Evaluation of Facial Anthropometric Parameters in 11–17 Year Old Boys

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Background and Objective: *Anthropometry is the study of qualitative specifications based on linear and angular measurements of human body. The aim of the present study was to determine anthropometric parameters of 11-17 year old boys of northeast Iran.* ***Method:*** *This cross-sectional analytical study was conducted on 583 boys of Fars ethnicity living in Mashhad with Class I skeletal and dental relationships. Digital photographs in natural head position were transferred to a computer and the desired anthropometric landmarks were traced on each image. Anthropometric parameters including the width of the forehead, the width of the face, the width of the cranial base, intergonial width, intercanthal width, binocular width, nasal width, mouth width, facial and nasal height and depth of superior, middle and inferior one-third of the face were measured by "Smile Analyzer" software. ANOVA, Tukey test, and linear regression were used for statistical analysis.* ***Results:*** *Most of the parameters studied increased gradually with age. A growth spurt was evident at the ages of 15-16 years old for binocular width, nasal width, nasal height and depths of middle and inferior one-third of the face. Facial height was among some parameters which were found to increase slightly after 16. Unlike the other parameters, intercanthal width showed an irregular pattern of changes and statistical analysis did not show any significant differences among different age groups (P-value = 0.362).* ***Conclusion:*** *Aging of the face occurs in spurts and at different periods of life. During the studied time span, significant growth in most anthropometric parameters except intercanthal width was obvious.*

Keywords: *Anthropometry-Face-Iran*

J Clin Pediatr Dent 37(1): 95–102, 2012

INTRODUCTION

Anthropometry is the study of qualitative specifications based on angular and linear measurements of the human body.[1] Anthropometric data is beneficial in treating congenital or post-traumatic facial disfigurements. Normative data of facial measurements are invaluable for the determination of the degree of deviations from the norm.[2] Determining these variables can help to set standards for soft tissues of the head and neck. They can also be of great benefit for reconstruction of craniofacial structures in patients with cleft lip and palate and unilateral asymmetric patients.[3] In addition, they can predict postsurgical development in growing patients.[4]

Multiple factors including gender, age, environmental factors, geographical situation and ethnicity influence anthropometric parameters. Thus, reconnaissance of the development of facial structures and determination of normal and abnormal faces in each nation, not only can help the medical scientists to diagnose and treat facial malformations, but can also be helpful in anthropometric field in order to differentiate ethnicities and their attributes.[1]

Farkas *et al* studied growth related changes in the faces of 1594 healthy North American Caucasians 18 years of age and found that the face matured between 12 and 15 years in males and 2 years earlier in females.[5]

In his other study in 2005, Farkas *et al* carried out an international anthropometric study on facial morphology in different races. The study group consisted of males and females from Europe, the Middle-East, Asia and Africa and found that in relation to North American whites, the nose was significantly wider in both sexes of Asian and black ethnic groups. In the Middle Eastern groups nose width was identical to those of North American whites, but the height was significantly higher.[2]

In a similar study, Choe *et al* evaluated anthropometric dimensions of Korean – American females. Although, the results showed that 24 of 26 criteria were different between

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two groups, in attractive Korean – American females, only nine ratios were significantly different between two ethnic groups.[6]

In this regard, Borman *et al* evaluated anthropometric dimensions of 1050 Turkish young adults and showed midface was more protruded with respect to the chin and forehead.[7]

Although facial analysis and proportions are well discussed in whites[2,8,9] and African-Americans,[10,13] only a limited number of studies exist for Asians especially Iranians.[14-19]

It is easy to see that intermingling has played an important role in history of modern populations, so anthropometric evaluation of craniofacial structures in adolescents of this area, can interestingly help us compare craniofacial growth changes from East Asia to the West in this age group.

On the other hand, medical professionals strongly require anthropometric databases, but they have not been provided until now in our country.

So, the aim of this study was to evaluate anthropometric measurements of facial soft tissues among 11-17 year old Iranian boys living in Mashhad, Iran.

MATERIALS AND METHOD

This cross-sectional analytical study was carried out on 583 eleven to seventeen-year-old boys living in Mashhad, Iran.

