TURKISH JOURNAL of ORTHODONTICS

DOI: 10.5152/TurkJOrthod.2022.21083

Original Article

Cephalometric Mandibular Dimensions in Growing Turkish Children: Trends of Change, Sex-Specific Differences, and Comparisons with Published Norms

Hande Pamukçu[1], Nilüfer İrem Tunçer[1], İsmail Can Pelin[2], Hatice Yağmur Zengin[3]

[1]Department of Orthodontics, Başkent University, Faculty of Dentistry, Ankara, Turkey
[2]Department of Anatomy, Başkent University, School of Medicine, Ankara, Turkey
[3]Department of Biostatistics, Hacettepe University, School of Medicine, Ankara, Turkey

Cite this article as: Pamukçu H, Tunçer Nİ, Pelin İC, Zengin HY. Cephalometric mandibular dimensions in growing Turkish children: Trends of change, sex-specific differences, and comparisons with published norms. *Turk J Orthod.* 2022;35(3):198-206.

Main Points

- Girls show significant increase for effective mandibular length between ages 8-10, 10-12 and 11-13 years, while boys between ages 8-10, 9-11 and 13-15 years. This finding not only demonstrates that boys and girls have distinctive timing for growth spurt but also both sexes manifest not one but more growth spurts.
- Ethnic differences and secular trends result with a continuous change in mandibular dimensions; therefore, using recent norms representative of the studied population is advised.
- The growth curves obtained in this study can be used to designate a patient as early-, average- or late-maturer, as well as to predict the approximate mandibular dimensions at a particular age.

ABSTRACT

Objective: The aims of this study were to investigate cephalometric mandibular dimensions in growing Anatolian Turkish children and to identify the periods of rapid growth for boys and girls. Furthermore, the secondary aim was to compare obtained values with published standards in the literature.

Methods: A total of 528 pretreatment lateral cephalometric radiographs, grouped according to age and sex, were analyzed. Effective mandibular length, ramus height, and corpus lengths were comparatively evaluated within age groups for boys and girls and between sexes for the same age group. Data acquired from this study were compared with American, Canadian, Chinese, and European norms. Growth curves for mandible were constructed for each sex group.

Results: Effective mandibular length was almost always significantly longer in boys, except for 9- and 12-year-age groups. Effective mandibular length in girls increased significantly between ages 8 and 10, 10 and 12, and 11 and 13 years, while in boys between ages 8 and 10, 9 and 11, and 13 and 15 years. Turkish girls had significantly shorter effective mandibular lengths than American girls at age 14. No significant difference was found between Turkish and Chinese girls and boys. Turkish girls and boys had significantly shorter corpus lengths from their Norwegian counterparts at age 12.

Conclusion: Except for 9- and 12-year-age groups, effective mandibular length was almost always significantly longer in boys compared to the girls. It is suggested to use norm values from more recently conducted studies and which are representative of the studied population. Growth curves can be used to predict the approximate mandibular dimensions at a particular age.

Keywords: Corpus length, mandibular dimensions, mandibular length, ramus height, Turkish children

INTRODUCTION

Among the bones of the craniofacial region, mandible has a unique development pattern and a growth rate which changes over the development period.[1] The success of orthopedic treatment modalities for skeletal Class II discrepancies characterized with retrognathic mandible depends on accurate estimation of the most rapid growth period. Therefore, it is clear that diagnosis, treatment planning, and prognosis of mandibular

Corresponding author: Nilüfer İrem Tunçer, e-mail: iremtuncher@gmail.com

Received: April 21, 2021
Accepted: December 17, 2021
Publication Date: September 26, 2022

growth disorders depend on clinician's knowledge of mandibular growth and development.

During its growth, the mandible shows a simultaneous antero-inferior movement as a result of the expansion of the orofacial matrix.[2] On the average, mandibular length increases by 2.4 mm/year which is almost entirely provided by the condylar growth.[3] A peak at the rate of mandibular growth has been found in many studies, and the timing tends to occur 1.6 years earlier in girls than boys. Furthermore, a considerably higher percentage of boys shows annual mandibular increase of more than 1 mm when compared to girls.[4]

Radiographic cephalometric analysis is an essential tool for orthodontic diagnosis and treatment planning, as well as for examining treatment- and growth-related changes besides predicting residual growth potential for an individual patient. Athanasiou[5] highlighted the importance of cephalometric data for monitoring populations based on age, and ethnic and racial differences. Furthermore, norm values for 1 group should not be considered normal for every other population. Different ethnic groups must be treated according to their norms, and patients' cephalometric findings must be compared with the norms of the included ethnic group for accurate diagnosis.[5-10]

Some studies investigated the Turkish population's ideal norms but none of them evaluated mandibular dimensions in growing children according to age and sex.[6-10] The objectives of this study were to (1) determine cephalometric mandibular dimensions in a large group of patients to provide the clinician normative values for growing Anatolian Turkish children, (2) compare the differences between sex and age groups, (3) compare the Turkish data with other published standards, and (4) create mandibular growth curves in order to predict dimensions of the mandible in the following years.

