Original Article

Cervical Headgear Effects on the Morphology of the Cervical Vertebrae and Cervical Posture

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ABSTRACT

Objective: To test the hypothesis that use of cervical headgear has an important effect on the morphology of the cervical vertebrae and cervical posture.

Materials and Methods: The material consisted of pretreatment and posttreatment lateral cephalograms and initial hand-wrist films of 30 subjects who were receiving cervical headgear therapy. Preobservation and postobservation control cephalograms and preobservation hand-wrist films of 15 untreated subjects served as controls. The average treatment time for the treatment group was 9.06 ± 1.02 months, and the average observation period for the control group was 10.0 ± 1.1 months. A paired *t*-test was applied to compare the changes occurring during the examination and observation periods in both groups. In addition, Student's *t*-test was performed to assess the differences between the groups.

Results: The results of the paired *t*-test showed that within each group there were statistically significant differences in the majority of measurements concerning the morphology of the cervical vertebrae, whereas the measurements concerning cervical posture showed no significant changes in either group. According to the results of the Student's *t*-test, however, no statistically significant changes between the treatment and control group were present except with regard to two measurements.

Conclusions: Changes in the cervicovertebral morphology in the treatment group were achieved more by growth than by cervical headgear treatment. Although high individual variations were found in postural variables, cervical posture did not change over a period of 9 months either in the treatment group or in the control group.

KEY WORDS: Cervical headgear; Morphology; Cervical vertebrae; Cervical posture; Cephalometrics

INTRODUCTION

Many cephalometric studies have examined the effect of cervical headgear (CHG) on craniofacial growth, and the inhibition of maxillary growth has been commonly described as an important effect of treatment with CHG.[1–6] Besides, several cephalometric studies have examined the effect of the use of CHG on mandibular growth[1–5,7,8] and mandibular position.[9,10] Many workers have reported that CHG had no influence on mandibular growth,[1,5,11] whereas others reported that it inhibited forward growth of the mandible.[2,12] Conversely, some researchers[3,4,6–8] demonstrated that CHG facilitated mandibular growth. In addition, Üşümez et al[13] investigated the effect of CHG wear on dynamic measurement of head position and reported that CHG wear causes a significant amount of cranial flexion, which may be responsible for its effects on the mandible.

More studies dealing with CHG have been concerned with the effects of the use of CHG on the position and growth of craniofacial structures, upper airway dimensions, and head posture. However, the changes in overall cervicovertebral morphology and cervical posture because of the use of CHG have not

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been investigated in detail. The hypothesis tested in this study was that the use of CHG has an important effect on the morphology of the cervical vertebrae and cervical posture.

Therefore, the aims of this study were to:

1. Examine the changes in the morphology of the cervical vertebrae and cervical posture because of the use of CHG;
2. Compare these changes with an untreated control group.

MATERIAL AND METHODS

The material comprised pre– and post–CHG treatment lateral cephalometric head films and initial hand-wrist radiographs of 30 subjects, 15 females and 15 males, who were receiving CHG therapy as part of their orthodontic treatment with fixed edgewise technique at the Department of Orthodontics of Atatürk University. Pre– and post–observation period lateral cephalograms and preobservation hand-wrist radiographs of 15 untreated subjects, 7 females and 8 males, selected from the files of the same department served as controls. The mean pretreatment and preobservation ages were 12.59 ± 1.33 years for the treatment group and 12.04 ± 0.63 years for the control group.

All of the subjects had a Class II occlusal relationship, were nose-breathers with a complete dentition except for the third molars, and had no wound, burn, or scar tissue in the face and neck region and no signs of functional disturbances of the masticatory system. All cephalograms in both treatment and control groups were taken at natural head position (NHP) with the subjects standing in an orthoposition looking into a mirror.[14] A metal chain was suspended in front of the film cassette to indicate the true vertical.

