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Original Article

Neck Pain in Adults with Forward Head Posture: Effects of Craniovertebral Angle and Cervical Range of Motion

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ABSTRACT

Objectives: The purpose of this study was to determine whether the cranial vertebral angle (CVA) and the range of motion (ROM) was different between participants with a forward head posture (FHP), with or without pain.
Methods: Forty-four participants who had FHP participated in this study. The FHP was assessed digitally by measuring a lateral view the CVA for each subject. A cervical ROM device measured the cervical ROM. The volunteers were allocated to either, with pain (n = 22), or without pain (n = 22) groups, and pain was evaluated using the Numeric Pain Rating Scale.
Results: The FHP in the pain group showed a significant difference in the CVA, and the cervical ROM in both flexion and extension, compared with those in the FHP without pain group ($p < 0.05$). Logistic regression analysis indicated that the occurrence of cervical area pain was higher amongst subjects who had a decreased CVA and flexion motion.
Conclusion: This study suggested that decreased CVA and cervical flexion range, were predictive factors for the occurrence of pain in the cervical region.

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Introduction

Body posture can be defined as a state of alignment of the body for a specific amount of time, while ideal posture describes a state of maintaining balance in the body using minimal musculoskeletal activity without causing pain or discomfort [1,2]. The tendency to stay seated for long periods of time is increasing as is the percentage of the population that use a personal computer or smartphone [3,4]. This can cause changes in the alignment of the spine, leading to improper posture, such as a rounded shoulder or forward head posture (FHP) [5].

This change in posture can lead to a spatial change between the spine and the line of gravity, causing an overload on muscles and connective tissues [6]. Neck pain or neck dysfunction is a musculoskeletal disorder caused by improper posture with physical impairment or functional limitation. The FHP is known as an internal factor that causes dysfunction with shoulder and neck pain [7,8]. A FHP results in a posture in which the extended head and upper cervical, and the lower cervical vertebrae flex [9]. This increases the length of the external moment (the arm) by moving the gravitational center (the head) ahead of the load bearing axis [10]. The exposure to this constant load on the craniovertebral extension muscles and the noncontractile structures causes a change in the biomechanical movement, and this increased stress can cause musculoskeletal damage or pain [11]. In addition, FHP can also limit the functional movement in the head and neck area

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[12]. These limitations are caused by irregular rotation and gliding movement inside the articular capsule whilst moving the joint. Moreover, it was reported that extended periods of FHP can result in a decreased number of sarcomere, as well as shortening of the muscle fibers, which can affect muscular contraction [5,13,14].

As mentioned above, there are frequent occurrences of functional movement limitations or non-specific pain in the head and neck region in patients with FHP [15]. Therefore, many studies have described the aspects of FHP that lead to functional movement limitations, and the pain in the head and neck area [7,10,16]. In a study by Kim et al on the correlation between the degree of the FHP, according to the craniovertebral angle (CVA), and the neck disability indices, it was reported that the degree of FHP according to the CVA, can be used as a significant index in determining the resulting functional disability of the neck [17]. Furthermore, it was reported that the CVA is related to the manifestation of neck pain, and the severity of the pain is related to the degree of the functional disability [8,18,19]. As such, FHP is closely related to functional movement limitations and the manifestation of pain. However, most of the previous studies have been limited to functional movement, muscular strength, and muscle activity, by comparing the participants with and without FHP, or by correlating how movement and pain influence patients with FHP [5,6,10,20,21].

There has been no study to date, examining whether there is a difference between the CVA or the functional movement in those with FHP, with and without pain. This study aimed to determine whether functional movement limitations or CVA could be used as factors to predict the occurrence of pain. Therefore, the differences in the CVA and the active range of motion (ROM) of the cervical area were determined in this study in subjects with FHP who were either with or without pain around the neck.

Materials and Methods

1. Participants

FHP in volunteers employed at the J Hospital in Jeollabuk-do, Republic of Korea were selected for this study (n = 44). The criteria for participants also included having a CVA of < 52° and aged between 20 and 40 years. There were 22 participants without pain, whose Numeric Pain Rating Scale (NPRS) score was < 1, and 22 participants who experienced pain and their NPRS score was > 3. The exclusion criteria included those with complaints of dizziness, a medical diagnosis of damage in the central nervous system or vestibular organs, complaints of radicular pain, had surgery in the last 6 months due to orthopedic damage, pathology in the spine or the upper limbs, and patients currently undergoing treatment or taking medication due to neck pain.

Prior to participation, the purpose of this study was explained, and written informed consent was given by all participants. This study was conducted in accordance with the ethical standards of the Declaration of Helsinki. Ethical approval was given by the local university research ethics committee (the Institutional Review Board of a Daejeon University, Daejeon, Republic of Korea; 1040647-201706-HR-013-03).

2. Measuring the Presence of Pain

The NPRS is used to evaluate the neck pain index of the participants. On a scale of 0 to 10, 0 being no pain and 10 being excruciating pain, the patient was asked to mark the average pain felt in the last 24 hours. The NPRS expresses pain in a simple way, and the reliability was reported to be 0.90 [22].

