Sexual dimorphism in normal craniofacial growth

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Since the development of standardized cephalometric techniques, facial growth has been the subject of extensive investigation, using both cross-sectional and longitudinal data. Cross-sectional studies present limitations of data interpretation and the conclusions drawn should be confirmed by longitudinal assessment.[1] Longitudinal cephalometric studies allow verification of changes in the individual craniofacial complex during different maturational stages, but because of difficulties in data acquisition, such studies encompassing large intervals of craniofacial growth are rare.

In selecting samples for longitudinal investigations, two main approaches have been used. The first used the criteria of acceptable to ideal occlusions and balanced facial proportions.[2-7] The second approach did not consider the occlusal relationships and included malocclusions.[8-14] While the latter is more representative of the general Caucasian population in the United States and Northern Europe, the former represents efforts to establish "norms" to which other populations can be compared.

One aspect of craniofacial growth that has received only limited attention is sexual dimorphism. According to Broadbent and co-workers,[4] "sexual dimorphism is in the main an expression of secondary sexual characteristics that occur after puberty and during the adolescent years". On average the craniofacial complex is between 5% and 9% larger in males than females, depending upon the measurement taken.[1,15] Significant size differences between males and females also have been reported using measurements from dry skulls[16] and adult subjects.[17,18] This dimorphism

Abstract
The purpose of this investigation is to re-evaluate an existing sample of Caucasian individuals, of mostly Northern European ancestry and undefined ethnic origins, who have been characterized as having excellent occlusions and balanced facial proportions (from a subjective assesment). The focus is the emergence of sexual dimorphism in the skeletal and dental relationships. Serial lateral cephalograms of 51 subjects were obtained from the Bolton-Brush Study at ages 6, 9, 12, 14, 16 and 18 yrs. At each age, the records of 16 males and 16 females were selected. Cephalometric evaluation indicated that the length of the anterior cranial base was larger in males but the cranial base angle was similar for both sexes at all age intervals studied. The effective lengths of the maxilla and mandible were similar in both sexes up to 14 years; thereafter in females this length remained relatively constant while in males it increased. The direction of facial growth was similar for both sexes, with a tendency towards a more horizontal growth pattern in females.

Key Words
Bolton Standards • Facial Form • Sexual Dimorphism • Cephalometrics • Craniofacial Growth

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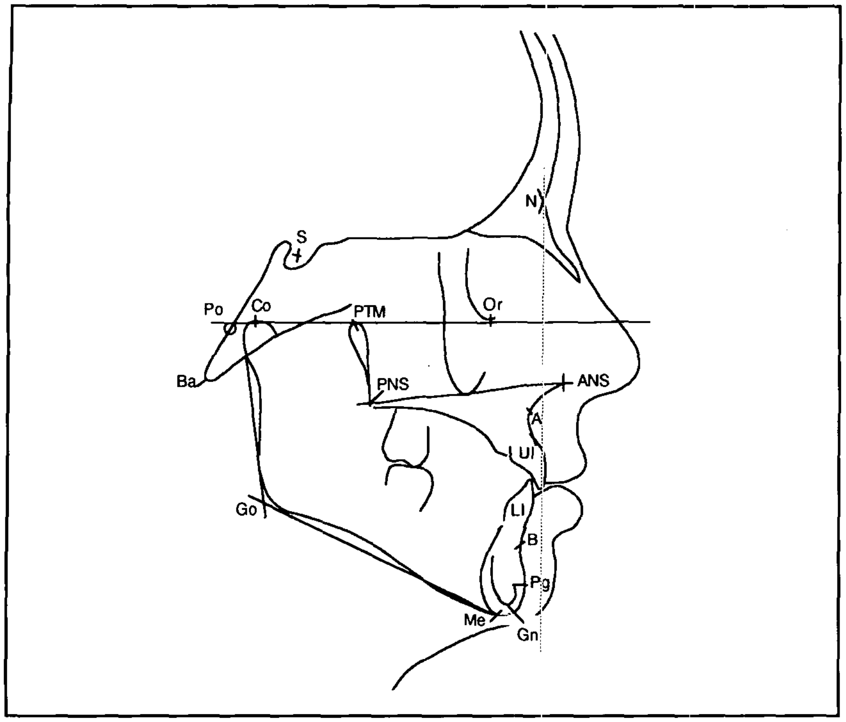

Figure 1
Diagram showing the digitized landmarks.