METHODS

This retrospective study was approved by the Ethics Committee and Institutional Review Board of Başkent University (Protocol Number D-KA17/23). Written informed consents had already been collected at the beginning of treatment as a standard procedure. Complete pretreatment records (demographic, radiographic, and medical) of patients who were referred to the Orthodontics Department of Başkent University were evaluated according to the following inclusion criteria: (1) patients who are Turkish Anatolian citizens with Turkish parents, (2) who are 8-17 years old, (3) with skeletal Class I relationship (ANB angle between 1° and 5°),[11] (4) with normo-divergent facial type (SN-MP angle between 27° and 37°), (5) presenting normal growth and development, and no history of significant medical problem or trauma, (6) without previous history of orthodontic treatment and any kind of maxillofacial surgery, and (7) who have high-quality digital lateral cephalometric radiographs.

A total of 528 lateral cephalometric radiographs which met the inclusion criteria were included in the study. Of these radiographs, 306 belonged to girls (median age 13 years, range 8-17 years) and 222 belonged to boys (median age 12 years, range 8-17 years). These radiographs were first grouped according to sex to assess differences between boys and girls at the same age. Then within each sex group, subgroups were formed according to consecutive age intervals to study the trend of growth and periods of rapid growth, as well as for comparison with the published norms. Mandibular growth curves were constructed for each parameter for boys and girls in order to reveal the growth trend figuratively and to create an easy tool to predict future dimensions of the mandible.

Lateral cephalometric radiographs were obtained in a standard position with Frankfort horizontal plane parallel to the floor, lips relaxed, and teeth in centric occlusion. All of the radiographs were in digital format, taken with the same x-ray device (Veraviewepocs 2D, Morita, Calif, USA) and radiology technician team who were educated on dental radiography.

Image enlargement was 11%. As the objectives of this study entailed the use of actual measurements, image enlargement was eliminated using the standardized metallic ruler image on the right-hand side of the radiograph. The data of this study were compared with the norms from McNamara's Bolton-Brush and Burlington samples, the norms of Chinese population, and Oslo sample of Norwegian children.[12-14] Bolton-Brush and Burlington studies, and Chinese norms were used to compare effective mandibular length (Co-Gn), while Oslo sample of Norwegian children was used to compare corpus length 1 (Go-Me). Data from Chinese population and Oslo sample were available for 12-year-old children only. Therefore, comparisons were made with the concerning age group. McNamara's Bolton-Brush and Burlington data which had 8% enlargement, Chinese data which had 8.8% enlargement, and Norwegian data which had 6% enlargement were adjusted to the actual dimensions for accurate comparison.

Cephalometric Analysis

Lateral cephalometric radiographs were digitally traced and measured using Dolphin Imaging program (Vers 11.5 Premium, Patterson Dental, Calif, USA).

Cephalometric landmarks used in the study were as follows:

S: Sella (the center of sella turcica), *N:* Nasion (the most anterior limit of nasofrontal suture), *A:* A point/subspinale (the point at the deepest midline concavity on the maxilla between the anterior nasal spine and prosthion), *B:* B point/supramentale (the point at the deepest midline concavity on the mandibular symphysis between infradentale and pogonion), *Co:* Condylion (the most superior point on the head of the mandibular condyle), *Go:* Gonion (the most outward point on the angle formed by the junction of the ramus and body of the mandible), *Me:* Menton (the most inferior midline point on the mandibular symphysis), *Gn:* Anatomical gnathion (the most anteroinferior point of the mandibular symphysis), *Ar:* Articulare (the point of intersection of the images of the posterior border of the condylar process of the mandible and the inferior border of the basilar part of the occipital bone).

Parameters used in the study were as follows:

- *Co-Go:* Ramus height (the distance from condylion to gonion),
- *Go-Me:* Corpus length 1 (the distance from gonion to menton),
- *Go-Gn:* Corpus length 2 (the distance from gonion to anatomic gnathion),
- *Co-Gn:* Effective mandibular length (the distance from condylion to anatomic gnathion).

Landmark identification was performed by 2 experienced investigators working independently. Intra-examiner reliability was tested by remeasuring 20% of the radiographs 3 weeks after the initial evaluation. Inter-examiner reliability was tested by comparing the data of the two investigators.

Statistical Analysis

Statistical analysis was performed using SPSS software package (SPSS for Windows, version 23.0, IBM SPSS Corp., Armonk, NY, USA) and R-4.0.4 (R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria). Inter- and intra-examiner reliability levels were assessed by using intra-class correlation coefficient (ICC) with 2-way mixed effect model.

