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Original Paper

Associations between Forward Head Posture and Cervical Extensor Muscle Thickness in Asymptomatic Subjects

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Key words: head, neck, posture, muscle thickness, ultrasound imaging

Abstract

This study aimed to clarify the association between forward head posture and cervical extensor muscle thickness in asymptomatic subjects; hence, 35 asymptomatic men were recruited for the study. The forward head posture was assessed by measuring the neck-to-horizontal, head-to-horizontal, and neck-to-head angles using a right sagittal view image. The thickness of the right upper trapezius, splenius capitis, semispinalis capitis, and deep cervical extensor (semispinalis cervicis, multifidus) muscles were measured using ultrasonography. The relationships between the three angles and the cervical extensor muscle thickness were evaluated using Spearman's correlation coefficient. A significant negative correlation was observed between the upper trapezius muscle thickness and neck-to-head angle. An increase in the upper trapezius muscle thickness was observed with a decrease in the neck-to-head angle. The results indicated that inhibition of the upper trapezius muscle activity should be considered to correct severe head protrusion with neck extension during sitting.

1. Introduction

The most prevalent risk factor for neck pain is sustained awkward posture[1]. The forward head posture is not recommended during prolonged sitting conditions, especially in front of computers[2]. In a typical case of forward head posture, anterior translation of the head occurs because of lower cervical flexion with an increase in upper cervical extension[3]. Neck and head postures are assessed by measuring the neck-to-horizontal and head-to-horizontal angles[2] (Figure 1). A meta-analysis showed that adults with neck pain had a lower neck-to-horizontal angle than that in asymptomatic adults, although, in adolescents and adults aged above 50-years, there was no difference in the neck-to-horizontal angle among asymptomatic persons and those with neck pain[4]. In a systematic review, three studies that included adolescents, adults, including older adults, and participants with a broad, unmatched age range, respectively, showed no between-group differences; the head-to-horizontal angle in the neck pain group was higher than that in the asymptomatic group in the study that included only adults[4]. Not all cases of forward head posture require corrective

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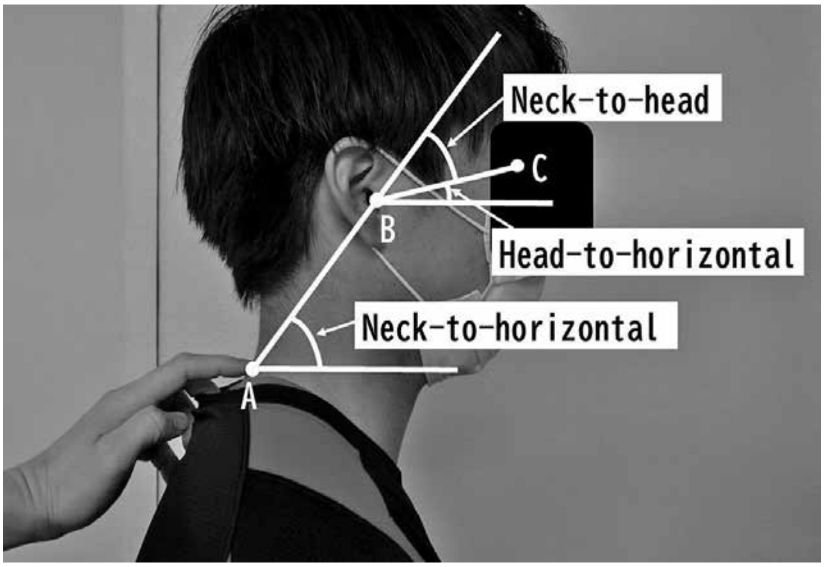

Figure 1 Assessment of absolute neck and head angles with forward head posture

The absolute neck and head angles were assessed by measuring the neck-to-horizontal angle between the C7 spinous process (A), tragus of the ear (B), and horizontal line and the head-to-horizontal angle between the tragus of the ear, lateral canthus of the eye (C), and horizontal line, respectively. The relative head angle (neck-to-head) was defined as the difference between the neck-to-horizontal and head-to-horizontal angles.

interventions; however, some individuals with forward head posture experiencing moderate neck pain (non-specific neck pain or pain resulting from cervical spondylotic radiculopathy) require therapeutic exercises (stretching, strengthening, and stability of the neck, thoracic, and shoulder muscles) for correcting the neck-to-horizontal angle[5,6)].