Study samples were selected from guidance schools and high schools by stratified cluster randomized sampling technique. The schools were stratified by housing density and housing/living conditions of each school district. Nine schools were selected randomly and random number tables were used to select the boys within the schools.

The questionnaires were delivered to parents by the pupils with a cover letter requesting that the forms be completed by the mother (with the assistance of a literate family member if necessary). The questionnaire included questions about previous history of trauma to the head and face, cleft lip and palate or cosmetic surgery. In addition, parents signed informed consents before their children participated in this study.

The results from the questionnaires were reviewed by the authors and if any question had not been answered, the questionnaires were excluded and replacement students were selected from the same schools.

After subject selection, the authors examined subjects' face and dentition for facial asymmetry, aesthetics and proportions, skeletal and dental relationships in transverse, antero-posterior and vertical dimensions. All the subjects had Class I skeletal and dental relationships and permanent dentition. If they had extensive tooth decay or extractions, they were excluded from the study. Overweight children were not included either.

A D40 Nikon digital camera with 18/135 lens (Nikon Inc, Japan) was used to take frontal full-face photographs of each child while his head was in a natural head position (NHP).

Digital photographs were taken in the natural head position (NHP) in order to be reproducible. NHP is a stable and standard upright head posture when an individual looks at a distant point at eye level.[20] Therefore, the head of patients did not have any tilt in up or down directions. The patients were in a state of relaxation during the imaging and no special facial expressions such as smiling, laughing or frowning were detectable in their faces.

A paper length of 10 mm was placed on each patient's forehead before taking photographs to estimate amount of magnification.

The images were then transferred to a computer and classified according to the age of the samples. Using Adobe Photoshop software (Adobe Inc, USA), the points indicating the desired anthropometric landmarks were put on each image. Only one orthodontist traced all landmarks on photographs. 20 samples were traced by the same examiner after 2 weeks and the intra examiner correlation was found to be more than 90%.

Newly developed software by the Orthodontic Department of Mashhad Dental School, which is called "Smile Analyzer", was used to measure the anthropometric parameters on each image. This software has been specifically designed for precise measuring of desired distances or angles on images and radiographs.

Eleven soft tissue landmarks were traced on all photographs according to Farkas anthropometric landmarks[21] (Also see Figure 1):

1 – Gelabella (g): the most anterior midpoint of frontoorbital soft tissue contour
2 – Zygion (zy): the most lateral point on the soft tissue contour of each zygomatic arch
3 – Gonion (go): the most lateral point on the soft tissue contour of each mandibular angle
4 – Gnathion (gn): the most inferior point on the soft tissue contour of the chin
5 – Endocanthion (en): the soft tissue point located at the inner commissure of each eye fissure
6 – Exocanthion (ex): the soft tissue point located at the outer commissure of each eye fissure
7 – Nasion(n): the midpoint on the soft tissue contour of the base of the nasal root at the level of the frontonasal suture
8 – Alare (al): the most lateral point on each alar contour
9 – Subnasal(sn): the midpoint on the nasolabial soft tissue contour between the columella crest and the upper lip
10 – Cheilion (ch): located at each labial commissure
11 – Tragion (t): located at the upper margin of each tragus

Eight anthropometric parameters related to craniofacial width, including the width of the forehead (ft-ft), the width of the face (zy-zy), the width of the cranial base (t-t), intergonial width (go-go), intercanthal width (en-en), binocular width (ex-ex), nasal width (al-al), and mouth width (ch-ch) were measured. In addition, parameters such as facial and

