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Original Paper

Influence of the Craniocervical Flexion Position during Oscillating Exercises on the Neck Muscles

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Key words: electromyography, neck muscles, exercise

Abstract

Manual therapy plus exercise for the neck muscles are recommended for treating neck pain in individuals with impairment of movement coordination. The use of an oscillating blade in the mouth as a low intensity coordination exercise for the neck muscles was previously investigated. However, influence of the craniocervical flexion position during oscillating exercises on the neck muscles was not shown. Twenty healthy male participants were asked to hold their cervical joints isometrically and oscillate a blade through knee flexion-extension both in and out of the craniocervical flexion position. Both exercises were performed in the standing position. Head and neck inclination angles in the starting posture were measured during both exercises. The activities of the sternocleidomastoid and cervical extensor muscles were measured while using an oscillating blade held in the mouth. The co-contraction index for the pair of neck muscles was calculated. The head inclination angle and activity of both neck muscles in the craniocervical flexion exercise were significantly higher than those in the exercise without craniocervical flexion. There was no significant difference in the co-contraction index between exercises. The craniocervical flexion position should be used to increase neck spinal stability during oscillating exercises for the neck muscles.

1. Introduction

Neck pain is a common health problem[1)]. Manual therapy plus exercise for the neck muscles are recommended for treating neck pain in individuals with impairment of movement coordination[2)]. For spinal muscles, maintaining the vertebrae in the neutral zone is an important task to avoid distributed loading on all supporting structures[3)]. Therefore, it is necessary to pay attention to cervical spine stability when individuals with neck pain perform coordination exercises for the neck muscles.

An oscillating blade (Facial Fitness PAO; MTG Co. Ltd., Aichi, Japan) with a natural frequency of 3 Hz is made of a flexible polyurethane (width, 540 mm; depth, 65 mm; height, 35 mm; and weight, 1.7 N) (Figure 1). This device was developed to strengthen the facial muscles around the mouth. The literature shows that coordinated use of an oscillating device by holding it in the hands enhances instantaneous spinal stability by causing cyclic activation of trunk muscles[4)]. Therefore, using an oscillating device by holding it in the mouth might be a type of coordination exercise for the cervical muscles. The use of an oscillating blade in the

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mouth as a low intensity coordination exercise for the neck muscles was previously investigated[5]. Although all cervical muscles contribute to stabilize the cervical spine, a requirement for early and specific training of the deep cervical flexor muscles (longus colli and longus capitis) has been demonstrated[6]. The deep cervical flexor muscles primarily contribute to craniocervical flexion[7,8]. Holding an oscillating blade in the mouth in combination with the craniocervical flexion position might be a coordination exercise that enhances neck spinal stability. Therefore, the purpose of this study was to show the influence of the craniocervical flexion position during oscillating exercises on the neck muscles.

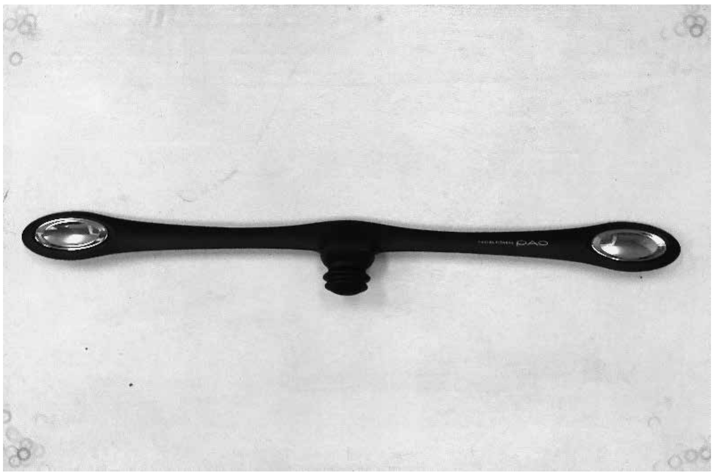

Figure 1 Oscillating blade

2. Methods

2.1 Participants

Subjects were recruited from the Kawasaki University of Medical Welfare. Twenty healthy male volunteers participated in this study. Subjects were excluded if they had experienced neck pain in the past 12 months, had a history of orthopedic disorders affecting the neck, neurological disorders, or a history of spinal surgery. Subject age, height, and weight (mean ± standard deviation) were 20.8 ± 0.8 years, 168.0 ± 6.2 cm, and 62.5 ± 9.8 kg, respectively. None of the subjects had previous experience of performing oscillating exercises. This study was approved by the Ethics Committee of the Kawasaki University of Medical Welfare (18-023). The subjects provided written informed consent prior to participation.