N	Nasion, the junction of the frontonasal suture at the most posterior point on the curve at the bridge of the nose.
S	Sella Turcica, the center of the pituitary fossa of the sphenoid bone.
Ba	Basion, the most inferior-posterior point on the margin of the foramen magnum.
Po	Porion, the most superior point on the averaged outlines of the external auditory meati.
Or	Orbitale, the lowest point on the average of the right and left borders of the bony orbit.
Co	Condylion, the most posterior-superior point on the curvature of the average of the right and left outlines of the condylar head.
PTM	Pterygo-maxillary fissure, the posterior-superior point on the average of the right and left outlines of the pterygo-maxillary fissure.
PNS	Posterior nasal spine, the most posterior point at the sagittal plane on the bony hard palate.
ANS	Anterior nasal spine, the tip of the median, sharp bony process of the maxilla at the lower margin of the anterior nasal opening.
A	Point A, the most posterior point on the curve of the maxilla at the lower margin of the anterior nasal opening.
Go	Gonion, the midpoint of the angle of the mandible.
Me	Menton, the most inferior point on the symphyseal outline.
Gn	Gnathion, the most anterior-inferior point on the contour of the bony chin symphysis.
Pg	Pogonion, the most anterior point on the contour of the bony chin.
B	Point B, the point most posterior to a line joining the anterior-superior point on the mandible at its labial contact with the mandibular central incisor and Pogonion.
UI, LI	Maxillary and mandibular central incisors.

also is related to the distinctly different patterns of maturational timing the sexes experience during adolescence, and, although male/female differences have been reported in longitudinal samples,[14] few studies have focused directly on this issue.

The purpose of the present investigation was to re-evaluate an existing sample of individuals who had been previously characterized by Broadbent and co-workers[4] as having excellent occlusions and balanced facial proportions. The focus was the emergence of sexual dimorphism in the skeletal and dental relationships. Serial lateral cephalograms were retraced and analyzed, with additional cephalometric measurements added to those reported in the Bolton atlas. Thus sexual dimorphism in a broad range of cephalometric relationships was examined in this study.

Materials and methods

This investigation used data from the Bolton-Brush Longitudinal Growth Study at Case Western Reserve University. The Bolton Study was conducted between the second and the sixth decade of this century with some 22,000 examinations. The original sample included approximately 5,000 individuals, mostly of European ancestry. The uniqueness of this sample is derived from its size, duration of record gathering and precise methods of standardization.

The records used in this study were lateral cephalograms of the children selected, analyzed and reported by Broadbent and co-workers comprising the "Bolton Standards". These individuals were selected based on excellence of the occlusion, good health history with no major medical problems, esthetically pleasing facial contours and the availability of long-term records.

The records of 16 males and 16 females were retrieved at ages 6, 9, 12, 14, 16 and 18 years. These records were drawn from a total of 51 individuals, 23 males and 28 females (Table I), as the "Bolton Standards" were derived from a mixed longitudinal sample with voids present in the long-term series.