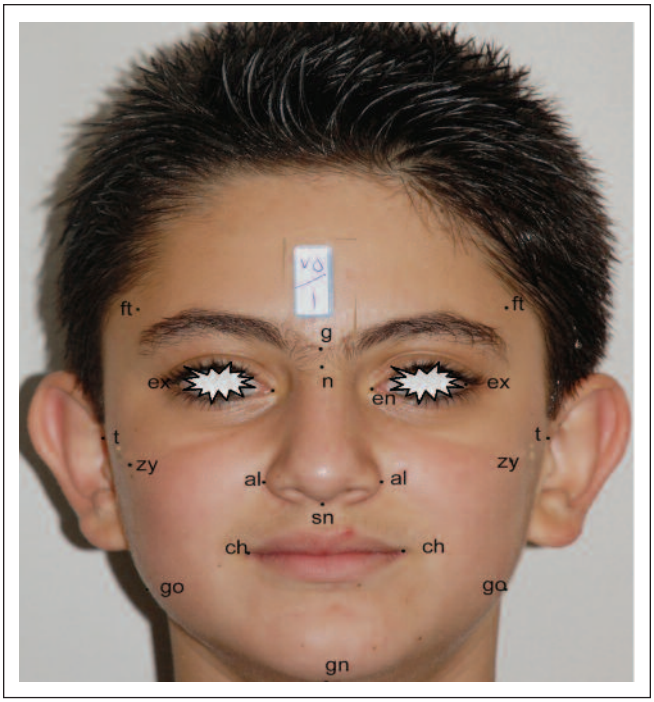

Figure 1. Soft tissue landmarks traced on photographs, also see the paper on the patient's forehead for estimation of magnification

nasal height (n-gn ,n-sn) and depth of superior, middle and inferior one-third of the face(t-g, t-sn, t-gn) were included.

Extracted data were entered into the Microsoft – Excel software program, and were statistically analyzed using SPSS software, version 11.5.

Considering normal distribution of data, the ANOVA test was used for statistical analysis. Level of significance was set at < 0.05. Tukey test was conducted after ANOVA analysis to reveal any significant differences between each of two age groups. Regression equations were developed for each anthropometric parameter to predict their value based on their senile age.

RESULTS

Five hundred and eighty-three Iranian boys between the ages of 11-17 years old were included in the study. They were classified into 6 groups according to their age (11-12, 12-13, 13-14, 14-15, 15-16, and 16-17 years old). There were 100, 99,96,99,95 and 94 individuals in the first to sixth group, respectively.

Anthropometric parameters related to craniofacial width (Table 1)

1. Width of the forehead (ft-ft)

At age 11, the width of the forehead reached 113.7 mm (94.4% of its adult size). It increased further between 11-17 years of age by a mean of 6.7mm.A growth spurt was observed between the ages of 15 to 16, which increased by a mean of 2.7mm. It remained relatively constant from the age of 16 through 17.

There were significant differences between 11-12 years old with the other age groups, also significant differences between 12-13years old with other age groups were found except for 13-14 (P = 0.843) and 14-15 year old boys (P=0.129).

On the other hand, there were significant differences between 13-14 years old samples with the other groups except for 14-15 year old boys (P = 0.795).

However, there were no significant differences between 13-14 and 14-15 year old samples with the other groups except for 11-12 year old boys (P=0.000). Also, there was no significant difference between 15-16 and 16-17 year old boys (P = 1.000).

Linear regression analysis estimated an equation of Y = 97.55 + 1.37 (age), whereas Y represents predicted value of the parameter.(r^2 = 0.17)

2. Binocular Width (ex-ex):

At age 11, binocular width approached 86.3mm (97.3% of its adult size). At age 17, it increased to 88.7mm. Slight incremental growth was observed between the ages of 12 to 15 by a mean of 0.8mm, while a faster rate of growth was observed between 15 to 16 years of age, which increased by 1.5mm. Similar to most of the other anthropometric parame-

Table 1. Anthropometric parameters related to facial width

parameter	11-12 Mean±SD	12-13 Mean±SD	13-14 Mean±SD	14-15 Mean±SD	15-16 Mean±SD	16-17 Mean±SD	Total incremental growth(mm)	P-value
ft – ft	113.7±4.9	115.9±5.4	116.8±5.6	117.7±5.6	120.4±4.6	120.4±4.9	6.7	.000
ex-ex	86.3±3.8	87.2±3.7	87.8±3.9	88.0±3.7	89.5±3.6	88.7±3.5	2.4	.000
en-en	31.2±2.5	31.2±2.5	31.0±2.5	30.7±2.7	31.5±2.7	31.0±2.6	-0.2	0.362
t-t	134.8±6.4	136.1±6.3	137.9±6.7	138.6±7.4	141.5±6.5	141.8±6.3	7.0	.000
zy-zy	122.0±6.4	122.4±6.1	123.5±6.7	122.4±7.4	6.6±124.6	125.0±6.4	3.0	.003
al-al	35.8±2.5	36.7±2.5	38.0±2.9	38.5±2.9	39.9±2.5	39.5±2.7	2.5	.000
ch-ch	45. ±73.3	47.± 54.0	48.7±3.6	48.4±3.6	49.5±3.8	49.7±3.9	4.0	.000
go-go	102.9±10.8	106.2±9.9	106.9±9.4	107.9±10.4	110.5±8.9	112.0±8.7	9.1	.000

SD: Standard Deviation

ters, a decline was observed after the age of 16 by a mean of 0.8mm.