Normality of the numerical variables was assessed by using Shapiro–Wilk normality test in age and sex groups. Homogeneity of variances was tested using Hartley's and Levene tests while comparing the results of this study with published norms.

Student's *t*-test was used to compare mandibular dimensions between boys and girls, and the results of this study with published norms when parametric test assumptions were met. If not, Mann–Whitney *U* and Welch's *t*-tests were used to compare mandibular dimensions between sexes and the results of this study with published norms, respectively. In order to compare mandibular dimensions between different age groups within each sex, one-way analysis of variance and Kruskal–Wallis variance analysis were used. Median, minimum, and maximum values were given as descriptive statistics since both parametric and nonparametric hypothesis testing approaches were used within the study.

Nonparametric quantile regression method with smoothing by B-splines (quadratic) was used to construct growth curves. Knots were selected as leap points of growth for each sex depending on the literature. To obtain growth curves R splines, quantreg and ggplot2 packages were used. Significance level was set at $\alpha = 0.05$.

RESULTS

Intra-class correlation coefficient values for intra- and inter-examiner reliabilities ranged between 0.954 and 0.986 and between 0.913 and 0.978, respectively. Ramus height (Co-Go) had the lowest and effective mandibular length (Co-Gn) had the highest repeatability rates for both intra- and inter-examiner reliabilities (Table 1).

Descriptive statistics and significance levels for mandibular dimensions according to age and sex are presented in Table 2. In general, all parameters increased by age. Ramus height (Co-Go) and corpus lengths (Go-Me and Go-Gn) after age 15 and effective mandibular length (Co-Gn), except for 9- and 12-year-age groups, were significantly greater for boys than girls.

Multiple comparisons, conducted to detect significant increases in the mandibular dimensions within age groups, showed significant differences in effective mandibular length (Co-Gn) when assessed biyearly. According to this, girls showed significant increase between ages 8 and 10, 10 and 12, and 11 and 13 years, while boys between ages 8 and 10, 9 and 11, and 13 and 15 years.

Effective mandibular length (Co-Gn) and corpus length 1 (Go-Me) were compared with children of American, Canadian, European, and Asian descent using published norms in the literature (Table 3). When compared with the 14-year-old group in Bolton-Brush and Burlington studies reported by McNamara, it was found that Turkish girls had significantly shorter mandibles than 14-year-old American girls in the Bolton-Brush study (P = .003). Comparisons with Chinese norms revealed no significant difference between neither girls nor boys. On the contrary, corpus length 1 (Go-Me) from Oslo sample of Norwegian children proved to be significantly longer in Norwegian boys and girls when compared to their Turkish counterparts (P = .001).

Growth curves were established by using nonparametric quantile regression method for a set of 7 percentiles (5%, 10%, 25%, 50%, 75%, 90%, and 95%) (Figure 1 and 2). These growth curves can be interpreted as when a group of 100 children of the same age, sex, and ethnicity gather; a child with a mandibular dimension on the 25th centile would be expected to have a longer

Table 1. Intra- and inter-examiner reliability analyses for the cephalometric measurements

	Intra-Examiner Reliability			Inter-Examiner Reliability		
Measurement	**ICC (3,1)**	**95% CI for ICC**	***P***	**ICC (3,1)**	**95% CI for ICC**	***P***
Ramus height (Co-Go)	0.954	0.889-0.982	<.001*	0.913	0.784-0.967	<.001*
Corpus length 1 (Go-Me)	0.971	0.929-0.988	<.001*	0.963	0.904-0.986	<.001*
Corpus length 2 (Go-Gn)	0.974	0.935-0.990	<.001*	0.962	0.901-0.986	<.001*
Effective mandibular length (Co-Gn)	0.986	0.963-0.994	<.001*	0.978	0.942-0.992	<.001*

ICC (3,1), intraclass correlation coefficient in form of 2-way mixed effects model.
Significance level was set at 0.05.

Table 2. Descriptive statistics for mandibular dimensions and patient distribution