Each lateral cephalometric radiograph was traced by one investigator and checked for accuracy by a second. Specific landmarks were digitized (Figure 1) at the Center for Human Growth and Development at the University of Michigan and cephalometric variables were computed based on the following cephalometric analyses; Downs,[19] Riedel,[20] Steiner [21] and Ricketts.[22] In addition, seven angular and 10 linear variables devised by Harvold,[23] McNamara[24] and Ellis and McNamara[25] were included. The craniofacial complex was divided into five components: the cranial base,

Table I
Distribution of the subjects used to compose the Bolton Standards at each age

ID	6	9	12	14	16	18
MALES (23)						
0105	X	X	X	X	X	X
0134	X	X	X	X	X	-
1139	X	X	X	X	X	X
1186	X	X	X	X	X	X
2032	X	X	X	X	X	X
2112	X	X	X	X	X	X
2131	X	X	X	X	X	X
2210	X	X	X	-	-	-
2242	X	X	X	X	X	-
2260	X	X	-	-	-	X
2516	X	X	X	X	X	-
2540	X	X	X	X	X	X
2747	-	X	X	X	X	X
2770	-	-	-	-	-	X
2792	-	-	-	-	-	X
3059	X	X	X	-	X	X
3061	X	-	-	-	-	-
3065	X	X	X	X	-	-
3098	X	X	X	X	-	X
3156	-	-	-	X	X	X
3338	-	-	-	X	X	X
3408	-	-	X	X	X	-
3498	-	-	-	-	X	X
FEMALES (28)						
0115	X	X	X	X	X	X
0131	X	X	X	X	-	X
0133	X	-	X	X	X	-
1123	-	X	X	X	X	X
1197	X	X	-	X	-	X
1208	X	X	X	X	X	-
1212	X	X	X	X	X	X
1242	X	-	-	X	X	-
2030	X	-	-	X	X	-
2053	X	-	-	X	X	X
2097	X	X	X	X	X	X
2140	X	X	X	-	X	-
2144	-	X	-	X	X	X
2157	X	X	-	X	-	-
2187	X	X	X	-	X	-
2254	X	X	X	-	-	-
2299	-	-	-	-	-	X
2339	-	-	X	-	-	-
2462	X	X	X	X	X	-
2517	-	X	X	-	X	X
2537	-	X	-	-	X	X
2629	-	-	-	X	-	-
2894	-	-	-	-	X	X
3037	X	X	-	X	-	-
3195	-	-	X	-	-	X
3234	-	-	X	-	-	X
3269	-	-	-	-	-	X
3461	-	-	X	-	-	X

KEY: (X) subject was used; (-) subject was not used

Table II
Cranial Base Relationships
(* denotes level of significance for sexual dimorphism)

		6		9		12		14		16		18	
		X	SD	X	SD	X	SD	X	SD	X	SD	X	SD
MALES	S-N	67.4**	2.5	70.5**	2.8	72.1*	3.0	73.9**	2.3	75.9***	2.8	77.0***	2.8
	S-Ba	42.1ns	3.0	42.1ns	3.0	44.7ns	2.7	45.6ns	2.8	47.0*	3.2	48.0**	3.1
	N.S.Ba	127.1ns	4.8	126.5ns	5.9	126.9ns	4.7	126.0ns	5.2	127.0ns	4.8	125.4ns	5.7
FEMALES	S-N	65.0**	1.9	67.6**	1.9	70.6*	2.1	71.3**	2.2	71.2***	2.6	71.4***	2.9
	S-Ba	38.6ns	1.8	42.2ns	2.1	43.9ns	1.9	44.4ns	2.1	44.9*	1.9	44.8**	2.6
	N.S.Ba	127.4ns	2.2	126.1ns	3.9	127.7ns	2.5	127.4ns	3.2	127.5ns	5.1	125.8ns	4.3

ns= Not significant
* Significant at the 0.05 level of confidence
** Significant at the 0.01 level of confidence
*** Significant at the 0.001 level of confidence

