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Longitudinal Posteroanterior Changes in Transverse and Vertical Craniofacial Structures Between 10 and 14 Years of Age

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ABSTRACT

Longitudinal growth changes in the transverse and vertical craniofacial dimensions occurring between 10 and 14 years of age were evaluated in 22 female and 23 male subjects. All subjects were healthy, had a clinically acceptable occlusion, and had not received orthodontic or orthopedic therapy before. Serial cephalometric radiographs were taken at ages 10, 11, 12, and 14 years. In studying the P-A cephalograms, seven transverse and five vertical measurements were used. The effects of age and sex on the transverse and vertical growth of the craniofacial structures were investigated by means of analysis of variance and Bonferroni multiple comparison test. The results of the study revealed that all measurements studied were affected by age, and cranial, facial, nasal, and maxillary widths were affected by sex. The most pronounced age-related increases occurred in the mandibular width for transverse measurements and in the total facial height for vertical measurements in both sexes during this study.

KEY WORDS: Posteroanterior, Cephalometrics, Longitudinal growth changes.

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INTRODUCTION Return to TOC

Most growth studies have used lateral cephalometric radiographs to analyze changes in the vertical and sagittal dimensions of the face. Most of the normative data have been based on sagittal aspects of dentofacial structures, with the current emphasis on orthodontic diagnosis obtained from information on these films. However, evaluation of the transverse structure of the face is needed for a comprehensive dentofacial analysis.[1–3]

Bilateral facial asymmetries and development of the oronasal area can be better assessed from a transverse analysis of posteroanterior cephalometric radiographs.[2,4–8] Furthermore, analysis of vertical components, although easily viewed from sagittal cephalograms, also cannot be fully understood without the assistance of a posteroanterior cephalometric radiographs because bilateral vertical asymmetries can best be evaluated from a frontal view.[2]

Longitudinal data presented on a yearly basis are of great value to orthodontists interested in the detailed study of facial growth. The use of normative cephalometric standards obtained for subjects at one age, in the diagnosis of individuals who might be of a completely different age group or a different sex (or both), could aversely influence both the diagnosis and the treatment plan.[9]

On the other hand, the period between 10 and 14 years of age is a stage at which corrective orthodontic treatment is most frequently applied. Therefore, an evaluation of the transverse and vertical growth changes normally occurring during this period could provide valuable information for treatment planning.

The purpose of this study was to investigate the longitudinal growth changes occurring in the transverse and vertical dimensions of the face between 10 and 14 years of age.

MATERIALS AND METHODS Return to TOC

Longitudinal posteroanterior cephalometric radiographs of 45 (22 female and 23 male) subjects were selected from the files of the Orthodontic Department at Atatürk University. The selection of all subjects was based on normal growth and development, a balanced skeletal profile and Class I occlusion, the presence of only minimal dental crowding, the absence of crossbites, and a no history of orthodontic treatment. Serial posteroanterior cephalometric films were exposed annually at 10, 11, 12, and 14 years of age. The mean age of the sample at the beginning of this study was 9.94 ± 0.36 years for female and 10.05 ± 0.37 years for male subjects. The mean age of the total sample was 10.0 ± 0.37 years.

The posteroanterior cephalometric films were taken by standard methods. The cephalometric tracings were performed on acetate paper by a single investigator. The landmarks, reference lines, and measurements used in the study are described in Figure 1. Twelve linear measurements were used to assess longitudinal growth changes in the transverse and vertical dimensions of the face.

Error study

To assess intraexaminer reliability, 20 randomly selected cases were retracted and remeasured by the same examiner. Examiner variability of repeated measurements was evaluated by calculating the interclass correlation coefficient and error of measurement for each linear distance.

Statistical analysis

Data were analyzed, using a statistical Package program SPSS Version 10.0 (SPSS Inc., Chicago, Ill).

The Student's *t*-test was used to determine whether the groups were homogeneous with regard to age. Descriptive statistics, including the means and standard deviations, were calculated separately for each sex on an annual basis. In addition, two-way repeated measures analysis of variance (ANOVA) was used to assess the effects of age and sex on the longitudinal growth changes in the measurements used in the study. This analysis was also used to examine the interaction effects between the age and sex. Furthermore, Bonferroni multiple comparison tests were applied to the measurements at which *F* values were found to be statistically significant. *P* values of .05 or less were considered to be statistically significant.

RESULTS Return to TOC

The intraexaminer errors of measurements for all distances were less than 0.5 mm, and the corresponding intraclass correlation coefficients were greater than 0.90. No statistically significant difference existed between the chronological ages of the sexes at the beginning of this study according to the Student's *t*-test ($t = 1.05$).