A standard-type CHG including face bow with safety caps (Dentaurum, Ispringen, Germany) and neck pad with safety module (Dentaurum, Ispringen, Germany) was used in the study. The outer bows of the face bows were bent approximately 30° upwards according to the occlusal plane. The force application point on the outer bow was located approximately on the trifurcation of the roots of the upper first permanent molars. A standard cervical traction of 300 g per side was applied. The amounts of the force used were adjusted at 6-week intervals. Children were asked to keep daily diaries of their headgear wearing. Cooperation was estimated according to the diary notes and signs of use in the headgear such as tearing of the elastic band and neck strap.

According to these observations, 22 children had good cooperation and eight had moderate cooperation. Patients with poor cooperation were not included in this study. The 30 cases in the treated group wore the CHG 16 to 18 hours per day for a mean treatment period of 9.06 ± 1.02 months, and no Class II elastics were used during CHG treatment. The mean observation period for the control group was 10.0 ± 1.1 months. Developmental stages of the patients were determined using the skeletal maturation criteria described by Fishman.[15]

The cephalometric measurements used in the study are described in Figure 1 for morphological variables and in Figure 2 for postural variables.

Error of Measurements

Twenty randomly-selected radiographs were retraced and remeasured by the same investigator two weeks after the initial assessments. The error of the method was examined using the coefficient of reliability, calculated for each measurement: coefficient of reliability $= 1 - Se^2/St^2$, where Se^2 is the variance because of random error and St^2 is the total variance of the measurements.[16]

Statistical Analysis

Data were analyzed using SPSS for Windows, version 10.0 (SPSS Inc, Chicago, Ill). The means and standard deviations of the pre– and post–study period measurements in both groups were calculated for each variable. To determine gender differences in both the treatment and control groups, Student's *t*-test was used. In addition, a paired *t*-test was applied to compare the changes that occurred during the examination and observation periods in the treatment and control groups. Furthermore, Student's *t*-test was performed to assess the differences between the treatment and control groups. $P \leq .05$ was considered statistically significant.

RESULTS

The value of the coefficient of reliability was above 0.90 (range 0.90–0.99) for all cephalometric measurements except the lower edge angle of C2 (0.86) and anterior intervertebral space of C5 (0.89) measurements. According to Student's *t*-test, no statistically significant gender differences were found in either the treatment or the control group. Therefore, data were pooled in both groups. The distribution of skeletal maturation stages and gender of the subjects for each group at the beginning of the study period is shown in Table 1. As seen in Table 1, skeletal maturation stages of the subjects in the treatment and observation groups were largely similar.

Descriptive statistics including the means and standard deviations for all measurements and the results