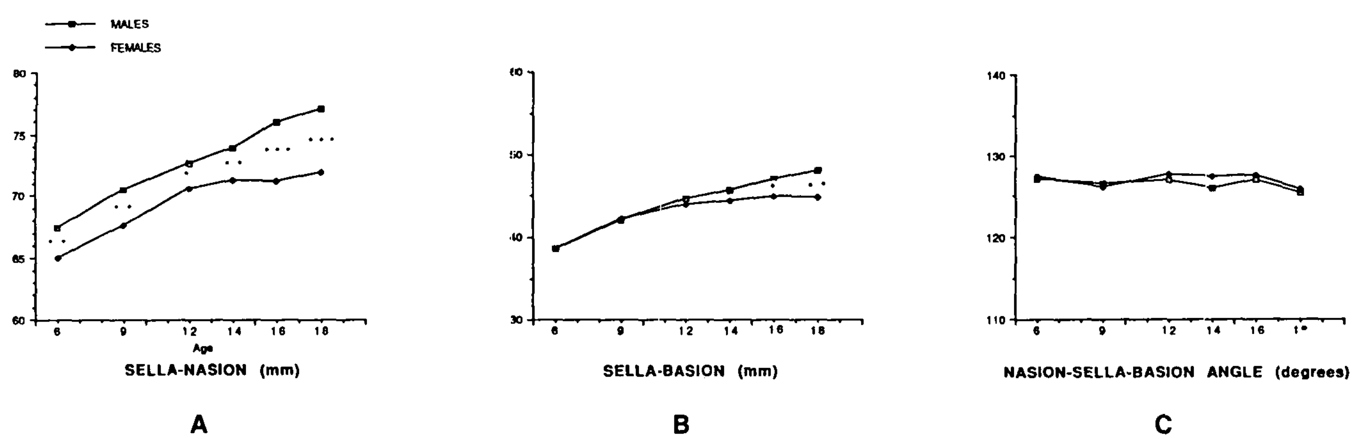

Figure 2A-C

Figure 2A-C
Cranial base evaluations
A: Sella-Nasion
B: Sella-Basion
C: Nasion-Sella-Basion

maxillary skeletal region, mandibular skeletal region, maxillary and mandibular dentoalveolar regions and the vertical dimension of the face.

Cranial Base

- The distance Sella-Nasion, S-N (mm).
- The distance Sella-Basion, S-Ba (mm).
- The angle Nasion-Sella-Basion, NSBa (°).

Maxillary Skeletal Region

- The angle Sella-Nasion-Point A , SNA (°).
- The distance Point A to the Nasion Perpendicular, Pt A - N Perp (mm). The Nasion Perpendicular is constructed by first establishing the Frankfort Horizontal plane using anatomic Porion and drawing a perpendicular line from Nasion inferiorly.
- The distance from Condylion to Point A, Co-A (mm).

Mandibular Skeletal Region

- The angle Sella-Nasion-Point B, SNB (°).
- The distance from Pogonion to the Nasion Perpendicular, Pg-N Perp (mm).
- The distance from Condylion to Gnathion, Co-Gn (mm).

Maxillary and Mandibular Dentoalveolar Regions

- The distance from the Upper Incisor facial surface to the Point A Vertical, UI-Pt A Vert (mm, McNamara).[24]
- The angle between the Upper Incisor and the Palatal plane, UI.PP (°). The Palatal plane is formed by connecting the Anterior and Posterior Nasal Spines (ANS, PNS).
- The distance from the Lower Incisor facial surface to Point B Vertical, LI-Pt B Vert (mm, Ellis and McNamara[25]).
- The angle between the Lower Incisor and the Mandibular plane, IMPA (°). The Mandibular plane is formed by connecting points Menton and Gonial Intersection.

Vertical Facial Dimension

- The angle between the lines Basion-Nasion and Ptm-Gnathion, Facial Axis (°).

Table III
Maxillary Skeletal Relationships
(* denotes level of significance for sexual dimorphism)