		Age											Comparisons Between Age Groups
		8	9	10	11	12	13	14	15	16	17	P‡	Multiple Comparisons
Ramus height (Co-Go) (mm)	Female	44.3 (36.5-53.2)	46.3 (35-53.1)	47.4 (40.9-54.9)	49.2 (40.4-56.4)	51.3 (44.8-61.9)	51.5 (44.9-61.7)	53.7 (39.4-59.7)	52 (47.3-64.5)	54.1 (47.3-64.1)	55.7 (48.1-69.8)	<.001[a]	8-12, 13, 14, 15, 16, 17 9-12, 13, 14, 15, 16, 17 10-13, 14, 15, 16, 17 11-14, 15, 16, 17
	Male	46.6 (39.4-50.7)	46 (40.7-52.9)	45.2 (41.8-60.3)	51.2 (45.4-59.6)	49.6 (40.5-60.4)	54 (47.7-59.3)	53.4 (47.9-61.9)	56.8 (50.6-69.8)	58.1 (50.4-70)	61.7 (49.4-69.3)	<.001[a]	8-13, 14, 15, 16, 17 9-11, 13, 14, 15, 16, 17 10-15, 16, 17 11-15, 16, 17 12-15, 16, 17
	P†	.142[c]	.493[c]	.549[d]	.004[c]	.150[c]	.158[c]	.622[d]	<.001[c]	<.001[c]	.026[c]		
Corpus length 1 (Go-Me) (mm)	Female	56.7 (52.9-63.1)	60.8 (54.6-67.3)	62.2 (56.9-69.7)	62.8 (49.8-77.4)	64.6 (54-71.3)	67 (57-74.3)	66.8 (56.8-74.3)	66.2 (61.9-76.2)	67.1 (61.5-75.3)	68.4 (59.7-76.8)	<.001[a]	8-11, 12, 13, 14, 15, 16, 17 9-13, 14, 15, 16, 17 10-13, 15, 16, 17 11-15, 16, 17 12-17
	Male	59.1 (50.7-65.7)	60.5 (52.2-67.2)	63.2 (58-70.1)	63.8 (54.2-71.9)	65.3 (57.4-74.8)	66.6(59.7-78.7)	66.9 (63-77.6)	69.9 (62.7-77.3)	70.3 (62-79.7)	70.2 (63.9-81.5)	<.001[b]	8-10, 11, 12, 13, 14, 15, 16, 17 9-12, 13, 14, 15, 16, 17 10-15, 16, 17 11-15, 16, 17 12-15, 16, 17
	P†	.084[c]	.974[c]	.167[c]	.451[c]	.177[c]	.534[c]	.070[c]	.023[d]	.006[c]	.142[c]		
Corpus length 2 (Go-Gn) (mm)	Female	64.3 (59.1-70.2)	67.2 (60.9-75)	68.9 (61.2-76.1)	70.1 (57.3-85.2)	70.9 (44.9-76.9)	72.6 (64.5-83.7)	72.8 (62.2-81.9)	73.1 (65.4-82.9)	75.4 (68.4-82.6)	76.2 (67.1-85.1)	<.001[a]	8-11, 12, 13, 14, 15, 16, 17 9-13, 14, 15, 16, 17 10-13, 14, 15, 16, 17 11-16, 17 12-16, 17
	Male	66.2 (57.5-72.5)	67.9 (60.2-72.6)	70.3 (62-77.3)	71.6 (63.8-77.8)	72.2 (65.8-81.7)	72.7 (65.5-85.7)	74.4 (67.8-85.1)	76.5 (67.4-84.4)	78.3 (68.4-87.2)	77.1 (70.9-87)	<.001[a]	8-12, 13, 14, 15, 16, 17 9-13, 14, 15, 16, 17 10-15, 16, 17 11-15, 16, 17 12-16
	P†	.107[c]	.828[d]	.068[c]	.424[c]	.148[d]	.487[c]	.095[c]	.003[c]	.008[c]	.382[c]		

(*Continued*)

Table 2. Descriptive statistics for mandibular dimensions and patient distribution (*Continued*)

		Age											Comparisons Between Age Groups
		8	9	10	11	12	13	14	15	16	17	$P^‡$	Multiple Comparisons
Effective mandibular length (Co-Gn) (mm)	Female	93.5 (86.7-104.6)	97.5 (91.8-106.8)	98 (89.2-105.1)	99.6 (86.8-115.3)	104.7 (93-114.6)	105.6 (95.5-115.6)	106.1 (96.5-115.1)	107.7 (98.3-122.9)	108.7 (100.7-124.2)	110.8 (101.1-127.5)	<.001[b]	8-10, 11, 12, 13, 14, 15, 16, 17 9-12, 13, 14, 15, 16, 17 10-12, 13, 14, 15, 16, 17 11-13, 14, 15, 16, 17 12-16, 17 13-16, 17 14-17
	Male	97.4 (88.1-107.6)	98.8 (89.8-108)	101.2 (94.4-113.2)	105.5 (96.2-112.6)	103.8 (96.1-115.6)	108.5 (99.3-117.3)	107.8 (100.2-120.3)	115 (102.2-122.9)	116.2 (107.2-128.4)	116.5 (109.3-126.1)	<.001[b]	8-10, 11, 12, 13, 14, 15, 16, 17 9-11, 12, 13, 14, 15, 16, 17 10-13, 14, 15, 16, 17 11-15, 16, 17 12-15, 16, 17 13-15, 16, 17 14-15, 16, 17
	$P^†$	.008[c]	.127[c]	.030[c]	.005[c]	.487[c]	.037[c]	.020[c]	<.001[c]	<.001[c]	.001[c]		
Patient distribution per age group	Female (n = 306)	23	23	22	41	39	36	41	31	26	24		
	Male (n = 222)	20	25	16	26	30	22	19	20	24	20		