The abovementioned therapeutic exercises could effectively modify the neck-to-horizontal angle, and these exercises might improve neck pain but do not correct the head-to-horizontal angle[5,6)]. All studies included in the abovementioned systematic review[5)] reported strengthening of deep cervical flexors. Another study reported that the neck-to-horizontal angle improved after deep cervical extensor training[6)]. Morphology studies of cervical muscles in asymptomatic subjects may provide insights into how therapeutic exercise affects the forward head posture since neck pain induces muscle volume changes and activates cervical muscles[7)]. Ishida et al.[8)] showed a correlation between the neck-to-horizontal angle and deep cervical flexor muscle thickness in asymptomatic adult men. Bokaee et al.[9)] reported a higher sternocleidomastoid muscle thickness in subjects with a decreased neck-to-horizontal angle than that of the control subjects, but no increase in thickness of deep cervical flexor muscles was observed in asymptomatic adult women. These results support the concept of craniocervical flexor training with an emphasis on the coordinated action of the deep and superficial cervical flexor muscles[7)]. Cervical extensor muscles are as important as the flexor muscles for controlling the forward head posture[7)]. However, Goodarzi et al.[10,11)] reported that the thicknesses of the cervical extensor muscles (upper trapezius, splenius capitis, semispinalis capitis, semispinalis cervicis, and multifidus) of the subjects with decreased neck-to-horizontal angles were comparable with that of the control subjects. These muscle morphology studies used the neck-to-horizontal angle and not the head-to-horizontal angle to estimate forward head posture. Therefore, little is known about the relationship between the head-to-horizontal angle and cervical extensor muscle thickness. Moreover, to indicate the severity of head protrusion with neck extension[2)], the relative neck-to-head angle (the difference between neck-to-horizontal and head-to-horizontal angles) should be used for assessing the forward head posture (Figure 1). Therefore, in this study, we aimed to clarify the association between forward head posture and cervical extensor muscle thickness in asymptomatic subjects.

2. Methods

2.1 Participants

This study included 35 asymptomatic men. Their age, height, and weight (mean ± standard deviation) were 20.5 ± 0.5 years, 172.3 ± 5.2 cm, and 63.3 ± 7.7 kg, respectively. The exclusion criteria were as follows: the presence of neck and shoulder pain, presence of radicular pain, history of cervical surgery, history of neuromuscular disease, history of neck and shoulder pain in the previous year, or history of any specific neck-muscle training in the previous year.

2.2 Procedure

2.2.1 Forward head posture

Forward head posture was assessed in a relaxed sitting posture using a digital video camera (FDR-AXP35, Sony Co. Ltd., Tokyo, Japan) positioned on a tripod placed 0.8 m away from the participant[12]. The camera lens was at a height that corresponded to the C7 spinous process of the participant[12]. The assessor imaged the right sagittal view with a vertical reference line in the background of the image. The neck-to-horizontal angle and the head-to-horizontal angle were measured using ImageJ (US National Institutes of Health, Maryland, USA). The neck-to-head angle was calculated as the difference between the neck-to-horizontal angle and the head-to-horizontal angle (°). In recent studies, ImageJ was used frequently to assess head and neck posture[13,14], and high intra-rater and inter-rater reliabilities were confirmed in the measurement of angles during movement[15].

2.2.2 Cervical extensor muscle thickness

B-mode ultrasound imaging of the right cervical extensor muscles was performed for all the subjects (Hitachi Noblus, Hitachi Medical Corporation, Tokyo, Japan) with a 7-3 MHz linear probe (L34). The subjects were asked to lie down in the prone position on a table with arms flanked on both sides of the body. A comfortable position was fixed for the neck and head angle measurements by resting the face in the facial opening. The examiner identified the C7 spinous process by palpation. The transducer was placed longitudinally and moved laterally to identify the C6-C7 facet joint. From this position, the transducer was moved superiorly to identify the C5-C6 facet joint, and the examiner rotated the transducer transversely and moved it to identify the lamina at the C5 level (Figure 2). The cervical extensor muscle images were obtained twice. The caliper was positioned at 90° relative to the lamina. The measurement was performed where the examiner considered the muscular unit to be the thickest[16]. Inter-rater reliability was found to be good for the semispinalis capitis and moderate to poor for deep cervical extensors[16]. Intra-rater reliability was good for the semispinalis capitis and moderate for deep cervical extensors[16]. The average values of the two trials were used for the analysis (mm).

2.3 Statistical analysis

SPSS Statistics 23.0 (IBM Japan Inc., Tokyo, Japan) was used for the statistical analysis. The relationship between the three angles and the cervical extensor muscle thickness was assessed using Spearman's correlation coefficient. The significance level was set at $p < 0.05$.

