Cervical spinal pain in chronic craniomandibular pain patients. Recognition, prevalence and risk indicators

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Chapter 3

The relationship between posture and curvature of the cervical spine

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Abstract

The relationship between posture and curvature of the cervical spine was studied in 54 subjects (29 women, 25 men, mean age 24 years, range 20-31 years), who were free of craniomandibular and/or cervical spinal pain. Lateral radiographs of the head and cervical spine were taken while the participants were standing in a neutral position. Cervical spine posture was quantified by the angle of a reference line that was composed of reference points of the upper six cervical vertebrae, and the horizontal axis. The curvature of the cervical spine was classified visually as lordotic, straight or reversed. A relationship was found between posture and curvature of the cervical spine (p=0.006): a more forward posture was related to a partly reversed curvature; and a more upright posture to a lordotic curvature. Moreover, men more often exhibited a straight curvature, whereas women more often showed a partly reversed curvature.
Introduction

Patients with pain originating from the musculoskeletal structures of the masticatory system, usually aggravated by chewing or jaw function, suffer from a craniomandibular dysfunction (CMD) (Okeson, 1996). Some studies indicate that patients suffering from a CMD also more often show a cervical spine disorder (CSD, pain on cervical spine function and sometimes limited range of motion) than healthy individuals (Clark et al., 1987; Lobbezoo-Scholte, et al., 1995; De Laat et al., 1998). A forward head posture (FHP) is one of the suggested risk indicators a CMD and a CSD would have in common (Mannheimer and Rosenthal, 1991; Hackney et al., 1993; Haughie et al., 1995; Lee et al., 1995; Grimmer, 1996). A forward head posture may cause stress on the structures of the masticatory system and of the cervical spine, including the muscles and joints. It is also suggested that FHP is not only associated with the posture of the cervical spine but also with its curvature (Darnell, 1983; Rocabado, 1984; Braun and Amundson, 1989; Mannheimer and Rosenthal, 1991). However, whether a relationship between posture and curvature exists, was only described in these studies but not investigated. To investigate whether the reported increased prevalence of a cervical spinal pain in craniomandibular pain patients is associated with a deviant posture, curvature or both, it is important to know whether a relationship between curvature and posture exists. Therefore a study was started to the relationship between posture and curvature of the cervical spine, both in craniomandibular and/or cervical spinal pain patients and in healthy individuals. Since more women than men seek help for a CMD the influence of gender upon posture and curvature was also investigated. In the present study the results for the healthy individuals are presented.

The posture of the cervical spine was mathematically derived from the positions of the corpora of the individual cervical vertebrae on lateral radiographs taken from the head and the cervical spine. The curvature of the cervical spine was visually classified as lordotic, straight or reversed. Then the hypothesis was tested that different cervical spine curvatures correspond to different cervical spine postures.
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Materials and Methods

Participants
Eighty-six healthy students of the Academic Centre for Dentistry Amsterdam (ACTA) were invited to participate in the study. They had no history of craniomandibular or cervical spinal pain. After giving informed consent, they were screened for signs and symptoms of a craniomandibular disorder, using the protocol suggested by Bezuur et al. (1989). In addition, a physician examined the cervical spine for cervical spinal pain. When pain in the cervical spine upon movements, or an obvious hypomobility of the cervical spine was observed, the student was excluded from further participation. As a result of this clinical examination 3 participants were omitted from the study.

Procedure
Of the remaining 83 students a lateral radiograph of the head and cervical spine was taken, while they were standing in a neutral position. This position is defined as the position in which the subject is standing on bare feet in front of a vertically placed mirror while looking into the pupils of his/her eyes (Solow and Tallgren, 1971). To avoid lateroflexion or rotation of the head, a vertical light visor was projected on the subject's face and the subject was asked to orient his head in such a way, that the light visor was projected upon the midline of the face. A Kodak T-mat Blue Base film was used in a cassette with image intensifier. The distance between the radiographic apparatus and the cassette was 3.96 meters. A plumb line was mounted in front of the cassette to indicate the true vertical on the X-ray film.