There were significant differences between 11-12 year old with the other age groups except for 12-13 year old boys (P = 0.638), also significant differences between 15-16 year old with other age groups were found except for 16-17 (P= 0.694).

Furthermore, there were significant differences between 13-14 years old samples with the other groups except for 12-13 and 14-15 years old boys (P = 0.795).

There were not significant differences between 12-13 years old samples with the other groups except for 15-16 (P = 0.000) and 16-17 (P = 0.049) year old boys Tukey test showed no significant difference in binocular width between 15-16 and 16-17 years old boys (P = 1.000).

Linear regression analysis constructed an equation of Y = 80.07 + 0.541(age).

(r^2 = 0.05)

3. Intercanthal Width (en-en):

Unlike the other parameters, intercanthal width represented an irregular pattern of changes. By 11 years mean value of intercanthal width was found to be 31.2mm (100.6 of its adult size). A decrease of 0.5mm was observed in mean values between the ages of 12 to 15, followed by an increase to 31.5mm at age 16. Mean decrease of 0.5mm was measured after 16 years of age.

Tukey test did not find any significant differences between any two groups.

Linear regression analysis estimated an equation of Y=30.41+0.045(age).

(r^2 = 0.001)

4. Width of the Cranial Base (t-t):

By age 11, width of the cranial base approached a mean of 134.8mm (95.1% of its adult size).This parameter increases with age, reaching to its maximum size at the age of 17 (141.8mm).

There were significant differences between 11-12 years old with the other age groups except 12-13 years old boys (P = 0.711).

Also, Tukey test did not reveal any significant differences between 12-13 years old samples with the other groups except for 15-16 (P = 0.000) and 16-17 (P = 0.000) years old boys.

On the other hand, there was not a significant difference between 13-14 years old samples with 14-15 years old boys (P = 0.969), also between 15-16 with 16-17 years old samples (P = 0.999).

Linear regression analysis developed an equation of Y = 116.93 + 1.48 (age).

(r^2 = 0.12)

5. Width of the Face (zy-zy):

At age 11, average width of the face was found to be 122.0mm (97.6% of its adult size).It reached its adult size (125.0mm) at the age of 17.

Tukey test showed significant differences only between 11-12 with 16-17 year old (P=0.018) and 14-15 with 16-17 years old boys (P = 0.050)

Linear regression analysis estimated an equation of Y = 114.74 + 0.591 (age).

(r^2 = 0.02)

6. Width of the Nose (al-al):

By age 11, width of the nose approached 90.6% of its adult size (mean value of 35.8mm). A small increase in mean values was observed between the ages of 14 to 15 (0.5 mm). However, more rapid rate of growth was observed between 15 to 16 years old (1.4mm). A decrease of 0.4mm after the age of 16 was observed.

Tukey test revealed significant differences between most of the two age groups except for 11-12 and 12-13 years old (P = 0.19), 13-14 and 14-15 years old (P = 0.769), 14-15 and 16-17 years old (P = 0.131), and 15-16 and 16-17 years old (P = 0.942)

Linear regression analysis calculated an equation of Y = 26.38 + 0.807 (age).

(r^2 = 0.20)

7. Width of the Mouth (ch-ch):

By 11 years, width of the mouth was approximately 90.5% of its adult size (45.7mm). It reached its maximum values at the age of 17 (49.7mm). A slight decrease of 0.3mm was observed between 13 to 15 years old.

There were significant differences between 11-12 years old with the other age groups, also significant differences between 12-13years old with other age groups were found except for 13-14 (P = 0.285) and 14-15 year old boys (P = 0.526).