		6		9		12		14		16		18	
		X	SD	X	SD	X	SD	X	SD	X	SD	X	SD
MALES	SNA	81.3ns	3.8	81.4ns	3.5	81.8ns	3.3	82.6ns	2.9	82.7ns	2.7	83.6ns	2.7
	A-NPerp	-2.1ns	3.0	-1.4ns	2.5	-1.7ns	3.4	-1.2ns	2.3	-0.8ns	3.6	-1.5ns	2.9
	Co-A	79.7ns	3.4	85.6*	4.1	90.2ns	4.0	93.3**	3.1	97.0***	4.2	99.1***	3.8
FEMALES	SNA	82.6ns	2.5	82.2ns	2.3	82.0ns	1.9	83.8ns	2.4	83.7ns	2.2	83.4ns	1.9
	A-NPerp	-1.1ns	2.5	-1.9ns	2.3	-2.2ns	3.0	-1.3ns	1.5	-0.8ns	2.3	-1.2ns	2.7
	Co-A	77.8ns	2.1	83.1*	2.2	87.8ns	2.4	90.2**	2.7	90.8***	2.3	91.6***	2.9

ns= Not significant
* Significant at the 0.05 level of confidence
** Significant at the 0.01 level of confidence
*** Significant at the 0.001 level of confidence

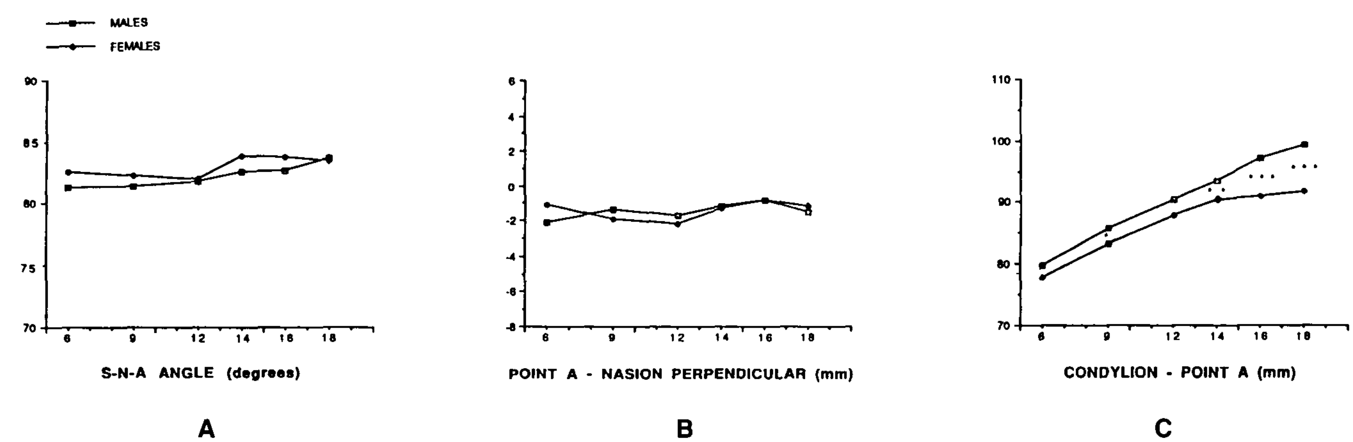

Figure 3A-C

- The angle Frankfort Horizontal to the Mandibular plane, FMA (°).
- The distance from Nasion to Anterior Nasal Spine (ANS), UAFH or upper anterior facial height (mm).
- The distance from Anterior Nasal Spine (ANS) to Menton, LAFH or lower anterior facial height (mm).

The magnification of each film was available in the data base and was standardized to an 8% enlargement factor. The statistical analysis was performed by standard methods. Males and females were compared by Student's *t* test for independent groups. Statistical significance was established for values of $p < 0.05$, $p < 0.01$ and $p < 0.001$. The error of the method for this technique has been examined previously[41] and has been shown to be within acceptable limits.

Results

Tables II to VI depict the measurements evaluated throughout the period studied. Means and standard deviations were reported as well as *t* test scores for sexual dimorphism. The results also are displayed graphically in Figures 2 to 6.

Cranial Base Relationships

Anterior cranial base length (Sella-Nasion) was the only measurement that showed significant dimorphism over the entire 12-year span. From ages 6 to 12, males had larger values, although both sexes were similar in their growth rates. Female values plateaued at age 12, but continued increased values were noted in males that further increased the size discrepancy into young adulthood (Table II; Figure 2A).

