Correlations between Forward Head Posture, Range of Motion of Cervicospinal Area, Resting State, and Concentrations of the Brain

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Abstract. [Purpose] This study used radiography measurements and brain wave analysis to examine the correlations between the forward head posture (FHP) of the neck, the range of motion of cervicospinal area, and neurological measures of mental rest, and concentration of college students in their 20s. [Subjects] The subjects of this study were 22 college students (10 males, 12 females) in their 20s. [Methods] The cervical lordosis angle, FHP, and the flexion and extension angles of the cervicospinal area were analyzed from lateral view radiographs, and mental rest and concentration of the brain were measured with a neuro-feedback device. [Results] A higher absolute rotation angle (ARA) was associated with lower anterior weight bearing (AWB) and greater range of flexion and extension motions (RFEM). A higher AWB was associated with a lower RFEM and mental resting state score. Positive correlations were found between increased range of motion of the cervicospinal area and the mental resting state score and between increased RFEM and mental concentration score. [Conclusion] The FHP decreases the range of motion of the cervicospinal area, and this biomechanical problem negatively influences the mental resting state and concentration.

Key words: ARA, Forward head posture, Concentration

INTRODUCTION

The thinking and behaviors of people are controlled by the cerebrum, while the functions of the cerebrum depend on the activities of many cranial nerves. The activities of the cranial nerves can be detected by an electroencephalogram (EEG)1). When analyzing human behaviors in relation to the brain waves that appear at various frequencies, the functional condition of the brain can be estimated by analyzing the dominant brain waves. In recent years, EEG has sometimes been used to improve cognitive functions such as concentration, reaction time, behavioral modification, accuracy, relaxation, and decision-making ability2).

The frequency of complaints of musculoskeletal problems of the neck and shoulders is increasing among students and workers who often use computers3). When the upper thoracic region is bent in a rounded shape while a person is in a sitting or standing position, the positions of the head and neck are also changed in a compensatory manner4). The forward head posture (FHP) caused by these types of incorrect postures has been reported to generate biomechanical stress on the neck5). As people with this problem of the cervicospinal area often experience reduced ranges of motion of flexion and extension and have bad head and neck postures6,7), it is an important component of patient evaluation to measure the head and neck postures and the range of motion of the neck in these patients8). According to the anatomical structures, the cervicospinal area has a close positional relationship with the brain. For this reason, this study investigated the effects of the FHP on the range of motion of the cervicospinal area and also on the brain waves measurable during mental rest and concentration. The aim was to provide basic data for the evaluation of patients with dynamic stress of the neck and for the improvement of the learning abilities of students.

SUBJECTS AND METHODS

The subjects of this study were 22 college students (10 males, 12 females) in the Department of Physical Therapy, G College in Gyeongsangbukdo, Korea. Their mean age, height and weight were 21.6±2.8 years, 167.1±9.8 cm, and 58.7±13.0 kg, respectively. Subjects with a history of surgical treatment of the cervicospinal area, systematic diseases (cancers) or rheumatism, patients with neck pain...
accompanied by pressure fracture, or a history of neurological problems were excluded from this study. The subjects who participated in this study voluntarily signed consent forms after receiving a thorough explanation about the purpose of the study and details of the experiments.

This study conducted a comparative analysis of the degree of cervical curvature obtained through lateral view radiographs. The absolute rotation angle (ARA), anterior weight bearing (AWB), and range of flexion and extension motions (RFEM) were measured to describe the rotation of the neck, the FHP, and the angles of flexion and extension of the neck, respectively. Radiographs were taken by the same radiologist at a distance of 1 m with X-ray equipment (DLD-150 RK, Dong-A company, Korea), with the root of the nose on the horizontal line drawn from the external occipital protuberance. The subjects stood in the most comfortable and natural posture with their eyes closed and the muscles of the neck, shoulder and upper arm as relaxed as possible. A 14×14 inch film size was used.

The ARA is the angle formed by lines extended from the back of vertebrae C2 and C7, while AWB is the horizontal distance from the vertical line from the projected part of the posterior inferior surface of the vertebra C7 to the projected part of the posterior superior surface of the vertebra C2. The RFEM is the sum of the angle between the line extended from the bottom surface of the vertebra C2 and the line extended from the top surface of the vertebra C7 and the angle between the line extended from the bottom surface of the vertebra C2 and the line extended from the top surface of the vertebra C7 (Fig. 1). The mental resting state and concentration were measured with a Neuro-Feedback System (Braintech Corp., Korea). This system can be used to control a computer through a game program and engages the interest of the subject, who wears a headband at the prefrontal lobe with sensors to measure brain waves. The reason for the frontal area of the headband is that it is easier to attach electrodes to the scalp in the frontal area and it is more appropriate for measuring brain waves than are other regions. In particular, the prefrontal lobe plays a central role in brain functions related to learning behavior because it controls essential functions for cognition, thinking, and creativity. For measurements, the subject assumed a comfortable seated position and wore the head band with the FPz part at the center of the head band attached to the center of the forehead with appropriate pressure. The ground electrode was connected to the left earlobe. To examine the differences between brain waves during rest and during concentration, a spoon-folding program was conducted and measurements were made for 2 min in the resting and concentration modes.

| Table 1. | Mean±standard deviation (Unit -ARA: °, AWB: mm, Ex: °, Fle: °, RFEM: °) |
|----------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| ARA      | AWB             | Ex              | Fle             | RFEM            | Rest            | Con             |
| 11.9±10.4| 22.9±11.0       | 53.9±9.7        | 20.9±6.7        | 74.8±10.3       | 61.6±18.9       | 54.4±21.8       |

ARA: absolute rotation angle, AWB: anterior weight bearing, Ex: extension, Fle: flexion, RFEM: range of flexion and extension motions, Con: Concentration
SPSS 12.0 KO (SPSS, Chicago, IL, USA) and the mean and standard deviations of the collected data are presented (Table 1). Pearson correlation coefficients were calculated to analyze the relationships among the ARA, AWB, the flexion and extension of the cervicospinal area, RFEM, and the brain waves during mental rest and concentration. The statistical significance level, \( \alpha \), was chosen as 0.05.