On the other hand, there were not any significant differences between 13-14 and 14-15 year old samples with the other groups except for 11-12 years old boys (P = 0.000)

Linear regression analysis estimated an equation of Y = 37.46 + 0.74 (age).

(r^2 = 0.10)

8. Width of the Mandible (go-go):

Mandibular width was found to be 102.9mm on average at the age of 11 (91.9% of its adult size). It achieved its maximum size at the age of 17 (112.0mm)

There were significant differences between 11-12 years old with the other age groups except for 12-13 years old(P=0.164).Also, significant differences were found between 12-13 years old boys with 15-16 (P = 0.025) and 16-17 (P = 0.001) groups.

Moreover, there were significant differences between 16-17 years old boys with the other groups except for 15-16 (P = 0.912).

Linear regression analysis estimated an equation of Y = 83.20 + 1.69 (age).

(r^2 = 0.08)

Anthropometric parameters related to height and depth of craniofacial structures (Table 2)

1. Height of the Face (n-gn):

At age 11, facial height was found to have a mean of 111.9mm (88.7% of its adult size).It increased further between the ages of 15 to16 by a mean of 2.6mm. There was not a decrease in mean values throughout the study, although the growth rate was different at each time interval.

Tukey test revealed significant results between groups, except for 11-12 with 12-13 years old (P = 0.118) , and 13-14 with 14-15 years old (P = 0.246).

Linear regression analysis constructed an equation of Y = 77.79 + 2.84(age).

(r^2 = 0.36)

2. Height of the Nose (n-sn):

By 11 years, height of the nose was found to be 93.2% of its adult size (50.5mm). It reached its maximum adult size at the age of 16 (54.4mm), followed by a decrease of 0.2mm towards 17. A greater amount of incremental growth was observed between the ages of 13 to 15, which increased by a mean of 1.7mm.

There were significant differences between 11-12 years old with the other age groups except for 12-13 (P = 0.984) and 13-14 years old (P = 0.086), also significant differences between 12-13years old with other age groups were found except for 13-14 years old (P = 0.357).

On the other hand, there were not any significant differences between 14-15 year old samples with the other groups except for 11-12 and 12-13 year old boys (P = 0.000). Morever, a significant difference was not found between15-16 with 16-17 groups (P = 0.999).

Linear regression analysis developed an equation of Y = 39.78 + 0.88(age).

(r^2 = 0.15)

3. Depth of the Superior Third of the Face (t-g):

At age 11, this anthropometric parameter approached 94.9% of its eventual size (74.8mm).A decrease of 0.9mm was observed between the ages of 13 to 15. Maximum adult size was achieved at the age of 17 (78.9mm).

There were significant differences between 11-12 years old with 13-14 (P = 0.018), 15-16 years old (P = 0.000), and 16-17 years old (P = 0.000).

Also significant differences were found between 14-15 years old with 15-16 (P = 0.013) and 16-17 years old (P = 0.011).

Tukey test did not find any significant differences between the other groups.

Linear regression analysis estimated an equation of Y = 66.85 + 0.71(age).

(r^2 = 0.05)

4. Depth of the Middle Third of the Face (t-sn):

By age 11, this parameter approached 96.3% of its maximum size (74.8mm). There was a gradual increase from the age of 12 towards 15.However, a rapid rate of growth was found between the ages of 15 to 16, by a mean of 1.7mm. A decrease of 0.8mm was observed after 16.

There were not any significant differences between groups except for 11-12 with 15-16 (P = 0.000), and 16-17 years old (P = 0.002), and 12-13 with 15-16 year old samples (P = 0.028).

Linear regression analysis calculated an equation of Y = 67.86 + 0.61 (age).

(r^2 = 0.03)

5. Depth of Lower Third of the Face (t-gn):

At age 11, this parameter achieved 90.9% of its eventual size (113.9mm). It reached its maximum size at the age of 17, by a mean of 124.0mm.

There were significant differences between 11-12 years old boys with the other age groups except for 12-13 (P = 0.485), on the other hand significant differences between 12-13 years old with other age groups were found.

In addition, there were significant differences between 13-14 year old samples with the other groups except for 14-15 (P = 0.336). Moreover, a significant difference was not found between 14-15 with 15-16 groups (P = 0.256).