In posterior cranial base length, sexual dimorphism was not evident until age 16, when males had a larger value. After 12 years of age, females did not show large increments, while growth continued in males until the last age evaluated (Table II; Figure 2B). Neither sex presented statistically significant differences in cranial base angle although both showed a slight decrease with growth (Table II; Figure 2C).

Figure 3A-C
Maxillary skeletal evaluation
A: SNA Angle
B: Pt A - N Perp
C: Co-A

Table IV
Mandibular Skeletal Relationships
(* denotes level of significance for sexual dimorphism)

		6		9		12		14		16		18	
		X	SD	X	SD	X	SD	X	SD	X	SD	X	SD
MALES	SNB	77.5ns	3.4	77.9ns	3.3	78.2ns	3.2	79.0*	2.8	79.6ns	2.9	80.8ns	3.2
	Pg-NPerp	-9.6ns	4.7	-7.1ns	3.6	-7.6ns	3.9	-6.4ns	3.3	-4.5ns	4.8	-4.3ns	4.6
	Co-Gn	96.9ns	3.6	105.4ns	3.9	112.1ns	4.2	118.2ns	4.0	124.4***	4.5	128.7***	4.6
FEMALES	SNB	78.6ns	2.4	79.2ns	1.7	79.3ns	1.6	81.3*	1.9	81.4ns	2.0	81.0ns	2.0
	Pg-NPerp	-8.6ns	4.3	-6.8ns	3.6	-6.6ns	5.0	-4.4ns	3.7	-3.1ns	4.1	-3.4ns	5.1
	Co-Gn	93.2ns	3.7	103.7ns	3.3	110.8ns	3.4	116.4ns	4.9	117.6***	3.4	119.0***	4.3

ns= Not significant
** Significant at the 0.01 level of confidence
* Significant at the 0.05 level of confidence
*** Significant at the 0.001 level of confidence