The results of repeated measures (ANOVA) of the sample data from 22 female and 23 male subjects are presented in Table 1. It can be seen from this table that all transverse and vertical measurements used in the study were significantly affected by age in both the female and male groups and the combined group. Cranial, facial, nasal, and maxillary widths were also significantly affected by sex. Furthermore, all measurements except maxillary and mandibular intermolar widths and upper facial height showed significant interaction effects between sex and age groups.

Descriptive statistics, including means and standard deviations, were determined for each age group from 10 to 14 years of age, and the results of Bonferroni multiple comparison test for female subjects are shown in Table 2 and for male subjects in Table 3. According to the results of the Bonferroni test, statistically significant growth changes were found between each age period for all measurements studied, except cranial and mandibular intermolar width in female subjects. In female subjects, these distances showed no significant growth changes between some age periods. All measurements used in the study demonstrated a significant increase with age. Male subjects exhibited an overall greater incremental growth change than female subjects between 10 and 14 years of age. The largest incremental growth changes during this period occurred in mandibular width for transverse measurements and in the total facial height for vertical measurements in both sexes.

DISCUSSION Return to TOC

The data from this longitudinal posteroanterior cephalometric study provide useful information for the assessment of the transverse and vertical dentofacial structures in children from 10 to 14 years of age.

The findings of this study indicate that all transverse and vertical distances demonstrated a progressive increase between 10 and 14 years of age in both sexes. The vertical growth of the face during this period was greater than the transverse facial growth. This result is consistent with the findings of previous studies.[2,10,11]

On the other hand, some statistically significant sex differences were found in the transverse widths. The main sex differences in transverse craniofacial widths were in the skeletal measurements that were significantly greater in male subjects than in female subjects. Furthermore, male subjects exhibited an overall greater incremental growth change than female subjects between 10 and 14 years of age. These findings are in agreement with previous studies.[2,12] Therefore, in this study, the findings on both male and female subjects are presented separately.

Transverse craniofacial growth

All skeletal and dental transverse widths demonstrated statistically significant incremental growth changes in both sexes during the period from 10 to 14 years of age. In both male and female subjects, the largest incremental growth was found in mandibular width for transverse measurements, whereas the lowest growth increment was observed in the mandibular intermolar width for male subjects and in the cranial width for female subjects. The mean change in the mandibular width was 9.2 mm for male subjects and 6.7 mm for female subjects. However, the mean changes in the intermolar width for male subjects and in the cranial width for female subjects were 2.7 and 0.80 mm, respectively.

The limited growth in cranial width, especially in female subjects, demonstrated that cranial width followed the neural growth curve. At the age of six years, the cranium had reached 94% to 95% of its width at age of 18 years for both male and female subjects.[13]

Ricketts et al[14] found that mandibular width, as measured from antegonial notch points, had a norm of 76.1 mm at the age of nine years and increased 1.4 mm per year. In this study, the mandibular widths measured as the bigonial distances were found to be 93.2 mm for male and 92.3 mm for female subjects at the age of 10 years. Mean increases per year were approximately 2.3 and 1.7 mm for male and female subjects, respectively.

The increments in the mandibular width were almost twice as great as the increments in the maxillary width for both sexes. Similarly, Huertas and Ghafari[15] found that the increase in mandibular width (AG-AG) was twice as much as that in maxillary width (J-J). Cortella et al[3] reported that the greater growth observed in mandibular width relative to the maxilla suggests the presence of a compensatory mechanism that allows the preservation of normal occlusion (no crossbite) between the posterior teeth. They also concluded that indicative of such a mechanism is the increase in maxillary intermolar width that represents about 52% of the increase in J-J between ages six to 18 years, whereas the widening of the mandibular intermolar distance is about 17% of that of AG-AG. These results are in agreement with the findings of the present study, where incremental growth in mandibular width was greater than in the maxillary, whereas the increment in the mandibular intermolar width was less than in the maxillary intermolar width. Several authors reported results similar to our findings.[1,2,16,17]

Sillman[18] and Moyers[19] found an increase in the maxillary and mandibular intermolar widths with age for both male and female subjects. The results of the present study confirmed the findings of these studies. However, Woods[20] found that maxillary intermolar width increased with age, whereas mandibular intermolar width showed a decrease with age in both sexes. Furthermore, Athanasiou et al[1] and Snodell et al[2] also found a decrease in the mandibular intermolar width with age in contrast to the findings of the present study.

Ricketts et al[14] found facial width to have a mean value of 115.7 mm at age nine years, with 2.4-mm increases per year. This study found mean facial width to be 125.4 mm for female subjects and 128.5 mm for male subjects at the age of 10 years. Mean increases per year were approximately 1.3 and 2.0 mm for female and male subjects, respectively.