3. Measurement of CVA

In order to accurately measure the degree of FHP, photogrammetry was used to measure the CVA on a sagittal plane. The CVA measurement is defined as the angle a horizontal line passing the neural spine of C7 in relation to the line connecting the tragus and the neural spine of C7 [19,23]. The greater the measured CVA value, the more ideal the alignment of the head and the neck; whereas the smaller the angle, the more serious the degree of FHP.

4. Measurement of Active ROM in Cervical

For the measurement of the ROM in the cervical area, CROM equipment (CROM Basic MedNet-Sites, USA) was used. First, the subject sat on a chair with a backrest that could support the spine. Next, the inspector placed the CROM equipment on the subject's head, and measured the movement of the head (i.e. flexion, extension, left/right rotation). Here, participants were asked to maximally move their head to each side, as far as possible. The test was performed twice for each side, and the average was recorded. The CROM equipment was reported to have a high reliability (intraclass correlation coefficient = 0.87–0.94 in asymptomatic participants and intraclass correlation coefficient = 0.88–0.96 in neck pain participants) [24,25].

5. Statistical Method

All data analysis of the measured values was performed using SPSS 22.0 (IBM Corp., Armonk, NY, USA). For the general characteristics of the participants (i.e. age, height, weight), descriptive statistics were used, and normality test was verified using the Kolmogorov-Smirnov test. For the comparison of

those with and those without pain among those with FHP, the CVA and cervical ROM of the flexion, extension, and left/right rotation were measured via independent t-tests. Additionally, a logistic regression was used to identify, whether the CVA and the 4 movements of flexion, extension, and left/right rotation are factors that can predict the occurrence of pain. The level of significance was set as $\alpha = 0.05$.

Results

In the general characteristics (i.e. gender, age, height, weight) of the participants with a FHP, no significant difference between the participants with pain and those without pain was observed (Table 1). There was a significant difference in the CVA and the cervical extension and flexion, but there was no significant difference in the left/right rotation (Table 2). Table 3 shows the analysis of factors affecting the occurrence of pain in those with a FHP using a logistic regression. These factors were the CVA [odds ratio (OR) = 0.513, 95% confidence interval (CI) = 0.286-0.922, $p < 0.05$] and the cervical flexion ROM (OR = 0.710, 95% CI = 0.515-0.981, $p < 0.05$). There was no significant relation to the cervical extension or the right/left rotation joint ROM.

χ_1 refers to the CVA, and χ_2 is the cervical flexion ROM. The regression equation of the logistic regression is as follows:

Risk of the occurrence of pain, $Y = 51.952 - (0.667 \times \chi_1 + 0.342 \times \chi_2)$

Table 1. General characteristics of the participants.

Parameters	With pain	Without pain	χ^2 or t	p	Total
Gender (male/female)	9/13	8/14	0.096	0.47	17/27
Age (y)	28.55 ± 5.15	26.64 ± 4.54	1.30	0.38	27.59 ± 4.90
Height (cm)	164.86 ± 7.83	166.93 ± 7.67	0.89	0.95	165.90 ± 7.73
Weight (kg)	60.18 ± 9.85	57.59 ± 8.80	0.92	0.54	58.89 ± 9.32

Data are presented as mean ± SD.

Table 2. Comparison of CVA and craniocervical ROM in individuals with a forward head posture who experience pain and those without pain.

Parameters	With pain	Without pain	t	p
CVA	44.44 ± 4.43*	48.63 ± 1.99	4.04	0.00
Flexion	32.32 ± 7.21*	41.05 ± 3.84	5.01	0.00
Extension	30.27 ± 8.11*	38.41 ± 6.46	3.68	0.01
RR	52.77 ± 6.36	53.14 ± 7.47	0.174	0.863
LR	53.55 ± 6.38	53.05 ± 6.14	0.265	0.792

Data are presented as mean ± SD.
* significant difference compared with the "without pain group" ($p < 0.05$).
CVA = craniovertebral angle; LR = left rotation; RR = right rotation.

Table 3. Logistic regression analysis of risk factor for the occurrence pain in individuals with a forward head posture.

Parameters	Beta	SE	p	OR	95% CI	
					Maximum	Minimum
CVA	- 0.667	0.299	0.026*	0.513	0.286	0.922
Flexion	- 0.342	0.165	0.038*	0.710	0.515	0.981
Extension	- 0.163	0.104	0.119	0.850	0.693	1.043
RR	- 0.142	0.112	0.207	0.868	0.697	1.082
LR	0.105	0.138	0.447	1 .111	0.847	1.456

*Statistically significant, $p < 0.05$.
CI = confidence interval; LR = left rotation; OR = odds ratio; RR = right rotation.

Discussion

This study focused on FHP and reported the differences in the CVA and the active cervical ROM in participants with and without pain, and identified whether these differences were related to pain. The results showed that there was a difference in the extension and flexion ROM in the cervical area and the CVA, in the participants that experienced pain, compared to those that did not experience pain. This indicated that a decreased angle of the lordotic curve, a decreased ROM in the cervical extension and flexion (due to a decreased CVA) was related to pain. Additionally, logistic regression analysis showed that the CVA and the cervical flexion were significant risk factors for pain.