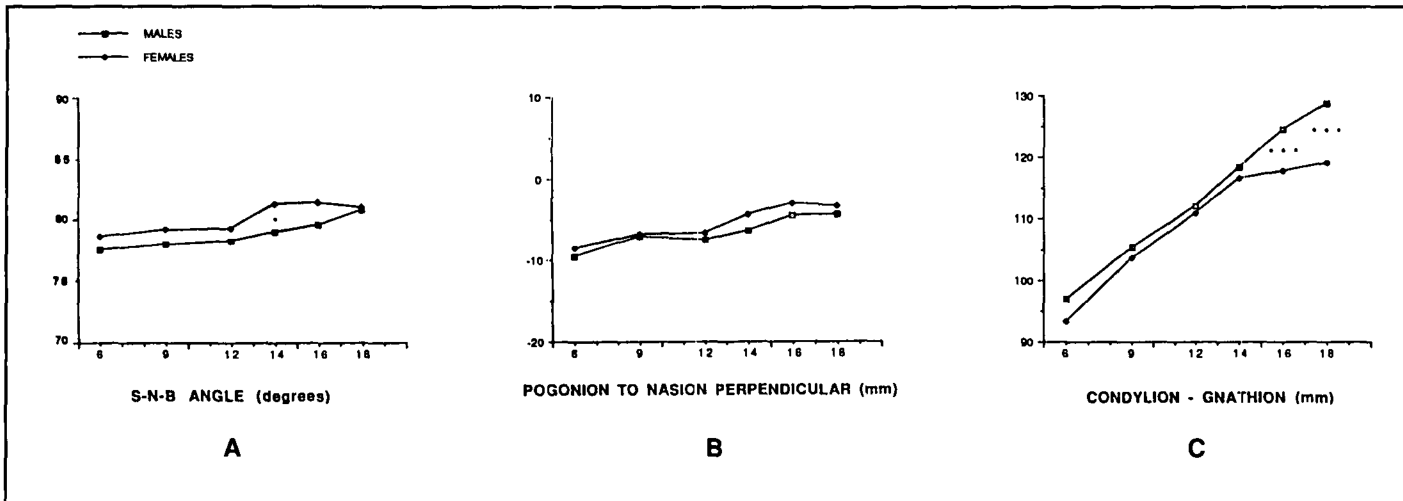

Figure 4A-C

Figure 4A-C
Mandibular skeletal evaluation
A: SNB Angle
B: Pg - N Perp
C: Co-Gn

Maxillary Skeletal Relationships

Neither evaluation for maxillary anteroposterior position, that is SNA angle and the distance from Point A to Nasion perpendicular, presented sexually dimorphic values (Table III, Figures 3A & 3B). There were no major changes in these variables over the period studied. The SNA angle did indicate a normal sagittal maxillary position when compared to the published norm (82°),[20] while the distance from Point A to the Nasion perpendicular showed a degree of maxillary retrusion when compared to the usual norm (0 mm at 9 yrs of age & 1 mm at adult).[24]

The effective midfacial length (Co-Point A) was larger in males at all ages, but this was significant only after age 14. Again females slowed in their growth by age 14 years but males continued to grow in large increments until the last age evaluated (Table III; Figure 3C).

Mandibular Skeletal Relationships

The evaluation of sagittal mandibular position from the SNB angle and the distance from Point B to Nasion perpendicular did not indicate any sexual dimorphism at most of the ages (Table IV; Figure 4A and B). Both these variables increased with age and only at 14 years did females present larger SNB values. At age 18, this angle was similar to the Steiner norm (80°)[21] while the distance from Pogonion to the Nasion perpendicular indicated a degree of mandibular retrusion in both sexes.[24]

The effective mandibular length (Co-Gn) was larger in males at all ages, but this was significant only after 14 years. The growth rates for this variable were similar for both sexes up to 14 years; thereafter, it increased in males and remained constant in females (Table IV; Figure 4C).

Maxillary and Mandibular Dentoalveolar Relationships

Evaluation of the anteroposterior positions (UI-Pt A Vert, LI-Pt B Vert) and axial inclinations (UI.PP, IMPA) of the upper and lower incisors did not show sexually dimorphic values at any age (Table V; Figures 5A-D). With growth, the max-

Table V
Maxillary and Mandibular Dentoalveolar Relationships
(* denotes level of significance for sexual dimorphism)

		6		9		12		14		16		18	
		X	SD	X	SD	X	SD	X	SD	X	SD	X	SD
MALES	UI-AVert			3.2ns	1.2	3.7ns	1.3	3.7ns	1.4	4.0ns	2.1	3.6ns	1.3
	UI-PP			109.7ns	5.1	108.3ns	6.2	108.4ns	6.9	109.4ns	6.4	107.5ns	6.1
	LI-BVert			0.4ns	1.5	0.3ns	1.4	0.1ns	1.6	0.5ns	1.5	1.0ns	1.8
	IMPA			93.4ns	5.9	93.3ns	6.3	93.8ns	6.1	94.3ns	5.5	92.1ns	6.3
FEMALES	UI-AVert			2.8ns	0.9	3.2ns	1.0	4.2ns	1.5	3.9ns	1.2	4.2ns	1.3
	UI-PP			109.7ns	4.7	109.2ns	2.6	108.6ns	5.1	107.3ns	5.5	108.6ns	4.2
	LI-BVert			1.3ns	1.1	0.9ns	1.1	0.2ns	1.0	1.2ns	1.0	0.4ns	1.1
	IMPA			91.7ns	4.6	92.3ns	4.2	93.8ns	5.4	92.5ns	4.3	91.1ns	5.4

ns= Not significant
* Significant at the 0.05 level of confidence
** Significant at the 0.01 level of confidence
*** Significant at the 0.001 level of confidence

illary and mandibular incisors tended to tip lingually. In addition the maxillary incisors were protruded relative to the cranial base; however, these changes were not significant.

Vertical Relationships

The individuals in this sample tended to have low facial axis angles (norm=90°),[19] implying horizontal growth. There was a significant difference for this angle between the sexes at 14 years, when females had a more horizontal mandibular position; however, after age 18, this difference was not significant (Table VI; Figure 6A).