Meredith[21] reported that male subjects had greater facial widths than female subjects. He observed a difference of 3.4 mm at the age of 10 years. The present study also found the sex difference to be 3.1 mm at the age of 10 years, which was similar to the finding of Meredith.

The results of this study indicated that incremental growth in the widths of the maxilla and the nasal cavity was similar in both sexes between 10 and 14 years of age. Snodell et al[2] found that nasal width correlated with maxillary width for both sexes, indicating a relationship between the airway and the width of the maxilla. These findings are in agreement with our study.

When the total size of the increment between 10 and 12 years was compared between male and female subjects for transverse measurements, differences were very small. Hence, most of the sex differences developed between 12 and 14 years.

Vertical craniofacial growth

All vertical measurements showed statistically significant incremental growth changes in both male and female subjects between 10 and 14 years of age. The largest incremental growth was found in the total facial height for both sexes. However, the lowest growth increments were found in the lower facial height for female and in the upper facial height for male subjects. The total increases in the vertical measurements were generally greater than in the transverse measurements for both sexes. This finding confirmed the work of Krogman,[22] who stated that first growth in width is completed, then growth in length, and finally growth in height. Furthermore, for the vertical measurements, the total increases in the 10- to 12-year age period were greater than in the 12- to 14-year age period for female subjects, whereas the total increases in the 12- to 14-year age period were greater than in the 10- to 12-year age period for male subjects. This finding can be explained by the fact that pubertal growth spurt in girls occurs earlier than in boys.

Because the subjects were selected on the basis of a balanced facial profile and normal occlusion, the differences between left ramus height and right ramus height were very small during the study period. Furthermore, ramus height, upper face height, and lower face height showed similar growth increments between 10 and 14 years of age for both male and female subjects. This finding supports the observation of Nanda,[23] who stated that the pattern of vertical facial development is established at an early age and is maintained during the progression of growth.

CONCLUSIONS Return to TOC

Based on the findings of the present study, the following conclusions can be drawn:

1. All skeletal and dental transverse and vertical measurements showed statistically significant incremental growth changes in both sexes between 10 and 14 years of age.
2. The vertical facial growth was greater than the transverse facial growth for both male and female subjects during this period.
3. Statistically significant sex differences were found in the skeletal transverse widths. Male subjects exhibited overall greater incremental growth changes than female subjects.
4. In both sexes, the most pronounced age-related increases occurred in mandibular width for transverse measurements and in the total facial height for vertical measurements during this study period.
5. The increase in mandibular width was nearly twice as much as that in maxillary width. However, the increase in mandibular intermolar width was less than in maxillary intermolar width. This finding indicated the presence of a compensatory mechanism that allows the preservation of normal occlusion.
6. In general, the incremental growth changes in the 10- to 12-year age period were greater than in the 12- to 14-year age period for female subjects, whereas the total growth increases in the 12- to 14-year age period were greater than in the 10- to 12-year age period for male subjects. This finding can be explained by the fact that girls reach maturity at an earlier age than boys.

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TABLE 1. The Results of Two-way Repeated Measures Analysis of Variance

Measurement	*F* Values				
	Among Time				
	Female Subjects	Male Subject	Combined	Between Sex	Time × Sex Interaction
Transverse measurement					
Cranial width	15.69***	33.05***	48.84***	5.42*	19.99***
Facial width	74.26***	68.38***	128.08***	7.86**	8.64***
Nasal width	76.69***	95.81***	168.78***	5.39*	5.73**
Maxillary width	61.66***	66.86***	126.27***	11.13**	2.05
Mandibular width	151.57***	372.91***	484.61***	1.37	15.01***
Maxillary intermolar width 6-6	35.97***	31.03***	76.20***	0.62	0.97
Mandibular intermolar width 6-6	51.79***	31.71***	64.25***	0.21	1.00
Vertical measurement					
Total facial height	125.00***	199.00***	317.60***	0.47	5.96**
Upper facial height	97.39***	96.81***	191.58***	0.10	1.70
Lower facial height	60.03***	88.93***	145.79***	0.40	7.92***
Right ramus height	96.44***	77.52***	161.73***	4.00	3.87*
Left ramus height	82.52***	61.44***	129.20	3.95	3.47*

* $P < .05$; ** $P < .01$; *** $P < .001$.