2.2 Oscillating exercise

After a brief instruction and practice session, subjects were tasked to oscillate the blade over a 10-s period with and without the craniocervical flexion position (Figure 2). Both exercises were performed while standing. During oscillation, participants were also asked to keep the amplitude of the outer blade at the height of the eyebrows. Visual feedback was obtained by the participant using a mirror that was positioned 1.5 m away from the face during the practice and recording. Verbal instructions for exercise with and without the craniocervical flexion position were "turn the head to nod. The craniocervical flexion axis of rotation during motion in the sagittal plane is at the mastoid process of the temporal bone. Then, isometrically hold your cervical joints with craniocervical flexion position and use your knee flexion-extension in achieving oscillation" and "isometrically hold your cervical joints at the usual position and use your knee flexion-extension in achieving oscillation," respectively. The craniocervical flexion position was performed with "light" effort, with a rating of 2 on the Borg scale[9]. The order of the exercises was randomized.

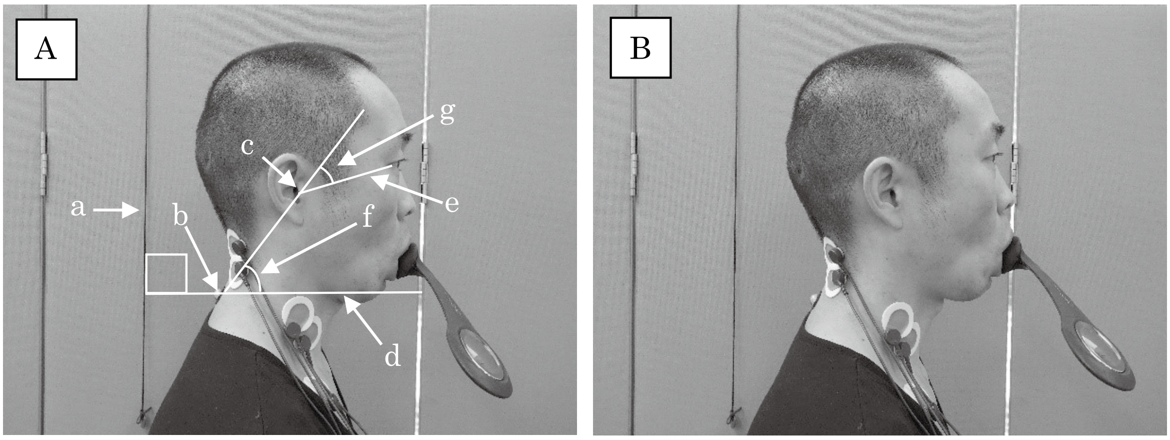

Figure 2 With and without craniocervical flexion

A: With craniocervical flexion; B: Without craniocervical flexion; a: Vertical reference line; b: C7 spinous process; c: Tragus of ear; d: Horizontal line; e: Orbitomeatal base line; f: Neck inclination angle; g: Head inclination angle

2.3 Head and neck inclination angles

Head and neck inclination angles in the starting posture of both exercises were measured using a digital video camera (DCR-PC300K, Sony Co. Ltd., Tokyo, Japan) that was positioned on a tripod 0.5 m from the participant (Figure 2). The axis of the camera lens was orthogonal to the sagittal plane of the participants at a height that corresponded with the C7 spinous process[10]. The C7 spinous process was first determined by palpation, and a marker was attached. A photograph of the right sagittal view was taken, with the vertical reference line in the background of the image. Participants were asked to stand with and without the craniocervical flexion position. The arms hung vertically beside the trunk. The feet were positioned one shoulder width apart. Participants looked at a marker at the level of their eyes installed on a mirror 1.5 m in front of them during photography. Photographs were taken twice. The order of the positions was randomized. The angle measurements were performed using imaging software (Image J; U. S. National Institutes of Health, Maryland, USA). Head and neck inclination angles were measured between a line drawn from the lateral canthus of the eye to the tragus of the ear (orbitomeatal base line) and an extension line drawn from the C7 spinous process to the tragus of the ear and between a line drawn from the C7 spinous process to the tragus of the ear and a line subtended to the horizontal, respectively (°). The average angle calculated from the two photographs was used for analysis.