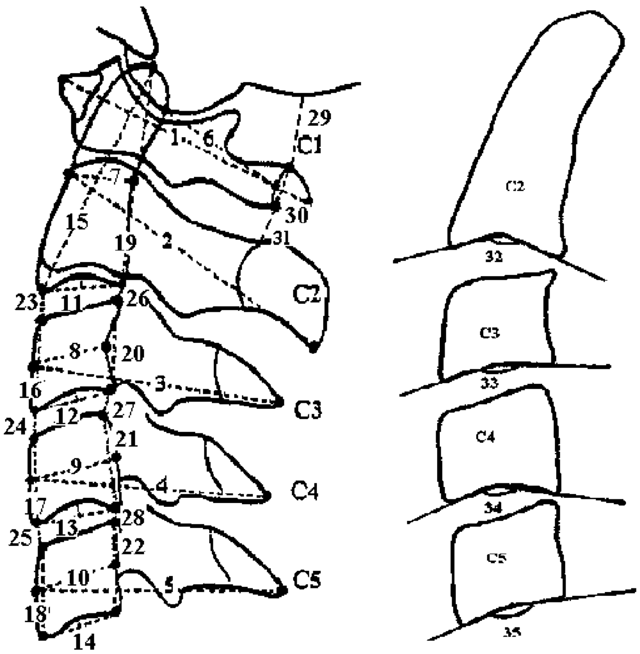

Figure 1. Morphological variables concerning cervical vertebrae used in the study. Linear variables: (1–5): TLC1–C5, total length of the cervical vertebrae, the maximum anteroposterior lengths of C1–C5; (6) LLC1, lumen length of the atlas, the distance from the dorsal border of the odontoid process of C2 to the anterior border of the dorsal arch of C1; (7–10) BLC2–C5, body length of the cervical vertebrae, the distances between the midpoints of the anterosuperior and anteroinferior points of the bodies of C2–C5 and the midpoints of the posterosuperior and posteroinferior points of C2–C5; (11–14) IDC2–C5, inferior depth of the cervical vertebrae, the perpendicular distances between the extreme superior points of the inferior border of the bodies of C2–C5 and the tangent lines to the anteroinferior and posteroinferior points of the bodies of C2–C5; (15–18) ABHC2–C5, anterior height of the bodies of the cervical vertebrae, the distances between the anterosuperior and anteroinferior points of the bodies of C2–C5; (19–22) PBHC2–C5, posterior height of the bodies of the cervical vertebrae, the distances between the posterosuperior and posteroinferior points of the bodies of C2-C5; (23–25) AISC2–C4, anterior intervertebral space of the cervical vertebrae, the anterior distances between the bodies of C2–C5; (26–28) PISC2–C4, posterior intervertebral space of the cervical vertebrae, the posterior distances between the bodies of C2–C5; (29) X, the shortest distance from the inferior surface of the occipital bone to the most superior point on the dorsal arch of the atlas; (30) Y, dorsal arch height of the atlas, the maximum vertical height of the dorsal arch of C1; (31) Z, the shortest distance from the most inferior point on the dorsal arch of the atlas to the most superior point on the dorsal arch of the second cervical vertebra. Angular variables: (32–35) LEAC2–C5, lower edge angle of the cervical vertebrae, the angles between the lines from anteroinferior and posteroinferior points of the bodies of C2–C5 to the extreme superior points of the inferior border of the bodies of C2–C5.

of the paired *t*-test are presented in Table 2 for the treatment group and in Table 3 for the control group. The results of the Student's *t*-test are given in Table 4.

The paired *t*-test showed that there were statistically significant within-group differences in the majority of measurements in both treatment and control groups.

