Trunk asymmetry and facial symmetry in young adults

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The aim of the present study was to detect possible associations between trunk and cervical asymmetry and facial symmetry. Frontal cephalograms prepared in the natural head position, representing 79 subjects (40 males, 39 females) with mild to moderate trunk asymmetry, were analyzed separately for thoracic humps, lumbar prominences, and cervical inclination by discriminating two groups: right-sided-dominant and left-sided-dominant. The differences between the groups were analyzed using an unpaired 2-group *t* test. The results showed that location of the thoracic humps and inclination of the cervical spine was predominantly right-sided, while the location of lumbar prominence was predominantly left-sided. Craniofacial morphological variables of the head and face were nearly equal for right-sided and left-sided thoracic humps and lumbar prominences, showing that moderate trunk asymmetry does not affect facial symmetry. Further, it was found that frontal head position in relation to the true vertical (VER/ORB) is stable in that the angle between the supraorbital and vertical lines is constantly maintained close to 90 degrees regardless of moderate trunk asymmetry, indicating that visual perception control is most important in orienting the head in frontal plane. Maintenance of the head position takes place by cervical spine adaptation. □ *Cervical inclination; craniofacial morphology; head position; head posture; trunk asymmetry*

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Existing reports about associations between spinal curvature and craniofacial morphology are contradictory. In the lateral projection, increased cervical lordosis has been associated with a reduced anterior face height and increased thoracic kyphosis with increased facial prognathism, while lumbar lordosis does not correlate with craniofacial variables (1). Also, the extension of head has been found to relate to steep forward inclination of the cervical column (2). In a recent study, however, thoracic kyphosis and head posture had no association with sagittal craniofacial morphology in young adults (3).

Only a few studies describing head posture in the frontal projection are available and these deal mainly with head posture in pathologic conditions such as scoliosis and torticollis. According to these studies, craniocervical relation is affected in association with post-surgical conditions of congenital torticollis and scoliosis (4, 5).

Contralateral head tilt resolved or improved significantly in patients with frontal plagiocephaly following resolution of strabismus (6). Also vision affects head position, since patients with vertical facial asymmetry adapt a spinal position in order to be able to maintain binocular vision (7).

Head position is the individual habit of maintaining the head in space (craniovertical relation), while head posture is defined as the relationship of the cranium to the cervical spine (craniocervical relation) (2, 3). These definitions can be used both in frontal and lateral aspects. In frontal view of the cephalogram the craniovertical relationship is defined as the angle between the gravity vertical line and the line of the upper margin of orbits (VER/ORB) (8). The craniocervical relation can be measured as the angle between the orbital line and the cervical midline (ORB/CERmid) (8). The craniocervical angle may thus be changed either by lateral tilting of the head or by lateral inclination of the cervical line.

No study focusing on the frontal aspect of head posture and craniofacial morphology has so far been published. The aim of the present study was to reveal possible associations between mild and moderate trunk and cervical asymmetries and facial symmetry in young adults selected from a population-based cohort.

Subjects and methods

The subjects comprised a population-based, representative cohort of 430 young Finnish adults (208 females, 222 males). The study was part of a research project focusing on growth of the spine and a long-term evaluation of trunk

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asymmetry (9–11). Initially, the cohort comprised 1060 children 11 years of age (12). Combined with a prospective follow-up study of the spinal growth in these subjects, an examination of craniofacial structures was included in the research protocol of the present study when the subjects were 22 years of age. The ethics committees of the Helsinki City Health Board and the Institute of Dentistry, University of Helsinki approved the study.