The upper six cervical vertebrae were used in this study. The seventh cervical vertebra was not included in the analysis, because this vertebra was missing on most of the radiographs. Twenty-nine radiographs were excluded because of over-exposure or because the sixth cervical vertebra was not completely visible. Thus, the radiographs of 54 subjects, 25 men and 29 women, were used in this study. The 54 subjects had a mean age of 24 years with a range of 20 to 31 years. Forty-nine of them were caucasian, 5 were non-caucasian.
Posture and curvature of the cervical spine

Measurements

Cervical spine posture. The position of each vertebra was characterised by four of the five reference points earlier described by Van Mameren et al. (1990) (Figure 1). The reference points for the first cervical vertebra were the most cranial and caudal points of the anterior arcus of the atlas and the most ventro-cranial and ventro-caudal points of the ventral side of the posterior arcus of the atlas. The second cervical vertebra was characterised by the ventral and dorsal transition points of the dens axis and the corpus of the axis and by the most ventro-caudal and dorso-caudal points of the corpus of the axis. The third to sixth cervical vertebrae were characterised by the most ventro-cranial, ventro-caudal, dorso-cranial and dorso-caudal points of the corpus of the vertebrae. The co-ordinates of the reference points were digitised by means of an x,y-tablet (Scriptel RDT). The centre of the four reference points of each cervical vertebra was regarded as the centre of the vertebral body. Based upon the least squares method, the linear equation of the line running as closely as possible along the centres of the six vertebrae was calculated; the Cervical Posture Line (CPL), see Figure 1. The angle between this line and the horizontal was used as a measure of the cervical spine posture (CPL/Hor).

Figure 1. Reference points and reference lines on a lateral radiograph. The reference points for the first to the sixth cervical vertebra, the Cervical Posture line (CPL) and the true vertical (Ver) and horizontal (Hor) are shown.
Cervical spine curvature. The curvature of the cervical spine was visually classified into three categories; a lordotic curvature, a predominantly straight one with an occasional small upper lordosis, and a partly reversed curvature (i.e., a high cervical lordosis and a low cervical kyphosis) (Figure 2).

![Figure 2. Examples of a lordotic (left), predominantly straight (middle) and partly reversed (right) cervical spine.](image)

**Tracing of the radiographs**
Two well-trained investigators independently traced each radiograph. The mean value of the two angles of the CPL/Hor was used for further analysis. Two investigators also independently classified the cervical spine curvature. In case the investigators did not agree, they discussed their classification and came to an agreement.

**Statistics**
Analysis of Variance (ANOVA) and Students $t$ tests were used to analyse the effects of the curvature and gender on the posture of the cervical spine. The $\chi^2$ test and binominal test were used to test gender distribution differences between the three subgroups of cervical spine curvatures. All statistical analyses were performed with significance set at the 0.05 probability level.
Results

The results of the classification of the curvature of the cervical spine into lordotic, predominantly straight and partly reversed spines are shown in Table 1 and the results of the Analysis of Variance are shown in Table 2.

Table 1. Visual classification of the cervical spine. For each subgroup of cervical spines, the number of subjects within that group, the sex distribution, the mean age and the mean value, standard deviation and range of the cervical spine posture (CPL/Hor) are given.

<table>
<thead>
<tr>
<th>Curvature</th>
<th>N</th>
<th>Male</th>
<th>Female</th>
<th>Mean</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lordotic</td>
<td>21</td>
<td>10</td>
<td>11</td>
<td>24.9</td>
<td>89.0</td>
<td>4.9</td>
<td>81.7 - 99.0</td>
</tr>
<tr>
<td>Reversed</td>
<td>15</td>
<td>2</td>
<td>13</td>
<td>24.3</td>
<td>83.0</td>
<td>3.0</td>
<td>76.4 - 87.5</td>
</tr>
<tr>
<td>Straight</td>
<td>18</td>
<td>13</td>
<td>5</td>
<td>24.7</td>
<td>86.4</td>
<td>6.7</td>
<td>74.5 - 100.9</td>
</tr>
</tbody>
</table>

Table 2. ANOVA: effect of the curvature of the cervical spine and of gender on cervical spine posture (CPL/Hor).