TABLE 2. The Means and SD of the Female Subjects From 10 to 14 y of age, and the Results of Bonferroni Multiple Comparison Test[a]

	Age, 10 y (1)		Age, 11 y (2)		Age, 12 y (3)		Age, 14 y (4)		Comparisons					
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	1–2	1–3	1–4	2–3	2–4	3–4
Transverse measurement														
Cranial width	156.1	4.6	156.2	4.6	156.4	4.6	156.9	4.7	NS	NS	***	NS	***	***
Facial width	125.4	4.7	126.6	4.4	128.4	4.8	130.6	4.7	***	***	***	***	***	***
Nasal width	30.1	1.5	31.2	1.5	32.1	1.4	33.5	1.8	***	***	***	***	***	***
Maxillary width	58.0	2.3	58.9	2.1	60.2	2.2	61.8	2.5	***	***	***	***	***	***
Mandibular width	92.3	4.3	94.1	4.2	95.4	4.1	99.0	4.3	***	***	***	***	***	***
Maxillary intermolar width 6-6	59.4	2.5	60.2	2.7	61.1	2.7	62.2	2.4	*	***	***	***	***	***
Mandibular intermolar width 6-6	58.1	2.1	58.4	1.9	59.2	2.1	60.6	2.1	NS	***	***	***	***	***
Vertical measurement														
Total facial height	107.4	5.7	110.2	6.1	112.7	5.9	117.9	6.4	***	***	***	***	***	***
Upper facial height	51.6	2.5	52.9	2.4	54.7	3.3	57.3	3.5	***	***	***	***	***	***
Lower facial height	55.9	3.7	57.3	3.8	58.4	3.4	60.5	3.9	**	***	***	***	***	***
Right ramus height	56.9	2.9	57.9	2.7	60.1	2.5	62.5	2.4	***	***	***	***	***	***
Left ramus height	57.3	2.7	58.3	2.6	60.5	2.5	62.8	2.3	***	***	***	***	***	***

[a] SD indicates standard deviation; NS, not significant.
* $P < .05$; ** $P < .01$; *** $P < .001$.

TABLE 3. The Means and SD of the Male Subjects from 10 to 14 Y of age, and the Results of Bonferroni Multiple Comparison Test[a]

	Age, 10 y (1)		Age, 11 y (2)		Age, 12 y (3)		Age, 14 y (4)		Comparisons					
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	1–2	1–3	1–4	2–3	2–4	3–4
Transverse measurement														
Cranial width	158.7	5.8	159.4	5.9	160.4	6.0	162.1	6.2	*	***	***	***	***	***
Facial width	128.5	3.9	129.5	4.3	131.4	4.9	136.6	5.9	**	***	***	***	***	***
Nasal width	31.4	2.6	32.2	2.6	33.2	2.5	35.9	3.3	***	***	***	***	***	***
Maxillary width	60.1	2.7	61.6	2.9	62.3	3.0	64.7	3.1	***	***	***	**	***	***
Mandibular width	93.2	5.0	95.1	4.8	96.4	5.0	102.4	5.3	***	***	***	***	***	***
Maxillary intermolar width 6-6	59.5	3.2	60.5	3.0	61.3	3.2	63.1	2.8	**	***	***	*	***	***
Mandibular intermolar width 6-6	58.3	2.2	59.2	2.6	59.8	2.7	61.0	2.7	*	***	***	***	***	***
Vertical measurement														
Total facial height	108.0	5.6	111.0	4.7	112.8	5.6	121.1	6.9	***	***	***	***	***	***
Upper facial height	52.0	3.8	53.2	4.0	54.4	4.0	58.1	4.0	***	***	***	***	***	***
Lower facial height	55.9	4.0	57.7	3.2	58.4	3.5	62.9	5.1	***	***	***	***	***	***
Right ramus height	58.9	4.0	59.8	4.1	61.3	4.3	65.8	5.5	***	***	***	***	***	***
Left ramus height	58.8	4.3	59.9	4.2	62.1	4.6	66.3	5.1	***	***	***	***	***	***

[a] SD indicates standard deviation.
* $P < .05$; ** $P < .01$; *** $P < .001$.

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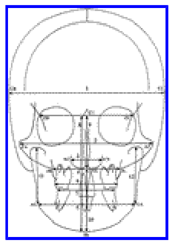

Click on thumbnail for full-sized image.

FIGURE 1. Cephalometric landmarks and measurements used in the study. (1) Cranial width (CW): the width of the cranium from the most lateral points on the cranium parallel to the superior aspect of the orbits. (2) Facial width (FW): the width of the zygomatic arch from their most lateral aspect. (3) Nasal width (NW): the width of the nasal cavity from the most lateral points on the nasal aperture taken parallel to the horizontal plane. (4) Maxillary width (MxW). (5) Mandibular width (MdW). (6) Maxillary intermolar width (MxW 6-6). (7). Mandibular intermolar width (MdW 6-6). (8) Total facial height (TFH). (9) Upper face height (UFH). (10) Lower face height (LFH). (11) Right ramus height (RRH). (12) Left ramus height (LRH)

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