A physiatrist examined the subjects to detect trunk asymmetry and spinal posture. With the participants in the forward bending position, measurements were made of trunk asymmetry (rib hump or lumbar prominence) as the vertical distance between the horizontal on a spirit level and the trunk on the concavity (9). This method has been described and illustrated in detail by Vercauteren et al. (13) and later by the current authors in a previous paper (3). Ninety-one subjects were found to have either trunk asymmetry $\geq$10 mm ($n = 75$) measured by the forward bending test (13), or thoracic kyphosis $\geq$50 degrees ($n = 12$) measured by spinal pantograph (14); 4 subjects had both trunk asymmetry $\geq$10 mm and thoracic kyphosis $\geq$50 degrees. All 79 subjects with trunk asymmetry and with or without thoracic kyphosis were referred for a frontal cephalometric radiographic examination of the head and cervical spine and constitute the subjects of the present study. Frontal cephalograms were taken in a natural head position in a rigid cephalostat with film-focus distance of 154 cm (140 cm from the focus to ear-rod plane). To define the natural head position, the fluid level method was used (15). Moreover, to avoid head rotation, specially designed ear rods were adjusted vertically, the amount respective to the tilt to maintain the habitual lateral head tilt shown by the fluid level device attached to the forehead. During exposure, the teeth were kept in centric occlusion. In cases of occlusal shift, a wax index prepared with the teeth in retruded contact position was used. For imaging of the gravity vertical, a plumb wire was suspended on to the cephalostat in front of the film cassette. The cephalograms were digitized using the X-Metrix software program (SmartSystems Oy, 1996). The digitized cephalometric landmarks and lines to describe the studied facial and cervical structures are shown in Figs 1–3. The cervical spine direction was described in two different ways (CERdens, CERmid). CERdens was defined by the tip of the dens (D) and the midpoint of the C4 corpus. CERmid was defined by C1 (midpoint of right and left At-points) and C4. In most cases these two lines merged; they were separate only if the dens location was not centric in relation to atlas. The data were analyzed separately for the gender and thoracic humps, lumbar prominences and cervical inclination by discriminating

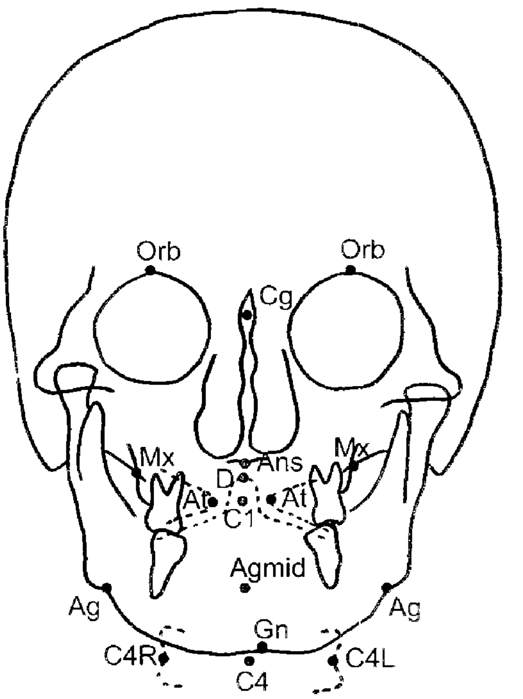

Fig. 1. The cephalometric landmarks. Ag—antegonion: the highest point in the antegonial notch (right and left); Ans—anterior nasal spine; Agmid—midpoint between left and right Ag points; At—the most median point at the tubercule of transverse ligament of atlas (right and left); Cg—crista galli: the horizontal center point of the base of crista galli; C1—the midpoint of the line connecting At right and left; C4R and C4L—the most concave point of the lateral mass of the C4 vertebra (right and left); C4—the midpoint of the line connecting C4R and C4L; D—dens: the tip of the dens; Gn—gnation: the mandibular midpoint; Orb—orbita: the extreme cranial point of the supraorbital margin (right and left).

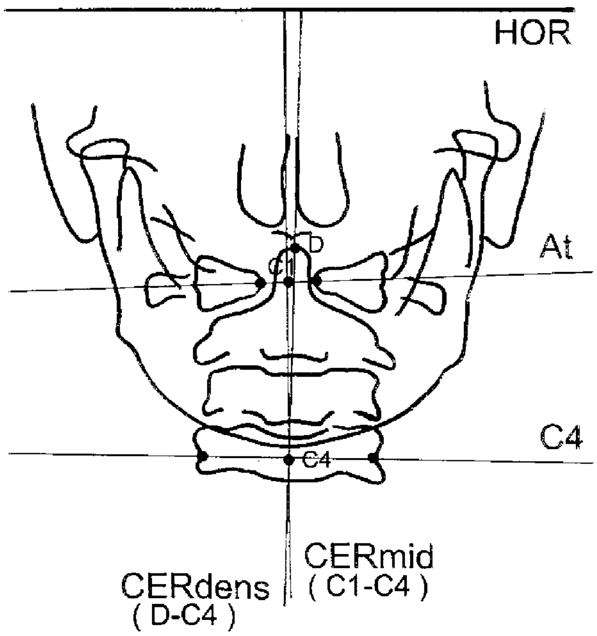

Fig. 2. The cephalometric lines to describe cervical structures. HOR—horizontal line: line perpendicular to the true vertical plumb line; At—atlas line: line through the right and left At-points; C4-line—line through the right and left C4-points; CERdens—cervical dens line: line through points D and C4; CERmid—cervical midline: line through points C1 and C4.