2.4 Electromyographic (EMG) recording

EMG recordings were taken using disposable electrodes (Blue Sensor P-00-S; Mets Co. Ltd., Tokyo, Japan). Bipolar electrode pairs were placed longitudinally over the muscle at 2.5-cm intervals. Recordings were taken from the right sternocleidomastoid muscle midway between the mastoid process and manubrium of the sternum and from the C4 cervical extensor muscles 2 cm lateral to the C4 spinous process using an EMG system (MyoSystem 1200; Noraxon Inc., AZ, USA). A grounded electrode was placed over the right collarbone. The EMG signals were stored at a sample frequency of 1000 Hz and band-pass filtered (10-500 Hz). Data were collected twice for 5-s in the middle of each exercise. The EMG values during exercise were full-wave rectified and normalized relative to the maximal voluntary contraction (%MVC), which was obtained during maximal isometric exertion, using a standard manual muscle test[11]. The MVC was held for 5-s. The co-contraction index, which provides a quantitative measure of the degree of co-activation for a pair of neck muscles, was calculated[12]. Figure 3 is a schematic diagram showing the time histories of the partial activities of the sternocleidomastoid and C4 cervical extensor muscles. The shaded area represents the antagonist activity, which was calculated as $I_{ant} = \int_{t1}^{t2} CE(t)dt + \int_{t2}^{t3} SM(t)dt$ where $CE(t)$ and $SM(t)$ are the C4 cervical

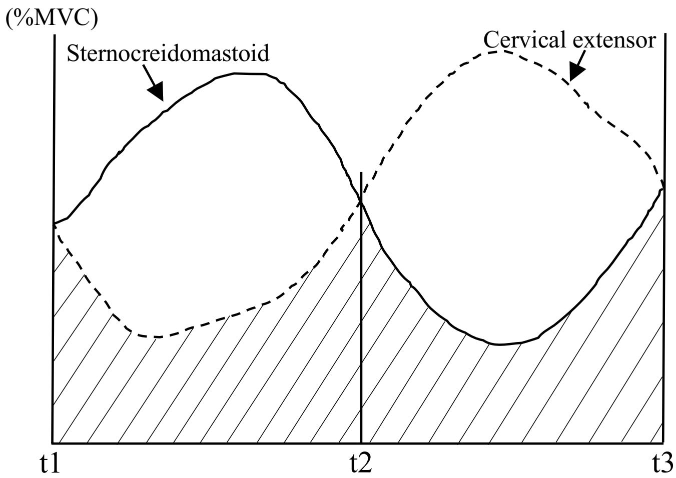

Figure 3 Hypothetical situation of partial activities of neck muscles to demonstrate co-contraction index (Based on Falconer and Winter[12])

Electromyographic signals were full-wave rectified and normalized to the maximal voluntary contraction (%MVC). From t1 to t2: the agonist is the sternocleidomastoid and the shaded cervical extensor activity is the antagonist activity. From t2 to t3: the role of the sternocleidomastoid and cervical extensor reverses, the shaded sternocleidomastoid activity is the antagonist activity.

extensor and sternocleidomastoid muscle activity, respectively. The integration of $CE(t)$ and $SM(t)$ = I_{tot}. The co-contraction index is defined as CI = $\frac{2I_{ant}}{I_{tot}}$ × 100 (%). The average of two EMG measurement values was used for analysis.

2.5 Statistical analysis

IBM SPSS Statistics version 23 (IBM Japan Inc., Tokyo, Japan) was used for all statistical analyses. The Wilcoxon signed-rank test was used to examine the significance of differences between exercises. P-values < 0.05 were considered statistically significant. To calculate the post-hoc actual power of the sample, G-Power software (Franz Faul, University Kiel, Germany) was used.

3. Results

Typical neck muscle electromyography during exercise is shown in Figure 4. The measured values are listed in Table 1. The head inclination angle and activities of the both neck muscles in the exercise with craniocervical flexion were significantly higher than those in exercise without craniocervical flexion. There was no significant difference in the co-contraction index between exercises.

4. Discussion

To our knowledge, this study is the first to show the influence of the craniocervical flexion position while using an oscillation blade in the mouth. Increases of head inclination angle in exercise with craniocervical flexion compared to that in exercise without, indicate flexion of the upper cervical joints. Although EMG recordings of the deep cervical flexor muscles were not quantified in this study, the deep cervical flexor muscles might be recruited to hold the craniocervical flexion position[7,8]. The activity of the deep cervical flexor muscles cannot be measured using surface EMG; to measure deep flexor muscle activity, bipolar electrodes housed within a nasopharyngeal catheter must be inserted into the posterior oropharyngeal wall adjacent to the uvula[13]. Further studies are therefore necessary to quantify the activity of the deep cervical flexor muscles.

