, there was no significant difference between the 2 groups for elasticity (Tables 2 and 3).

DISCUSSION

In the present study, the differences in tone, elasticity, and stiffness of the suboccipital muscles and upper trapezius were analyzed in patients with cervicogenic headache and healthy subjects.

Table 2. Comparison of suboccipital mechanical properties between the groups

	Mean ± standard deviation	
	Control group	Experimental group
Tone (Hz)	13.3 ± 3.3	15.6 ± 2.9*
Elasticity (Log decrement)	1.2 ± 0.1	1.3 ± 0.2
Stiffness (N/m)	260.1 ± 32.1	323.9 ± 35.9*

*Significant difference between the 2 groups ($p<0.05$).
Control group: patients with cervicogenic headache
Experimental group: healthy subjects

Table 3. Comparison of upper trapezius mechanical properties between the groups

	Mean ± standard deviation	
	Control group	Experimental group
Tone (Hz)	16.1 ± 1.3	19.4 ± 2.5*
Elasticity (Log decrement)	0.9 ± 0.1	1.1 ± 0.1
Stiffness (N/m)	293.4 ± 33.3	355.5 ± 56.7*

*Significant difference between the 2 groups ($p<0.05$).
Control group: patients with cervicogenic headache
Experimental group: healthy subjects

The tone of the suboccipital muscles and upper trapezius was higher in patients with cervicogenic headache than in healthy subjects, and there was a statistically significant difference ($p<0.01$). Muscle tone refers to the degree of tension in relaxed skeletal muscle, and the most significant factor affecting the level of tone is muscle contraction[15]. Kim et al.[12] found that greater tone indicated an increase in pain severity or exercise overload. Zito et al.[5] studied 27 patients with cervicogenic headache, 25 patients with migraine, and 25 healthy subjects to measure and analyze mobility and level of pain in the upper cervical spine, using manual examination and a verbal analogue scale (VAS). The results showed that patients with cervicogenic headache had lesser mobility in the upper cervical spine and an increased VAS score compared to other groups. Their findings were similar to the results of this study, in which the tone of the suboccipital muscles and upper trapezius was higher in patients with cervicogenic headache. Moreover, Zwart[7] studied 28 patients with migraine, 34 patients with tension headache, 28 patients with cervicogenic headache, and 51 healthy subjects to measure the mobility of the cervical spine, using Cybex device. The results showed that the cervicogenic headache group had less joint range of motion (ROM) in flexion-extension and rotation of the cervical spine compared to other groups. The findings were similar to the results of this study, in which the suboccipital muscles and upper trapezius in patients with cervicogenic headache showed greater muscle contraction than did healthy subjects, even in a resting state. The symptoms of reduced joint ROM and increased pain seemed to be the result of muscle overuse.

Elasticity of the suboccipital muscles and upper trapezius showed no significant differences in this study. Elasticity is an indicator of the ability of a tissue to recover its original shape[11]. Frohlich-Zwahlen et al.[16] compared 20 chronic stroke patients and 20 healthy subjects by measuring the elasticity of their lower extremity muscles in a resting, uncontracted state. The results showed no significant difference between the 2 groups for all muscles. These findings were similar to the results of this study. The lack of differences between the groups could have occurred because measurements of elasticity, indicating an increase and decrease in muscle fatigue, were obtained at rest, instead of before and after exercise. In this study, the stiffness of the suboccipital muscles and upper trapezius was greater in patients with cervicogenic headache than in healthy subjects, and the difference was statistically significant ($p<0.01$). Stiffness is caused by a lack of constrictive activity. With constant maintenance of a position in which the muscle length is shortened, and with a lack of active or passive exercise, changes occur at the cross-bridge attachment sites of muscle fibers, and the muscles become shorter and stiffer as the sarcomere disappears[17]. Zito et al.[5] evaluated the extensibility of the suboccipital muscles and upper trapezius in patients with cervicogenic headache, those with migraine, and a control group, and found that both muscles showed decreased extensibility in patients with cervicogenic headache compared to the other groups. Marusiak et al.[10] compared and analyzed the stiffness of the biceps brachii muscles in 8 patients with Parkinson's disease and 10 elderly subjects by using a myotonometer device. The results showed that the stiffness value was higher in patients with Parkinson's disease than in the control group. These findings are similar to the results of this study. The increased stiffness value of biceps brachii muscles in patients with Parkinson's disease seems to have been caused by a reduction in joint ROM and motility. The change in the characteristics of the muscles of patients with cervicogenic headache appears to have been caused by postural imbalance and decreased extensibility, which lead to shortening of the suboccipital muscles and upper trapezius.

This study compared and analyzed the objective mechanical properties of muscles in patients with cervicogenic headache

and healthy subjects, using the MyotonPRO device, and identified the differences between the experimental and control groups. These changes in the properties of muscles can be used to efficiently diagnose and treat patients with cervicogenic headache.

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