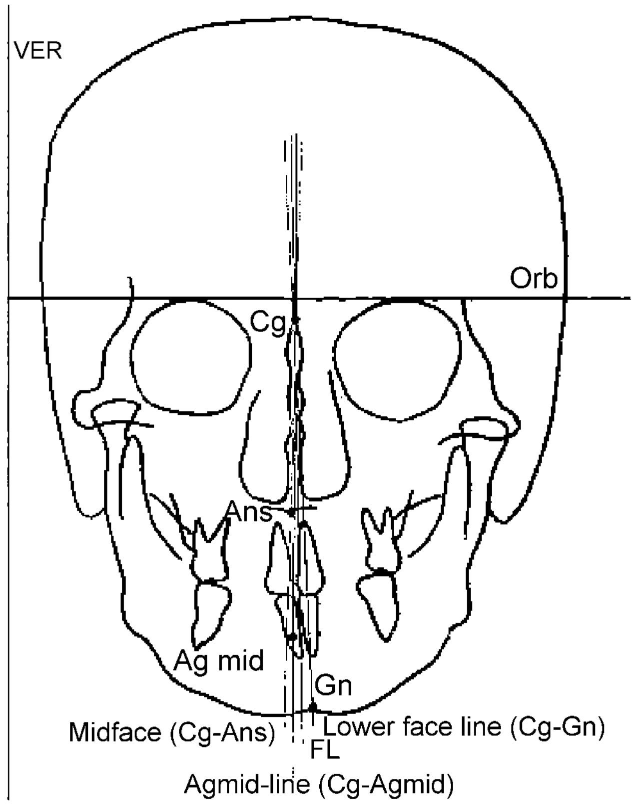

Fig. 3. The cephalometric lines to describe facial structures. VER—vertical line: the true vertical plumb line; Orb—orbital line: line through the right and left orbita points; Midface—midfacial line: line through points Cg and Ans; FL—facial line: line perpendicular to orbital line through the point Cg; Agmid-line—line through points Cg and Agmid; Lower face line—line through points Cg and Gn.

two groups: right-sided and left-sided (Tables 1–3). All variables were then statistically analysed using Student's *t*-test for unpaired samples. Level of significance was 95%.

In order to calculate errors in landmark identification, 10 cephalograms were redigitized after 2 months. The error variance for each measurement was calculated from Dahlberg's formula $S_{(i)} = \sqrt{\Sigma d^2/2N}$, where d is the difference between the first and second digitization and N is the number of double digitizations. The range of error variance between two digitizations was 0.41–1.75 degrees. This was considered acceptable.

Results

None of the variables studied showed statistically significant differences in values between males and females (Table 1). Inclination of the cervical spine and location of thoracic humps were predominantly towards the right side (65% in cervical inclination and 59% in thoracic inclination); however, location of lumbar prominence was predominant towards the left side (74%). When the subjects were divided based on the right- or left-sidedness of cervical inclination, the craniocervical variables showed difference between the groups (Table 2). However, the

Table 1. Mean values (in degrees) and standard deviations (*s*) of the variables describing position and posture of the head and cervical spine and craniofacial morphology in young adults with mild to moderate trunk asymmetry

	Mean Male (n = 40) Female (n = 39)	*s*
Craniocervical positional		
VER/ORB (°)	90.32	1.98
	89.94	2.23
HOR/CERdens (°)	91.77	2.89
	90.66	4.24
HOR/CERmid (°)	91.25	3.04
	90.31	3.89
Craniocervical postural		
ORB/CERmid (°)	90.98	3.60
	90.37	3.55
ORB/CERdens (°)	91.46	3.47
	90.72	3.86
Cranial-morphological		
ORB/Midface (°)	89.46	1.75
	89.71	1.34
ORB/Lower face line (°)	89.97	1.72
	90.47	1.72
ORB/Agmid line (°)	89.73	1.66
	90.06	1.47
Cervical		
At/C4 (°)	2.13	4.33
	−0.21	4.49

Table 2. Mean values (in degrees) and standard deviations (*s*) for variables describing position and posture of the head and craniofacial morphology in young adults with mild to moderate trunk asymmetry categorized according to left- or right-sided inclination of the cervical spine