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curvature</td>
<td>2</td>
<td>5.81</td>
<td>0.006</td>
</tr>
<tr>
<td>Gender</td>
<td>1</td>
<td>0.24</td>
<td>0.626</td>
</tr>
<tr>
<td>Curvature * Gender</td>
<td>2</td>
<td>0.66</td>
<td>0.522</td>
</tr>
</tbody>
</table>

ANOVA showed a relationship between cervical spine curvature and posture (p=0.006). This relationship was independent of the gender. Also the cervical spine posture (CPL/Hor) was independent of gender (p>0.05). Its mean value for the complete sample was 86.4 degrees with a standard deviation of 5.6 degrees. The reversed curvatures showed a significantly smaller CPL/Hor than the lordotic curvatures (Table 1, Student's t test, p< 0.01) whereas the posture of the straight curvatures did not differ from the posture of the other two groups.

The gender distribution was different for the three subgroups ($\chi^2$ test; p< 0.01): in the partly reversed group there were more women (binominal test, p< 0.01), in the straight group more men (p< 0.05) and in the lordotic group no difference was found between the number of men and women.
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Discussion

In this study the relationship between the cervical spine posture and its curvature was studied in a group of healthy participants, standing in a neutral position. Posture and curvature were quantified by means of a lateral radiograph taken from the head and the cervical spine. In the literature, several methods are suggested to describe cervical posture and curvature with the use of these radiographs. Cervical posture has been measured by using reference lines of anatomical points of only a small part of the cervical spine; two or three vertebrae (Solow and Tallgren, 1971; Hellsing et al., 1987). In our study the cervical spine posture was measured using the positions of the centres of all of the corpora of the upper six cervical vertebrae. Since usually the degree of anteroposition of the head is expressed as the position of the head in respect to the lower part of the cervical spine, the CPL can also be used as a measure for the amount of forward head posture. Cervical spine curvature has been quantified using measurements of the depth of the cervical lordosis (Borden et al., 1960) or of the angle between a reference line of the upper and of the lower part of the cervical spine (Gore et al., 1986; Hellsing et al., 1987; Plaugher et al., 1990). However, these quantifications cannot discriminate a reversed cervical spine from a lordotic or straight one. That's why we preferred to use a visual classification which is in accordance with classifications earlier described (Borden et al., 1960; Juhl et al., 1962; Fineman et al., 1963).

The results of our study have shown, for the first time, a statistical relationship between cervical spine curvature and posture. A partly reversed cervical spine showed, on the average, a more forward bending of the cervical spine whereas a lordotic curvature is related to a more upward cervical posture. This relationship proved to be independent of gender. These results are in agreement with earlier suggestions made by Darnell (1983) and Rocabado (1984) that subjects with a forward head position show a backward bending of the upper cervical spine and occiput and a forward bending of the lower cervical and upper thoracic spine. Juhl et al. (1962) studied the changes in the cervical spine curvature when subjects attained different cervical spine postures. When they changed their neutral position into a military one (thus probably with a greater CPL/Hor), many lordotic cervical spines changed into reversed or
straight ones. This relationship between curvature and posture was different from the one we have found. However, Juhl et al. (1962) studied changes in cervical spine curvature within subjects, whereas in our study the curvatures between subjects, all standing in a neutral position, were compared. Moreover, a military position is maintained by voluntary muscle contraction, which may have its effects on the cervical curvature, whereas a neutral position is a position with much less muscle activity.

It is, to our knowledge, also for the first time that a statistical relationship was found between the curvature of the cervical spine and gender (Table 1). That the partly reversed group consisted of mainly women, the lordotic group of men as well as women and the straight group mainly of men is striking and needs further investigation. No difference in cervical spine posture was found between men and women.

This study has shown that lordotic, straight and reversed spines as well as a wide range of cervical spine postures can be found in healthy people without a history of cervical spinal or craniomandibular pain. Whether individuals with pain complaints in the neck or the masticatory system show a different cervical spine posture, curvature or relationship between these two characteristics is now being investigated within our department. In conclusion, this study has shown that, in healthy individuals, different cervical spine curvatures are associated with a different cervical spine posture and gender.