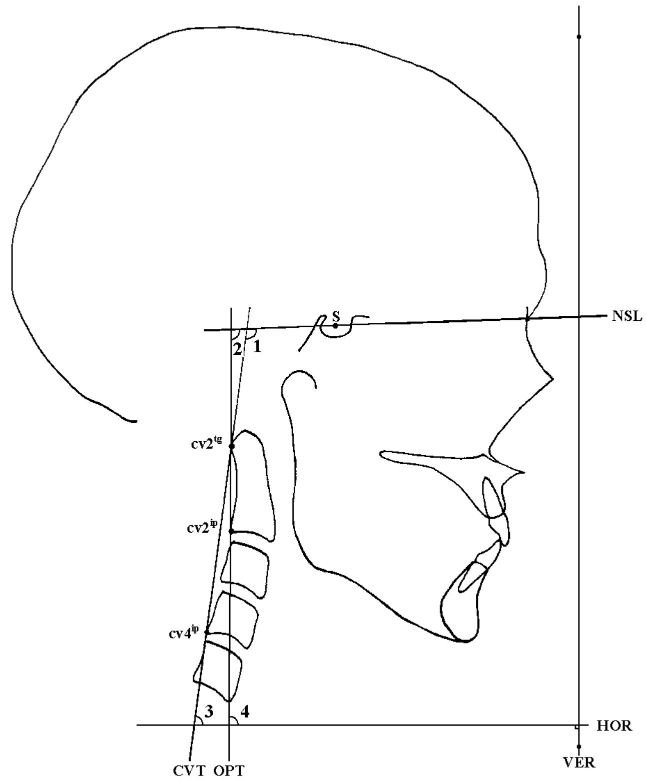

Figure 2. Postural variables used in the study. (1) NSL/CVT, the angle between the nasion-sella line and the posterior tangent to the cervical vertebrae ($cv2^{tg}$-$cv4^{ip}$). (2) NSL/OPT, the angle between the nasion-sella line and the posterior tangent to the odontoid process of the second cervical vertebra ($cv2^{tg}$-$cv2^{ip}$). (3) CVT/HOR, the angle between the posterior tangent to the cervical vertebrae ($cv2^{tg}$-$cv4^{ip}$) and the true horizontal. (4) OPT/HOR, the angle between the posterior tangent to the odontoid process of the second cervical vertebra ($cv2^{tg}$-$cv2^{ip}$) and the true horizontal.

Table 1. Distribution of the Skeletal Maturation Stages (SMS) and Gender of the Subjects for Each Group at the Beginning of the Study Period[a]

		No. of Subjects	
	SMS	Male	Female
Treatment group (n = 30)	MP_3	2	1
	S	4	2
	MP_{3cap}	6	6
	DP_{3u}	2	5
	MP_{3u}	1	1
Control group (n = 15)	MP_3	1	1
	S	2	1
	MP_{3cap}	4	3
	DP_{3u}	1	2
	MP_{3u}	—	—

[a] MP_3 indicates the middle phalanx of the third finger—the epiphysis equals its diaphysis; S, the first mineralization of the ulnar sesamoid bone; MP_{3cap}, the middle phalanx of the third finger—the epiphysis caps its diaphysis; DP_{3u}, the distal phalanx of the third finger—complete epiphyseal union; and MP_{3u}, the middle phalanx of the third finger—complete epiphyseal union.

Table 2. Pretreatment of Posttreatment Means and Standard Deviations and the Results of the Paired *t*-Tests for the Treatment Group

	Pretreatment		Posttreatment		
	Mean	SD	Mean	SD	*t* Values
Morphological variables					
Linear					
TLC1	47.25	1.83	48.50	2.47	−4.932***
LLC1	21.60	1.45	21.62	1.62	−0.130
TLC2	48.52	2.82	50.83	3.50	−6.094***
BLC2	12.32	0.87	12.27	1.24	0.224
ABHC2	37.73	3.18	39.65	2.87	−7.064***
PBHC2	34.42	2.27	35.65	2.25	−5.524***
IDC2	1.40	0.70	1.83	0.74	−5.517***
AISC2	4.82	0.97	4.28	1.18	2.623*
PISC2	2.67	0.91	2.85	0.73	−0.983
TLC3	43.68	2.86	45.68	3.13	−4.933***
BLC3	15.02	1.19	15.45	1.18	−2.644*
ABHC3	10.73	2.27	12.52	2.43	−6.386***
PBHC3	12.75	1.76	13.75	1.76	−5.133***
IDC3	1.00	0.74	1.43	0.73	−5.277***
AISC3	5.00	1.22	4.38	1.28	3.249**
PISC3	2.53	0.73	2.08	0.87	2.645*
TLC4	42.95	3.04	44.35	2.86	−3.640***
BLC4	14.90	1.17	15.35	1.35	−2.594*
ABHC4	10.18	2.12	12.02	2.43	−8.279***
PBHC4	12.67	1.64	14.17	1.76	−5.665***
IDC4	0.72	0.68	1.17	0.77	−7.449***
AISC4	4.67	1.18	4.02	1.15	3.412**
PISC4	2.62	0.83	2.28	1.02	1.551
TLC5	43.40	2.84	44.58	3.21	−2.401*
BLC5	14.73	1.02	15.18	1.23	−2.851**
ABHC5	10.42	1.95	12.03	2.14	−6.823***
PBHC5	12.28	1.66	13.80	1.72	−5.939***
IDC5	0.60	0.59	0.95	0.72	−4.372***
X	8.57	2.82	8.78	2.78	−0.602
Y	9.47	1.60	10.10	1.66	−3.229**
Z	6.23	2.60	6.50	2.51	−0.934
Angular					
LEAC2	156.15	12.18	150.12	12.59	5.554***
LEAC3	163.52	13.07	154.28	11.86	7.286***
LEAC4	166.62	12.53	159.73	13.85	6.600***
LEAC5	169.08	10.70	163.75	12.30	5.639***
Postural angles					
NSL/CVT	102.42	8.62	102.25	6.76	0.139
NSL/OPT	98.15	8.38	97.83	6.89	0.269
CVT/HOR	83.50	8.13	82.02	5.31	1.238
OPT/HOR	87.90	7.81	86.25	5.76	1.398