	Mean Right-sided (n = 51) Left-sided (n = 28)	*s*
Craniocervical positional		
VER/ORB (°)	90.27	2.00
	89.88	2.29
HOR/CERdens (°)	93.28	2.50
	87.47	2.02***
HOR/CERmid (°)	92.65	2.40
	87.38	2.45***
Craniocervical postural		
ORB/CERdens (°)	93.01	2.67
	87.60	2.44***
Cranial-morphological		
ORB/Midface (°)	89.70	1.45
	89.37	1.74
ORB/Lower face line (°)	90.45	1.52
	89.78	2.01
ORB/Agmid line (°)	89.98	1.60
	89.74	1.54

*** $P < 0.001$ (Student's *t*-test).

head position (VER/ORB) remained close to normal in both groups and there were no statistically significant differences in craniomorphological values. All postural and morphologic variables were almost similar in the right-sided and left-sided thoracic hump and lumbar prominence groups (Table 3).

Discussion

This study has shown that trunk asymmetry in young adults clinically expressed as thoracic humps or lumbar prominences does not affect facial symmetry. However, in the majority of the subjects the cervical inclination was to the right, which is in accordance with previous findings (15). A distinct pattern of trunk surface asymmetry is a well-known phenomenon. There is a trend to skew to the right at thoracic level and to the left at lumbar and cervical level (9). It has previously been reported that the lateral bending of the spine in adolescent idiopathic scoliosis is predominantly right-sided whenever the thoracic spine is affected and left-sided when the lumbar spine is involved (16, 17).

In this study, the head position (VER/ORB) in the frontal view remained close to 90 degrees in trunk asymmetry groups. Adaptation to the trunk asymmetry possibly takes place in the cervical region, since the cervical variables expressed the largest standard deviations. The stability of the craniovertical relation is most likely an indication of visual perception mechanisms in the head posture control. A recent study on the postural etiology of scoliosis in the visually impaired population shows 5 times more back surface abnormalities in the blind population (18). The head is tilted only when normal binocular vision is impaired as a result of for example strabismus, facial asymmetry conditions with different levels of eyes and torticollis (6). In the cohort of the same young adults as in this study we have earlier reported that thoracic hyperkyphosis is associated with a large atlanto-cervical angle without affection on the craniocervical relation. This, too, we proposed as being related to a craniocervical adaptation due to the visual perception control system for constant maintainance of the visual axis (3).

In this study, the cephalograms were taken with the head in the natural position with fluid level control and specially designed ear rods adjusted vertically to take account of the amount respective to habitual head tilt. This precise positioning of the head during X-ray exposure can be considered important, since the placement of ear rods can greatly affect the position of the head in space. Especially in frontal aspect, proper placement of the skull is essential for the true interpretation of facial structures (19). Apart from correct positioning of the subject, attention should also be paid to the method error when assessing craniocervical structures in frontal aspect. Inter-examiner reproducibility of orbital and cervical reference lines has been reported to be in the magnitude of 0.3–0.7

Table 3. Mean values (in degrees) and standard deviations (*s*) for variables describing position and posture of the head and cervical spine and craniofacial morphology in young adults with mild to moderate trunk asymmetry categorized according to location of the thoracic hump ($n = 39$) and lumbar prominence ($n = 50$). None of the variables showed significant dierence when evaluated with Student's *t*-test

	Thoracic hump Mean Right-sided ($n = 23$) Left-sided ($n = 16$)	(*s*)	Lumbar prominence Mean Right-sided ($n = 13$) Left-sided ($n = 37$)	(*s*)
Craniocervical positional				
VER/ORB (°)	90.62	1.98	89.48	2.49
	90.38	1.89	90.49	2.02
HOR/CERdens (°)	92.71	3.85	91.75	2.35
	90.84	2.48	91.61	3.08
HOR/CERmid (°)	92.09	3.40	90.88	1.76
	90.66	2.05	91.09	3.38
Craniocervical postural				
ORB/CERmid (°)	91.49	3.23	91.38	2.28
	90.29	3.22	90.62	3.77
ORB/CERdens (°)	92.10	3.76	92.26	2.78
	90.49	3.59	91.13	3.51
Cranial-morphological				
ORB/Midface (°)	89.43	1.50	89.54	1.14
	89.79	1.48	89.64	1.55
ORB/Lower face line (°)	90.05	1.62	90.36	1.30
	90.41	1.63	89.99	1.76
ORB/Agmid line (°)	89.69	1.32	90.14	1.91
	90.13	0.18	89.91	1.63
Cervical				
At/C4 (°)	2.22	4.45	0.95	4.27
	1.26	5.99	0.58	5.22

degrees (8), which is slightly less than the method error in the present study. However, this should not affect the interpretation of our results. When the error of the method increases, the variance will increase as well, and as a consequence from the statistical calculation the magnitude of the difference between the means of two groups has to be increased accordingly in order to display statistical significance.