$P < .05$, descriptive statistics are represented as median, and minimum and maximum values in parenthesis.
[a]: Kruskal–Wallis variance analysis (with Dunn–Bonferroni post hoc test results).
[b]: One-way analysis of variances (with Tukey post hoc test results).
[c]: Independent samples *t*-test.
[d]: Mann–Whitney *U* test.
$P^†$ Comparison between sexes.
$P^‡$ Comparison between age groups.
Significance level was set at 0.05 for all analysis and represented as bold.

Table 3. Comparison of effective mandibular length (Co-Gn) and Go-Me between Anatolian Turkish Children and published data (McNamara Bolton-Brush, Burlington, Chinese, and European norms)

Sex	Age	Anatolian Turkish Co-Gn (Corrected for 11% Enlargement)	Anatolian Turkish Go-Me (Corrected for 11% Enlargement)	McNamara Bolton-Brush Co-Gn (Corrected for 8% Enlargement)	McNamara Burlington Co-Gn (Corrected for 8% Enlargement)	Chinese Norms Co-Gn (Corrected for 8.8% Enlargement)	Oslo Norms Go-Me (Corrected for 6% Enlargement)	*P* Bolton-Brush	*P* Burlington	*P* Chinese	*P* Oslo
Female	9	96.98 ± 3.845	60.63 ± 3.006	98.24 ± 3.150	95.65 ± 4.907	-	-	.291[a]	.256[a]	-	-
	12	104.13 ± 4.586	63.87 ± 4.651	104.72 ± 3.330	102.04 ± 5.926	104.15 ± 4.991	68.58 ± 3.768	.641[a]	.056[b]	.974[a]	<.001[a]
	14	105.8 ± 4.664	65.96 ± 4.205	110.09 ± 4.630	106.39 ± 6.574	-	-	.003[a]	.623[b]	-	-
	16	109.9 ± 4.945	67.86 ± 3.456	111.11 ± 3.150	108.98 ± 4.167	-	-	0.388[a]	0.388[a]	-	-
Male	9	98.84 ± 4.305	60.6 ± 4.118	99.72 ± 3.520	97.22 ± 3.843	-	-	0.500[a]	0.104[a]	-	-
	12	104.95 ±5.086	65.36 ± 4.323	105.93 ± 3.980	104.63 ± 4.731	104.73 ± 5.267	70.38 ± 3.493	0.509[a]	0.780[a]	0.837[a]	<.001[a]
	14	109.09 ± 5.615	68.06 ± 3.84	111.67 ± 3.980	110.37 ± 5.278	-	-	0.134[a]	0.380[a]	-	-
	16	116.54 ± 5.568	70.83 ± 3.862	117.41 ± 4.350	115.28 ± 5.528	-	-	0.603[a]	0.361[a]	-	-

[a]Independent samples *t*-test.
[b]Welch's t-test (used when the result of the Hartley's test for equal variances are significant).

mandible than 24 children and a shorter mandible than 75 children who constitute the group. If the child's mandibular dimension is on 50th centile, this shows a normal development. Early maturers were represented in the 90th and the 95th centiles, whereas late maturers were represented in the 5th and the 10th centiles.

DISCUSSION

Different ethnic groups have different dentofacial traits and norm values. Therefore, the primary aim of this study was to determine normative values for mandibular dimensions in Anatolian Turkish children. For this purpose, patients with skeletal Class I malocclusion with an ANB angle value of 1-5° according to Gazilerli's Turkish norm study and ones with Turkish parents were included in the study to be representative of the population we treat.[11] Furthermore, the reason for focusing on Anatolia was because it involves the majority of the Republic of Turkey. Also, we targeted growing subjects in various stages of puberty to examine different mandibular growth rates and to deduce the best age range to treat mandible-related growth problems.