RESULTS

An analysis of the sagittal plane of the cervicospinal area in the radiographs revealed a strong negative correlation between increased ARA and AWB, while a positive correlation was seen between ARA and the extension of the cervicospinal area. A weak positive correlation was observed between ARA and RFEM (Table 2). In addition, a negative correlation was found between AWB and extension, and a strong negative correlation was observed between AWB and flexion. A negative correlation was found between AWB and RFEM. A negative correlation was found between AWB and RFEM. With respect to correlations between FHP and the range of motion of the cervicospinal area and brain waves during mental rest and concentration, a weakly positive correlation was found between ARA and rest scores, and a negative correlation was observed between AWB and rest scores. A positive correlation was seen between flexion and rest scores. Positive correlations were also found between the extension angle and the concentration score and between the RFEM and concentration score.

DISCUSSION

Ro et al. reported on correlations between ARA, AWB, and RFEM in the herniation of intervertebral discs and showed that a lower ARA was associated with an increased AWB (r=-0.80) and a smaller RFEM (r=0.76), whereas a higher AWB was associated with a smaller RFEM (r=-0.83)\(^{12}\). This is similar to the results of the present study, in which increases in ARA were negatively correlated with AWB (r=-0.49) and positively correlated with RFEM (r=0.26), and increases in AWB were negatively correlated with RFEM (r=-0.59). In the present study, however, similar results were obtained even though the subjects were not C-HNP patients. Thus, a close correlation can be presumed to exist generally between the FHP and the range of motion of the cervicospinal area. Neurophysiologically, the alpha wave has traditionally been used to judge the function of the left and right hemispheres of the brain with respect to human behaviors, because it is a basic wave that reflects the stable state of the brain and is not much affected by artifacts\(^{13,14}\). The mental processes of people are the most efficient when the alpha wave appears\(^{15}\), and the appearance of alpha waves during meditation is used as a measure of emotional stability because it signifies a stable state of the brain. In contrast, the SMR wave, which is a beta wave, is associated with mental concentration such as that which occurs during the preparation for waking up or while assuming a standby state for the motor system\(^{16}\). Alpha wave training has been shown to improve the ability of abstract thinking, consciousness, the senses, and self control\(^{17}\).

This study found a weakly positive correlation between ARA and the mental rest score, and a negative correlation was observed between increased FHP and the mental rest score. This suggests that as the normal state of the cervical posture is approached, the alpha wave will increase in frequency, indicating a stable state of the brain. The association of higher RFEM with a higher mental concentration score also indicates that increased range of motion of the cervicospinal area results in increased SMR waves, which appear in higher states of mental concentration.

The FHP appears to reduce the range of motion of the cervicospinal area, and the continuation of this abnormal alignment may result in imbalance of the muscles and changes in anatomical structure. This may lead to a reduction in blood flow to the head, thereby affecting concentration, which is the basis of learning abilities. A reduced range of motion of the cervicospinal area associated with the FHP is believed to influence the appearance of the SMR waves among the alpha waves, which appear under conditions of emotional stability, and of the beta waves, which are activated during mental concentration.

In the future, correlation analyses for each waveform need to be conducted with respect to the effects of the FHP and the range of motion of the cervicospinal area on mental

### Table 2. Correlations of ARA, AWB, Extension, Flexion, RFEM, Rest and Concentration

<table>
<thead>
<tr>
<th>Category</th>
<th>ARA</th>
<th>AWB</th>
<th>Ex</th>
<th>Fle</th>
<th>RFEM</th>
<th>Rest</th>
<th>Con</th>
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</thead>
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<tr>
<td>ARA</td>
<td>1</td>
<td>-.497*</td>
<td>.390</td>
<td>-.171</td>
<td>.260</td>
<td>.268</td>
<td>.205</td>
</tr>
<tr>
<td>AWB</td>
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<td>1</td>
<td>-.310</td>
<td>-.467*</td>
<td>-.598**</td>
<td>-.301</td>
<td>-.027</td>
</tr>
<tr>
<td>Ex</td>
<td>.390</td>
<td>-.310</td>
<td>1</td>
<td>-.263</td>
<td>.779**</td>
<td>-.250</td>
<td>.405</td>
</tr>
<tr>
<td>Fle</td>
<td>-.171</td>
<td>-.467*</td>
<td>-.263</td>
<td>1</td>
<td>.400</td>
<td>.257</td>
<td>-.045</td>
</tr>
<tr>
<td>RFEM</td>
<td>.260</td>
<td>-.598**</td>
<td>.779**</td>
<td>.400</td>
<td>1</td>
<td>-.071</td>
<td>.356</td>
</tr>
<tr>
<td>Rest</td>
<td>.268</td>
<td>-.301</td>
<td>-.250</td>
<td>.257</td>
<td>-.071</td>
<td>1</td>
<td>-.051</td>
</tr>
<tr>
<td>Con</td>
<td>.205</td>
<td>-.027</td>
<td>.405</td>
<td>-.045</td>
<td>.356</td>
<td>-.051</td>
<td>1</td>
</tr>
</tbody>
</table>

*: p<0.05, **: p<0.01
stability and concentration of the brain.

REFERENCES