[a] See Figure 1 and 2 captions for definitions of variables.
* $P < .05$; ** $P < .01$; *** $P < .001$.

Table 3. Pretreatment of Posttreatment Means and Standard Deviations and the Results of the Paired *t*-Tests for the Control Group

	Preobservation		Postobservation		
	Mean	SD	Mean	SD	*t* Values
Morphological variables					
Linear					
TLC1	47.36	2.02	48.79	2.60	−3.490**
LLC1	21.68	1.62	22.14	1.65	−1.149
TLC2	48.25	2.74	51.29	3.40	−5.897***
BLC2	11.86	1.12	12.32	1.14	−2.061
ABHC2	37.32	2.18	39.82	2.61	−5.204***
PBHC2	33.75	2.34	35.57	2.53	−4.746***
IDC2	1.00	0.39	1.68	0.50	−5.467***
AISC2	4.32	1.32	4.21	0.87	0.278
PISC2	2.32	0.82	2.64	0.89	−1.290
TLC3	41.79	1.81	43.71	2.93	−3.739**
BLC3	14.39	1.06	14.86	1.20	−2.509
ABHC3	10.00	2.18	11.89	2.20	−4.311***
PBHC3	12.21	1.30	13.64	1.73	−3.822**
IDC3	0.68	0.42	1.29	0.51	−6.497***
AISC3	5.18	0.85	4.64	0.86	1.883
PISC3	1.79	0.83	2.21	0.83	−1.640
TLC4	41.21	2.61	43.14	3.18	−4.534***
BLC4	14.18	1.03	15.07	1.28	−3.890**
ABHC4	9.14	1.71	11.32	2.14	−5.901***
PBHC4	12.57	1.40	13.68	1.49	−3.419**
IDC4	0.50	0.34	1.11	0.59	−5.090***
AISC4	5.29	1.01	4.43	1.16	3.309**
PISC4	2.18	0.91	2.46	0.93	−1.017
TLC5	42.00	2.83	43.86	3.18	−4.414***
BLC5	14.25	1.12	15.04	1.39	−3.376**
ABHC5	8.75	1.55	10.82	2.01	−5.654***
PBHC5	11.89	1.55	13.21	1.79	−3.693**
IDC5	0.29	0.32	0.71	0.51	−4.837***
X	7.79	2.46	8.25	2.62	−0.791
Y	8.29	1.90	8.89	1.73	−3.319**
Z	6.43	2.80	7.25	2.86	−2.203*
Angular					
LEAC2	163.00	5.91	151.71	7.83	6.043***
LEAC3	169.29	7.66	159.00	7.34	7.305***
LEAC4	172.14	6.47	162.93	9.38	5.707***
LEAC5	175.36	4.72	168.00	7.96	5.251***
Postural angles					
NSL/CVT	100.29	6.34	101.11	5.53	−0.688
NSL/OPT	96.89	7.09	96.46	6.86	0.345
CVT/HOR	81.89	6.06	81.32	4.67	0.189
OPT/HOR	85.21	7.14	85.32	5.30	−0.056

[a] See Figure 1 and 2 captions for definitions of variables.
* $P < .05$; ** $P < .01$; *** $P < .001$.