Sex-Related Differences

The data were comparatively evaluated between boys and girls for sex-specific differences. Girls showed significant increase for effective mandibular length between ages 8 and 10, 10 and 12, and 11 and 13 years, while boys between ages 8 and 10, 9 and 11, and 13 and 15 years. These changes can be explained with the effect of sex chromosomes on sexual dimorphism which determines the distinctive timing of pubertal growth spurt between boys and girls and with the intensity of adrenarche.[15] It is acknowledged that Y chromosome contains genes which increases the quantitative outcome of general body growth resulting from increased height and body size in men.[16] This is also why cartilage tissue at the male epiphyseal plates ossifies in a much slower manner.[17] On the other hand, girls encounter adolescent growth spurt approximately 2 years earlier than boys and reach the end of growth much sooner, which is in accordance with the finding that girls between ages 11 and 13 and boys between ages 13 and 15 show a rapid growth period.[18] Also, even though growth of the mandible usually follows the general growth curve, a "juvenile acceleration" in the jaw growth, especially in girls, is reported which is related to the intensity of adrenarche, the activation of adrenal androgen production.[19] This "juvenile acceleration" takes place 1-2 years prior to the pubertal growth spurt and has a similar intensity as the pubertal acceleration.[17-19] Maj and Luzi[20] also reported that condylar growth is not constant but occurs in spurts; therefore, it does not follow a straight line but instead a curved path. All of these literature data support our finding that boys and girls manifest not one but more rapid growth periods as documented above.

Comparisons with Other Norms

In general, Turkish girls only at age 12 and 14 presented significant differences in mandibular dimensions with the published norms. Norwegian children have significantly longer mandibular dimensions than their Turkish counterparts. No significant differences were detected between Turkish and Chinese girls.

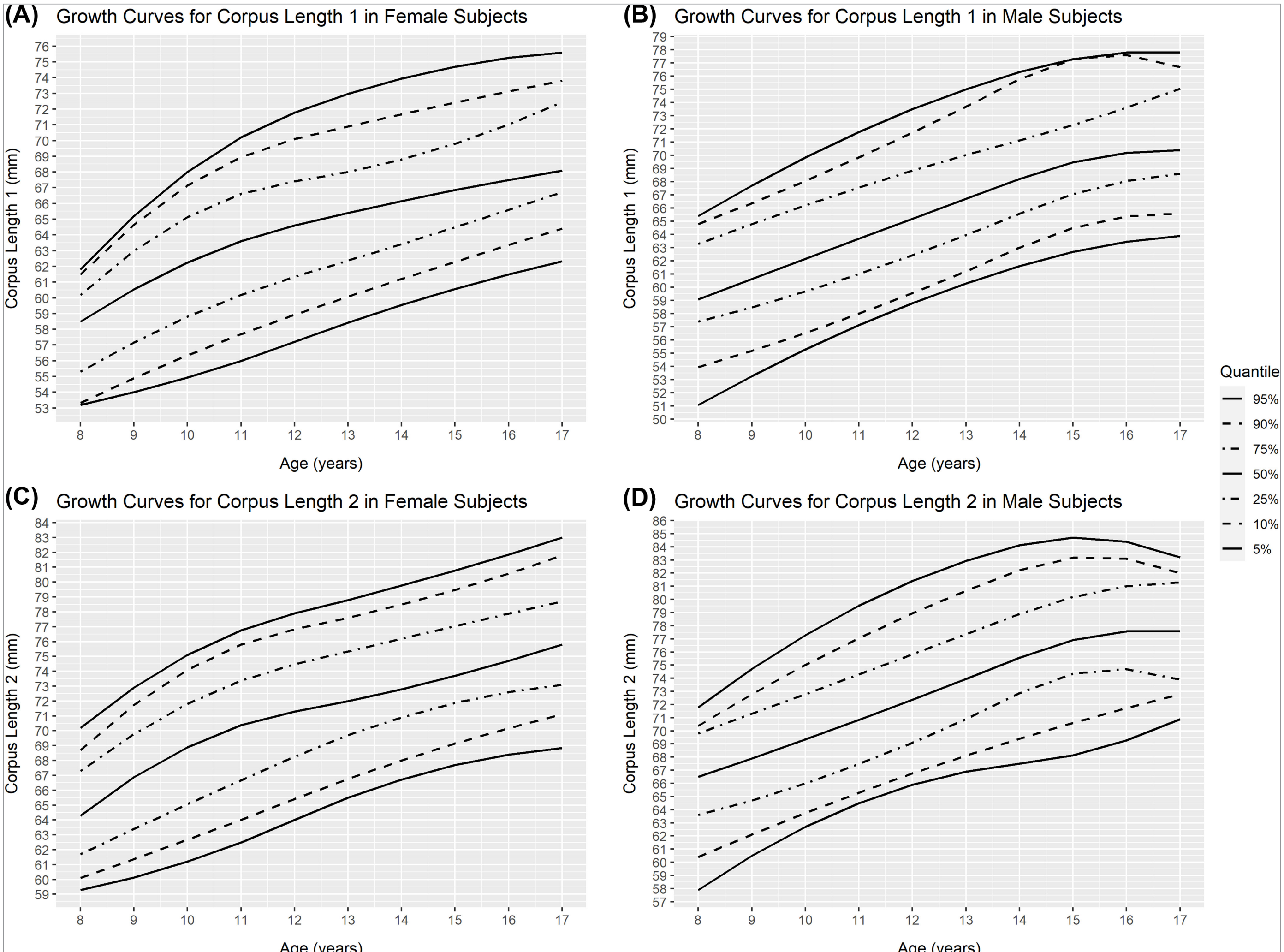

Figure 1. A-D. Growth curves for corpus length 1 in (A) female subjects and (B) male subjects. Growth curves for corpus length 2 in (C) female subjects and (D) male subjects.