3. Results

The obtained values are listed in Table 1. The correlation coefficients between the three angles and cervical extensor muscle thickness are listed in Table 2. A significant negative correlation was observed between the upper trapezius muscle thickness and the neck-to-head angle.

4. Discussion

In this study, the association between forward head posture and cervical extensor muscle thickness

Figure 2 Ultrasonographic measurements of the right cervical extensor muscles

(A) upper trapezius, (B) splenius capitis, (C) semispinalis capitis, and (D) deep cervical extensors (semispinalis cervicis, multifidus)

Table 1 Median (first-third quartile) values of obtained data

Neck-to-horizontal angle (°)	50.0 (45.6-53.4)
Head-to-horizontal angle (°)	16.7 (12.4-20.6)
Neck-to-head angle (°)	34.0 (25.6-39.4)
Cervical extensor thickness	
Upper trapezius (mm)	2.9 (2.4-3.6)
Splenius capitis (mm)	3.6 (3.0-4.1)
Semispinalis capitis (mm)	3.8 (3.0-4.5)
Deep cervical extensors (mm)	16.2 (14.8-17.8)

Table 2 Spearman correlation coefficients of the three angles and cervical extensor muscle thickness

	Neck-to-horizontal		Head-to-horizontal		Neck-to-head	
	r	p	r	p	r	p
Upper trapezius	-0.17	0.34	0.27	0.12	-0.35	0.04
Splenius capitis	-0.09	0.63	0.14	0.41	-0.23	0.19
Semispinalis capitis	-0.08	0.67	0.03	0.85	-0.04	0.83
Deep cervical extensors	0.17	0.33	-0.10	0.57	0.11	0.54

was examined in asymptomatic participants. No significant correlation was observed between the neck-to-horizontal angle and the cervical extensor muscle thickness. These results are consistent with the findings reported by Goodarzi et al.[10,11], who measured the neck-to-horizontal angle and cervical extensor muscle thickness in asymptomatic subjects. This is the first study to investigate the correlation between the head-to-horizontal angle and cervical extensor muscle thickness and to show no significant correlation between these factors. However, a significantly negative correlation between the neck-to-head angle and upper trapezius muscle thickness was confirmed. The results indicated that inhibition of upper trapezius muscle activity should be considered to correct severe head protrusion with neck extension while sitting.

An increase in the upper trapezius muscle thickness with a decrease in neck-to-head angle was observed in the participants. Regarding gravitational movements, the movement demand varies with the neck and head angles, and these movements increase with increasing degrees of flexion[17]. Activation of cervical extensor muscles increases with a decrease in neck-to-horizontal angle and/or the head-to-horizontal angle. However, in the present study, there was no significant correlation between the neck-to-horizontal and head-to-horizontal angles and cervical extensor muscle thickness. There might have been an imbalance of neck muscles in asymptomatic participants with increased upper cervical extension. Muscle imbalance occurs because hypertrophy or over-recruitment of one group of muscles might be associated with a corresponding decrease in size or recruitment of opposing muscles, one of which is the upper crossed syndrome[18]. Alterations in muscle activation include overactivity of suboccipitals, upper trapezius, levator scapula, and pectoral muscles, and underactivity of deep cervical flexors, rhomboid, and lower trapezius[17]. In the present study, an increased upper cervical extension angle indicated dysfunction of deep cervical flexor muscles, which might induce heightened antagonist muscle activity. Therefore, to correct upper cervical hyperextension, stretching exercises of the upper trapezius muscle and strengthening exercises of deep cervical muscles are recommended.

This study has some limitations. First, only asymptomatic adult male participants were recruited. No influences of neck pain, sex, and age were detected. Second, muscle activation was not measured in this study. Third, we only measured parameters related to cervical extensor muscles at the C5 level. Upper cervical muscle activation should be measured to evaluate occipital muscles. Additionally, regarding upper crossed syndrome, evaluation of cervical extensors, cervical flexors, and upper trunk muscle thickness should be performed. Fourth, to eliminate bias, it is desirable that different examiners record ultrasound images, measure muscle thickness, and analyze posture, independently. Finally, the cross-sectional design could not detect the cause-effect relationships. Therefore, a longitudinal study is required.

Ethical considerations

The Ethics Committee of the Kawasaki University of Medical Welfare approved the protocol (20-004). Written informed consent was obtained from each subject prior to participation. There is no conflict of interest.

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