In the treatment group, all of the measurements concerning cervicovertebral morphology except lumen length of C1, body length of C2, posterior intervertebral space of C2 and C4, and X and Z distances showed statistically significant differences. The majority of the measurements demonstrated significant increases, whereas others (lower edge angles of C2–C5, anterior intervertebral spaces of C2–C4, and posterior intervertebral spaces of C3 and C4) showed significant decreases. On the other hand, the measurements concerning cervical posture in this group showed no significant changes.

In the control group, all of the measurements concerning cervicovertebral morphology except body length of C2, anterior intervertebral space of C2 and C3, posterior intervertebral spaces of C2–C4, lumen length of C1, and X distance showed statistically significant differences. All of the measurements, except

Table 4. Results of the Student's *t*-Test Comparing the Differences Between the Treatment and Control Groups[a]

	Treatment Group		Control Group		
	Mean	SD	Mean	SD	*t* Values
Morphological variables					
Linear					
TLC1	−1.25	1.39	−1.43	1.36	0.400
LLC1	−0.02	0.70	−0.47	1.51	1.352
TLC2	−2.31	2.08	−3.04	1.93	1.092
BLC2	0.05	1.22	−0.46	0.84	1.422
ABHC2	−1.91	1.49	−2.50	1.80	1.134
PBHC2	−1.23	1.22	−1.82	1.44	1.406
IDC2	−0.43	0.43	−0.68	0.46	1.718
AISC2	0.53	1.11	0.11	1.44	1.075
PISC2	−0.18	1.02	−0.32	0.93	0.429
TLC3	−2.00	2.22	−1.93	1.93	−0.103
BLC3	−0.43	0.90	−0.46	0.69	0.114
ABHC3	−1.78	1.53	−1.89	1.64	0.216
PBHC3	−1.18	1.26	−1.43	1.40	0.580
IDC3	−0.83	0.51	−1.00	0.39	1.073
AISC3	0.61	1.04	0.54	1.06	0.239
PISC3	0.45	0.93	−0.43	0.98	2.869**
TLC4	−1.40	2.11	−1.93	1.59	0.832
BLC4	−0.45	.95	−0.89	0.86	1.483
ABHC4	−1.83	1.21	−2.18	1.38	0.842
PBHC4	−1.50	1.45	−1.11	1.21	−0.879
IDC4	−0.45	0.33	−0.61	0.45	1.311
AISC4	0.65	1.04	0.86	0.97	−0.627
PISC4	0.33	1.18	−0.29	1.05	1.679
TLC5	−1.18	2.70	−1.86	1.57	0.865
BLC5	−0.45	0.86	−0.79	0.87	1.197
ABHC5	−1.61	1.30	−2.07	1.37	1.064
PBHC5	−1.51	1.40	−1.32	1.34	−0.437
IDC5	−0.35	0.44	−0.43	0.33	0.594
X	−0.22	1.97	−0.46	2.20	0.374
Y	−0.63	1.07	−0.61	0.68	−0.083
Z	−0.27	1.56	−0.82	1.40	1.133
Angular					
LEAC2	6.03	5.95	11.29	6.99	−2.580*
LEAC3	13.40	8.48	17.57	6.55	−1.625
LEAC4	6.88	5.71	9.21	6.04	−1.238
LEAC5	5.33	5.18	7.36	5.24	−1.203
Postural angles					
NSL/CVT	0.17	6.54	−.82	4.47	0.510
NSL/OPT	−0.32	6.44	−0.42	4.65	−0.058
CVT/HOR	−1.48	6.57	−0.29	5.66	0.587
OPT/HOR	−1.65	6.47	0.11	7.14	0.812

[a] See Figure 1 and 2 captions for definitions of variables.
* $P < .05$; ** $P < .01$.

lower edge angles of C2–C5, demonstrated significant increases. In the control group, however, no significant change was observed in the measurements concerning cervical posture.

According to the results of the Student's *t*-test, no statistically significant changes were detected between the treatment and control groups, except for the measurements of the lower edge angle of C2 and posterior intervertebral space of C3. These results indicated that the changes in the treatment group were achieved more by growth than by CHG treatment.