CVA is a factor that significantly influences pain in those individuals with a FHP. The decreased CVA causes flexing of the cervical vertebrae in a forward position which if maintained for a long period of time, increases the load in the extension muscle (by increasing the external moment arm) and its surrounding connective tissues [10,19]. In previous studies, it has been reported that constant stress on the extension muscle and connective tissue in the craniocervical area, leads to an imbalance in the neck that induces pain [7,8,26]. Chiu et al reported that maintaining a FHP for a long period of time increases the load on noncontractive structures, causing abnormal stress on the extension muscle in the posterior craniocervical area, which can lead to myofascial pain [7]. Furthermore, it has been reported that if the CVA is 5° less than that reported in individuals who do not have FHP, then it can increase the stress in the posterior region of the craniocervical area [27]. In this study, the difference between individuals with FHP with and without pain, was 4.2°. A reason for differences in CVA may be due to the difference in the participants. While the previous study compared participants experiencing pain with either normal posture or FHP, in this study all participants had FHP either with or without pain. Additionally, Yip et al and Sohn et al, reported that the reduction of the CVA contributes significantly to the occurrence of pain in the craniocervical area, thus supporting the results of this study [19,23].

This study showed that active cervical ROM was decreased in the extension and flexion movements in the cervical area of participants with pain compared to those without pain, indicating pain is significantly associated with the decrease in the flexion and extension of the ROM in the cervical area. Specifically, the flexion ROM in the cervical area was shown to have a significant correlation with the occurrence of pain, along with the CVA, in logistic regression analysis. A FHP increases the external moment by moving the head forward, causing the rear extension muscles to contract persistently. Moreover, a FHP maintains tightness in the muscles through the shortening of the rear extension muscles in the craniocervical area and the lengthening of the front flexion muscles [10,11]. These biomechanical changes may affect the muscle thickness of the craniocervical area and may also affect the functional activity of the muscles in this area [20]. Sohn et al [23] showed that the ROM in the cervical area is more reduced in the FHP participants with a greater decrease of the CVA. In this study there was a significant decrease in the CVA in FHP participants with pain compared to those without pain, supporting the findings in the previous study. Walmsley et al and Ordway et al reported in their studies that a FHP can negatively affect movement in the craniocervical area because it overloads the facet joint and the posterior region of the spine, as well as creating a biomechanical change in the craniocervical area [28,29]. A FHP can also limit normal rotations and gliding movements in the glenoid cavity when joints move [14,28]. This limits functional movements in the craniocervical area. The reduced cervical ROM of flexion and extension in individuals with a FHP experiencing pain is considered to be as a result of the limitation of the arthrokinematic movements within the joint capsule, and the increased pressure between the facet joint in addition to the physiological change of the muscles around the craniocervical area, caused by a decreased CVA.

In this study, no significant changes were observed in the right/left rotation in individuals with a FHP. This posture is improper, with an extension in the upper cervical and a flexion in the lower cervical region. For this reason, it is considered that a FHP influences the posture change in the sagittal plane but cannot act as a significant factor in the right/left rotation, which is in a horizontal plane. Meisingset et al [29] also reported that cervical flexion and extension, which is a movement in the sagittal plane, was the only variable associated with neck pain and neck disability. These results are in agreement with a previous study which suggested that there was no significant difference in the movement in horizontal rotation when FHP was compared with normal participants [12]. Additionally, in this study a significant difference was observed in FHP between individuals with and without pain in the cervical extension as shown by using the independent *t* test used for analysis of 1 variable. However, a significant difference between both groups was not observed when FHP logistic regression was applied which is influenced by the interaction among other variables (e.g. CVA, Flexion, RR, and LR). Therefore, these results are probably due to differences in statistical analysis methods.

A FHP is an internal factor that leads to the development of pain through poor postural alignment. When comparing the FHP of participants with pain and those without pain, the individuals with pain had a reduced cervical ROM in the sagittal plane and a decreased CVA. These results suggest that a decreased CVA and ROM of cervical flexion, can be predictors

of pain. Therefore, the assessment of the CVA and the flexion joint ROM in the cervical area could be used clinically as a rudimentary reference to predict or possibly prevent the occurrence of pain in those with a FHP. However, there are limitations to this study.

Firstly, pain around the neck causes mechanical limitations to the cervical joint, which can lead to physical limitations such as the loss of ROM and contraction of muscle fibers, and ankyloses [18] but it could not be verified whether FHP influenced pain or limitations in movement caused pain. Secondly, variables that can predict the occurrence of pain in the cervical area (excluding the CVA and the ROM), could not be additionally examined and so many participants could not be included in this study. More scientific efforts to investigate variables that could affect the occurrence of pain in the participants with a FHP are required in further research.

Conflicts of Interest

No potential conflicts of interest relevant to this article was reported.

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