Turkish boys, on the other hand, were always in close proximity with the published norms. Variations between different populations' norms are an inherent possibility. These variations may derive from genetic, national, ethnic, seasonal, environmental, and cultural factors.[17] For example, some ethnic groups may mature later than others, as in Dutch boys being 5 cm taller than their American peers at age 10.[17] Furthermore, seasonal factors are also effective on the rate of growth, such as growth being faster in summer and spring and slower in winter and fall.[17] This is also true for the climatic state of the land that a population resides which basically changes the genetic material to adapt for the living conditions. Another environmental factor is proper nourishment that helps city children to mature faster than their rural peers as seen especially in less developed countries.[17] Last but not least, the amount of body fat is an important factor in alleviating estrogen levels to start menstruation in girls.[17] Therefore, physical traits and lifestyle habits, such as professional sportsmanship, defines the timing and even the continuity of menstruation. These facts prove that evolutionary changes in the genetic material and environmental factors that an individual is exposed to can define the morphologic differences between populations to a large extent. American girls at age 14 have significant differences with their Turkish peers. American norms for the 14-year-old group were significantly greater than Turkish norms for the corresponding age groups. These findings are in accordance with what Kılıç et al.[8] demonstrated in their study.

Using other populations' norms may mislead the clinician, especially during differential diagnosis of skeletal problems. For example, if Canadian norms are used for a 12-year-old skeletal Class III Turkish patient with a normal mandible and a deficient maxilla, the clinician can consider the mandible faulty and prefer to treat the "supposedly overgrowing mandible," although the real problem lies within the sagittal maxillary deficiency.

A very important concept worth mentioning under this section is "secular trend."[21] This concept basically refers to the changes in the average size and shape of individuals in a population that occur from one generation to the next.[22] The secular trends depend on the improvements in healthcare and living conditions. Also, a small contribution of heterosis, cross-breeding species for a genetically superior offspring, is mentioned to be present.[23,24] As shown by a recent study, secular trends are