In conclusion, it seems that visual perception control is most important in orientating the head in the frontal plane in young adults, with moderate trunk asymmetry and head position maintained by cervical spine adaptation. Thus the symmetry of craniofacial structures remains unaffected by moderate trunk asymmetry in young adults.

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References

1. Hellsing E, Reigo T, McWilliam J, Spangfort E. Cervical and lumbar lordosis and thoracic kyphosis in 8, 11 and 15-year-old children. Eur J Orthod 1987;9:129–38.
2. Solow B, Tallgren A. Head posture and craniofacial morphology. Am J Phys Anthrop 1976;3:417–35.
3. Zepa I, Hurmerinta K, Kovero O, Nissinen M, Könönen M, Huggare J. Associations between thoracic kyphosis, head posture, and craniofacial morphology in young adults. Acta Odontol Scand 2000;58:237–42.
4. Pirttiniemi P, Lahtela P, Huggare J, Serlo W. Head posture and dentofacial asymmetries in surgically treated muscular torticollis patients. Acta Odont Scand 1989;47:193–7.
5. Huggare J, Pirttiniemi P, Serlo W. Head posture and dentofacial morphology in subjects treated for scoliosis. Proc Finn Dent Soc 1991;87:151–8.
6. Gosain AK, Steele MA, McCarthy JG, Thorne CH. A prospective study of the relationship between strabismus and head posture in patients with frontal plagiocephaly. Plast Reconstr Surg 1996;97:881–91.
7. Shapiro IJ. Relation between vertical facial asymmetry and postural changes of the spine and ancillary muscles. Optom Vis Sci 1994;71:529–38.
8. Zepa I, Huggare J. Reference structures for assessment of frontal head posture. Eur J Orthod 1998;20:694–9.
9. Nissinen MJ, Heliövaara MM, Seitsamo JT, Kononen MH, Hurmerinta KA, Poussa MS. Development of trunk asymmetry in a cohort of children ages 11 to 22 years. Spine 2000;25:570–4.
10. Nissinen M, Heliövaara M, Ylikoski M, Poussa M. Trunk asymmetry and screening for scoliosis: a longitudinal cohort study of pubertal schoolchildren. Acta Paediatr 1993;82:77–82.
11. Nissinen M, Heliovaara M, Seitsamo J, Poussa M. Trunk asymmetry, posture, growth, and risk of scoliosis. A three-year follow-up of Finnish prepubertal school children. Spine 1993;18:8–13.
12. Nissinen M, Heliovaara M, Tallroth K, Poussa M. Trunk asymmetry and scoliosis, anthropometric measurements in prepubertal school children. Acta Paediatr Scand 1989;78:747–53.
13. Vercauteren M, van Benden M, Verplaetse R, Croene P, Uyttendaele D, Verdonk R. Trunk asymmetries in a Belgian School population. Spine 1982;7:555–62.
14. Willner S. Spinal pantograph: a non-invasive anthropometric device for describing postures and asymmetries of the trunk. J Pediatr Orthop 1983;3:245–9.
15. Huggare J. Natural head position recording on frontal skull radiographs. Acta Odontol Scand 1989;47:105–9.
16. Avikainen VJ, Vaherto H. A high incidence of spinal curvature. A study of 100 young female students. Acta Orthop Scand 1983;54:267–73.
17. Samuelsson L, Norén L. Trunk rotation in scoliosis. The influence of curve type and direction in 150 children. Acta Orthop Scand 1997:273–6.
18. Catanzariti JF, Salomez E, Bruandet JM, Thevenon A. Visual deficiency and scoliosis. Spine 2001;26:48–52.
19. Pirttiniemi P, Miettinen J, Kantomaa T. Combined effects of errors in frontal-view asymmetry diagnosis. Eur J Orthod 1996;18:629–36.

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