DISCUSSION

Previous investigations reported the existence of morphological associations between the cervical vertebrae and craniofacial structures.[17–24] In addition, correlations have been demonstrated between atlas morphology and head posture and between morphology of the atlas and axis and direction of the mandibular growth.[17–20] Nevertheless, until now, the effect of CHG wear on overall morphology of the cervical vertebrae and cervical inclination has not been investigated in detail. In the present study, therefore, the changes in the cervicovertebral morphology and cervical inclination because of the use of CHG were examined.

The results of the present study indicated that there were statistically significant changes in the morphology of the cervical vertebrae in the treatment group. However, almost all of these morphological parameters also showed statistically significant changes during the observation period in the control group. When the control findings were compared with those of the treated group, statistically significant change was detected only in the measurements of lower edge angle of C2 and posterior intervertebral space of C3. The results indicated that the changes in the parameters concerning cervicovertebral morphology in the treatment group were achieved more by growth than by CHG treatment. In addition, no statistically significant changes were determined in the cervical posture in either the treatment or the control group. The findings showed that use of CHG led to no statistically significant changes in cervical posture. However, it has been observed that the changes in postural variables were not uniform in both groups, and all measurements used in the study showed a considerable amount of variability with high standard deviation values (Table 4). This indicates that different subjects showed dissimilar responses in both groups. Therefore, it should be pointed out that long-term investigations including a larger sample of patients treated with CHG would be more useful.

The morphogenesis of the cervical vertebrae is obviously related to their main functions of protecting the spinal cord, supporting the head, and facilitating the head's mobility.[17] In view of the early completion of central nervous system growth,[25] especially in the case of the upper vertebrae,[26] it could be expected that the part supporting and protecting the spinal cord would remain largely unaffected by later environmental influences.[17] The results are in agreement with the findings of the present study, where we found that the morphology of the cervical vertebrae was not affected by CHG treatment.

Üşümez et al[13] investigated the effect of CHG wear on the dynamic measurement of head posture while walking, and reported that CHG wear causes a significant cranial flexion that may be responsible for its effects on the mandible. However, the effect of CHG on mandibular position is questionable. Although there are different concepts, many authors have reported that the use of CHG has no influence on mandibular growth. Therefore, cranial flexion attributed to CHG wear cannot be wholly accounted for by the effect of CHG on mandibular position.

On the other hand, our findings indicated that cervical posture was not affected by long-term wearing of CHG. This discrepancy can partly be explained by the duration of the CHG wear.

Hiyama et al[10] evaluated changes in the mandibular position and upper airway dimension by wearing CHG during sleep. They reported that the hyoid bone and the third cervical vertebra were moved significantly forward by the wearing of CHG, and that CHG significantly reduced the sagittal dimension of the upper airway, although there was no significant anteroposterior displacement of the mandible. However, they did not evaluate the effect of CHG wear on the morphology of the cervical vertebrae and cervical posture. Hence, the results of that study were not available for comparison with our findings.

Recently, Siersbæk-Nielsen and Solow[27] concluded that individuals tend to maintain their characteristic natural head positions over time. Consequently, they suggested that a developmental relationship exists between craniocervical posture and craniofacial morphology. Similarly, in a longitudinal study of NHP, Tallgren and Solow[28] found that head position in relation to true vertical showed no significant changes. Several authors, using different methods, have conducted NHP studies, and their data agree on the consistency of an individual's head posture over time.[14,29,30] The results are in agreement with the findings of the present study, wherein we found that the cervical posture did not change over a period of 9 months in either the control group or the group treated with CHG.

CONCLUSIONS

- Changes in cervicovertebral morphology in the treatment group were achieved more by growth than by CHG treatment.
- Cervical posture exhibited no significant change over a period of 9 months either in the control group or in the group treated with CHG.
- Individuals tend to maintain their characteristic natural head positions over time.

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