In this study, exercise using the craniocervical flexion position, was accompanied by increases in

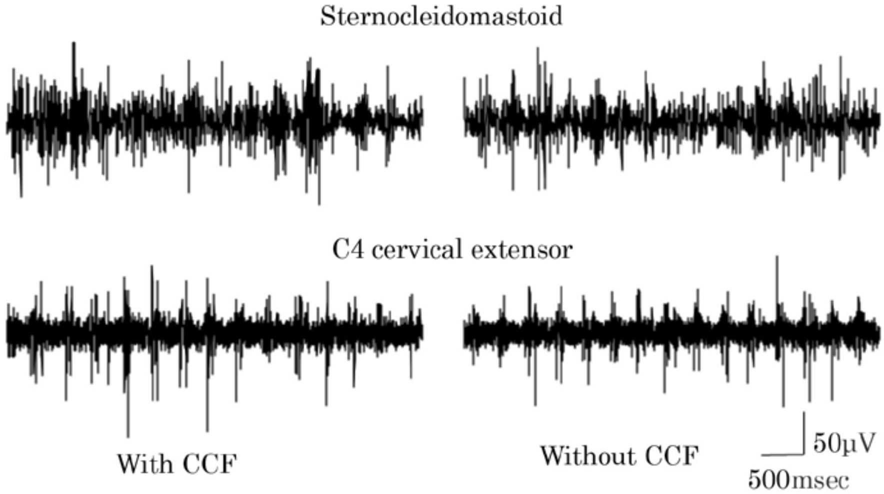

Figure 4 Typical neck muscle electromyography during exercise

CCF: craniocervical flexion

Table 1 Median (interquartile range) of measured values

		With CCF	Without CCF	P values	Power
Inclination angle (°)	Head	45.0 (37.1-48.3)	39.3 (32.1-42.4)	<0.001	1.00
	Cervical	50.9 (48.1-57.1)	52.6 (49.9-55.0)	0.151	0.12
Normalized EMG (%MVC)	Sternocleidomastoid	7.0 (3.1-12.8)	5.9 (2.2-11.1)	0.001	0.90
	Cervical extensor	15.3 (7.7-20.4)	11.8 (6.9-20.2)	0.007	0.70
Co-contraction index (%)		42.9 (33.0-42.9)	44.1 (30.1-57.2)	0.940	0.06

EMG: electromyography; MVC: maximal voluntary contraction; CCF: craniocervical flexion

sternocleidomastoid and cervical extensor muscle activity. The median activity of the cervical muscles during exercise with craniocervical flexion was less than 25 %MVC, which could be a muscle stabilizing stimulus[14]. Previous research has reported that the activity of the sternocleidomastoid increased in accordance with the craniocervical flexion test in healthy subjects[15]. In this study, increased activity of the sternocleidomastoid might be considered to be compensatory for craniocervical flexion[16]. The literature shows that abdominal bracing principally activates the abdominal muscles, as well as generates an erector spinae muscle contraction (antagonistic co-contraction)[17], which stiffens the trunk and increases spinal stability[18]. Therefore, the craniocervical flexion position should be used to increase neck spinal stability during oscillating exercises for the neck muscles. In this study, in order to maintain the neck curvature, the activation of the cervical extensor muscles might counteract the neck flexion moment induced by craniocervical flexion[17]. However, in this study, there was no significant difference in the co-contraction index between exercises, which means that not only higher co-activation but also higher cyclic activation of neck muscles is induced during exercise with the craniocervical flexion position than in exercise without craniocervical flexion. The center of gravity of the head is situated at the middle of the nasion-inion line, above and slightly in front of the external auditory meatus[19]. The cranium-C1 axis of rotation during motion in the sagittal plane is at the mastoid process, varying from the anterior mastoid process to an area slightly dorsal and cranial to the mastoid process[20,21]. Therefore, the center of gravity of the head tilted anteriorly during exercise with the craniocervical flexion position compared to without craniocervical flexion, would especially increase neck flexion and extension movement when the outer oscillation blade descends and rises, respectively. In order to maintain the neck position, the activation of the cervical extensor and sternocleidomastoid muscles might cyclically increase to counteract the increased neck flexion and extension moment, respectively.

Some limitations should be taken into consideration of this study's results. Although the craniocervical flexion position was defined at the degree of voluntary effort, the definition by the angle might be necessary because the angle of cervical joint movement for each subject was different. Because the cervical muscle activity before oscillating exercise during craniocervical flexion position was not measured, the degree of muscle activity that increased by oscillating exercise was unclear. Oscillation of the blade was not recorded during the exercises. Thus, oscillation of the blade may not have been uniform across the exercises. The results of this study might not be generalizable to subjects with neck pain, as it is unclear how the craniocervical flexion position will influence individuals with neck muscle dysfunction during oscillating exercises for the neck muscles[15].

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