Table 2. Anthropometric parameters related to facial height and depth

parameter	11-12 Mean±SD	12-13 Mean±SD	13-14 Mean±SD	14-15 Mean±SD	15-16 Mean±SD	16-17 Mean±SD	Total incremental growth(mm)	P- value
n-sn	50.5±3.3	50.8±3.4	51.8±3.5	53.5±3.7	54.4±3.7	54.2±3.5	3.7	.000
n-gn	111.9±6.3	114.3±5.9	118.3±7.4	120.3±6.1	122.9±6.0	126.2±6.7	14.3	.000
t-g	74.9±4.9	76.9±6.2	77.2±5.3	76.3±5.2	78.8±4.9	78.9±4.8	4.0	.000
t-sn	74.8±4.8	76.2±4.8	76.6±5.9	76.8±5.5	78.5±5.4	77.7±4.9	2.9	.000
t-gn	113.9±5.7	115.0±0.6	118.5±7.6	120.3±6.6	126.1±21.8	125.3±13.5	6.2	.000

SD: Standard Deviation

There was not a significant difference between 15-16 with 16-17 year old boys (P = 0.520)

Linear regression analysis developed an equation of Y = 88.51 + 2.11 (age).

(r^2 = 0.23)

DISCUSSION

Anthropometric parameters not only increase our knowledge about prevalent distribution of different human morphologies, but also can help provide criteria for the comparison of these parameters in different ethnicities and races.

Various factors such as gender, age, ethnicity, and nutrition can influence anthropometric values. Mean values found in a study cannot be applied as a standard for comparing other populations and ethnicities. The present investigation was conducted on Iranian boys aged between 11-17 years old.

As was shown in Tables 1 and 2, growth velocity is not the same at all ages. Most of the anthropometric variables increase rapidly between the ages of 15 and 16 years old, while they showed more gradual change at other ages.

Excluding facial height, a slight decrease was observed in all the other parameters after the age of 16. Furthermore, different parts of the face showed different degrees of incremental growth changes. They were also found to reach their pubertal growth at different ages. As is apparent in Table 2, height of the face showed the most incremental growth between 11 to 17 years old, while intercanthal width changes were the least at the same age range.

It has been claimed that as the patient gets older, and size of the body increases, vertical growth of the face dominates its horizontal growth.[22] Comparison of the changes of mean values of height and width of the face in the present study confirms this finding.

Facial height and width increase between 11-17 year olds was 14.3 and 3.0 mm, respectively. These values are similar to the results of Farahani's study on 12 year old Iranian boys.[23] This implies that these Iranian boys have more facial growth in the vertical dimension compared to their European counterparts.

The irregular pattern of changes of intercanthal width can be contributed to its relationship with the base of the skull. The brain reaches its mature size at the age of seven. Afterwards, its size usually begins to decrease,[24] but the changes are not statistically significant.

There is little evidence about the incremental growth changes at the age range studied here. The most famous study was Farkas' investigation on Canadian boys.[21] However, it should be kept in mind that he used sliding and spreading calipers as measuring devices. Moreover, he considered the face as an arch. In contrast to his study, we measured variables on two-dimensional photographs using smile analyzer software.

Therefore, smaller values were obtained in our study in comparison to the findings of Farkas. Among 13 anthropometric parameters studied here, 6 parameters showed less value in Canadian boys: height and width of the nose, height of the face, width of the forehead, mandible and binocular.

Thordarson *et al* studied craniofacial changes in Icelandic children between 6 and 16 years of age.[25] Comparison of our findings with his work indicates a wider face of Iranian boys at 16 years old in comparison to their Icelandic counterparts.

Based on the results of this study, 12-year-old Iranian boys have a wider forehead, mandible, and mouth and a longer nose compared to 12-year-old Chinese boys. Other anthropometric parameters of Iranian boys had less value than Chinese boys of the same age.[26]

Regarding distribution and combinations of different races in Iran, a comprehensive study in different races is strongly recommended. Also, further longitudinal investigations of anthropometric parameters are suggested.

CONCLUSION

On the basis of the results of this study, except intercanthal width which had an irregular pattern of changes, other anthropometric measurements of 11 to 17 year old Iranian boys increased gradually with age. At age 15 to 16 years, a growth spurt was evident in most of the parameters studied here.

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