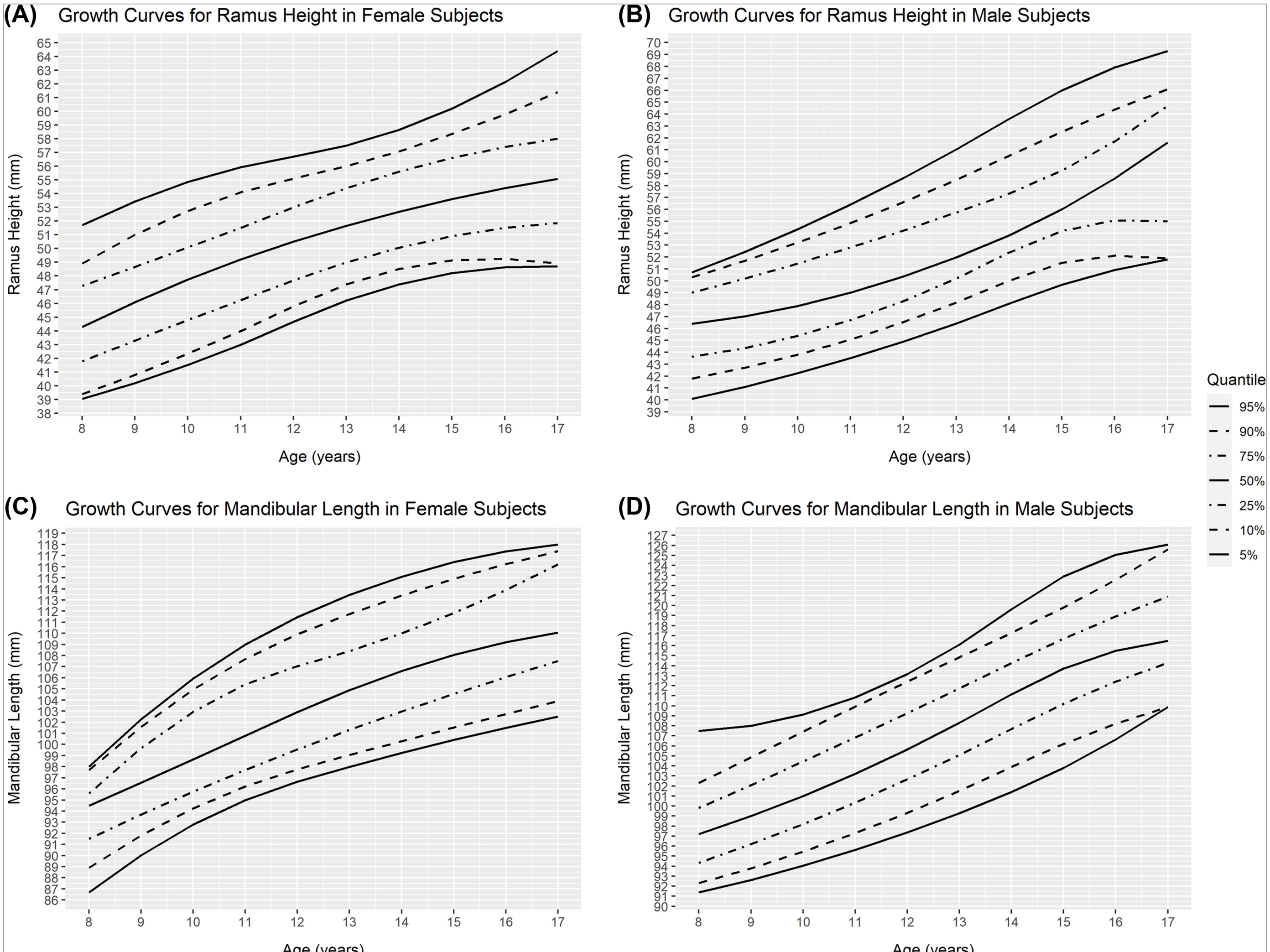

Figure 2. A-D. Growth curves for ramus height in (A) female subjects and (B) male subjects. Growth curves for mandibular length in (C) female subjects and (D) male subjects

evident in the cephalometric measurements derived from 9 historical studies (including Bolton-Brush and Burlington), and year of birth plays an important role on the magnitude of cephalometric variables.[25] The authors of the same study underlined the fact that significant growth changes can be detected between growth studies that are more than a few decades apart.

Growth Curves and Other Fields of Use

Several methods can predict mandibular growth but it is not clear which is the most accurate one. The growth curve method is a promising and practical method because it is easy for visual evaluation in clinical practice.[26] Therefore, data from this study are plotted as growth curves to present the growth-dependent changes. Growth curves can be used to designate the patient as early-, average- or late maturer, as well as to predict the approximate mandibular dimensions at a particular age. Furthermore, expected and achieved mandibular dimensions after functional orthopedic treatment can be comparatively evaluated for scientific purposes.

Other fields of use of cephalometric data are mostly legal medicine and forensic anthropology. These data help to determine sex and ethnicity and also to estimate age of the victim at the time of death. Furthermore, cephalometric data can also be used in combination with dental records in facial recognition systems to reveal the identity of an unknown person.[27] Although Demirjian's stages for dental development is a reliable method for age estimation, validity of this method is questionable after complete development of tooth roots.[28,29] Therefore, cephalometrics have been a fruitful field for forensic sciences for the past decades.

Although we have attempted to support out findings with scientific facts, we cannot rule out the impact of methodological differences between studies and cross-sectional nature of this study on the results. Growth studies can be designed as cross-sectional, longitudinal, or mixed-longitudinal. Longitudinal studies provide valuable information about growth variations and velocity, but it is not ethically appropriate to take annual cephalometric radiographs just for study purposes. The most common form of growth studies, on the other hand, is cross-sectional studies, by which mean annual growth can be estimated, but the data are not well-distributed like longitudinal studies, since the same individual is not followed at regular intervals.

To overcome the shortcoming of cross-sectional study design and to obtain a more homogeneous data that reflect the characteristics of a population, we kept the number of randomly selected individuals as high as possible.

CONCLUSION

Under the light of the findings of this study, the following points were concluded:

1. Effective mandibular length was almost always significantly longer in boys, except for 9- and 12-year-age groups.
2. Girls showed significant increase for mandibular length between ages 8 and 10, 10 and 12, and 11 and 13 years, while boys between ages 8 and 10, 9 and 11, and 13 and 15 years.
3. We suggest using norm values from more recent studies and that are representative of the studied subjects.
4. Growth curves can be used to predict the approximate mandibular dimensions at a particular age.

Ethics Committee Approval: Ethics committee approval was obtained from the Ethics Committee and Institutional Review Board of Başkent University (Protocol Number: D-KA17/23).

Informed Consent: Written informed consent was obtained from the patients.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - İ.C.P., H.P.; Design - İ.C.P., H.P.; Data Collection and/or Processing - H.P., N.İ.T.; Analysis and/or Interpretation - H.P., H.Y.Z., N.İ.T.; Writing - H.P., N.İ.T., H.Y.Z.; Critical Review - H.P., N.İ.T., H.Y.Z., İ.C.P.

Declaration of Interests: The authors have no conflict of interest to declare.

Funding: The authors declared that this study has received no financial support.

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