The mandibular plane angle did not present sexually dimorphic values at any age, although it decreased approximately four degrees over ages 6 to 18 (Table VI; Figure 6B).

The upper anterior facial height (UAFH) was slightly larger in males at ages 6, 9 and 12. This difference became significant after 14 years as males outgrew females (Table VI; Figure 6C). The lower anterior facial height (LAFH) followed a similar pattern with significant differences evident after age 16 (Table VI; Figure 6D).

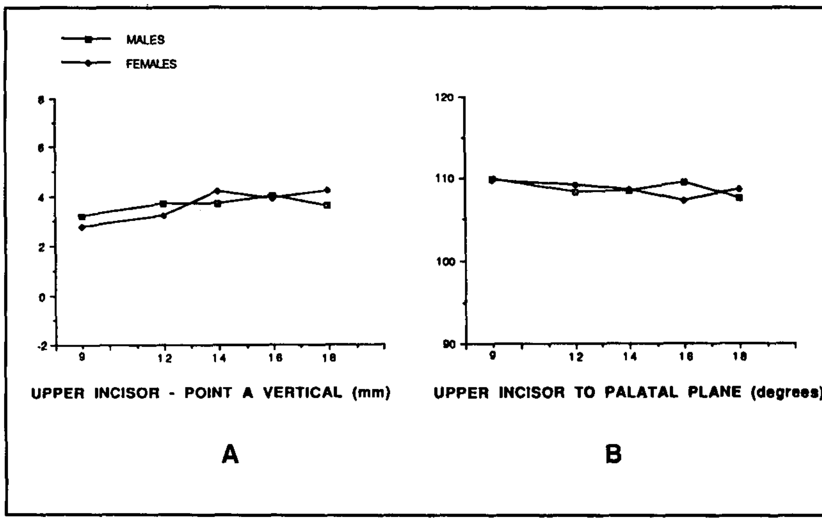

Figure 5A-B

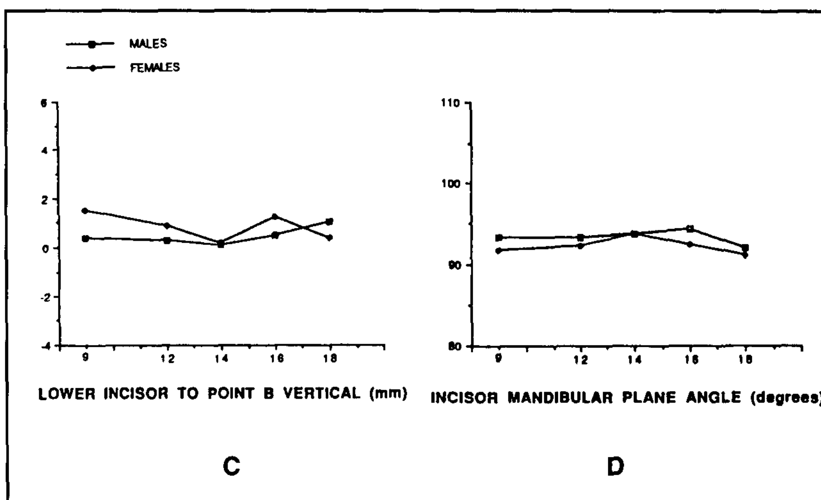

Figure 5C-D

Figure 5A-D
Maxillary and mandibular dentoalveolar evaluation
A: UI - Pt A Vert B: UI.PP C: UI - Pt A Vert D: IMPA

Discussion

The results of this study indicate that sexual dimorphism becomes apparent by age 14 in most skeletal measures while dimorphism is not apparent in dentoalveolar relationships at any age studied. These findings are discussed according to the craniofacial region analyzed.

The distinctly different patterns of sexual dimorphism in the anterior (S-N) and posterior (S-Ba) cranial base sizes were also reported by Roche and Lewis[26] and Lewis and Roche.[27] One possible explanation is that this region is associated with both neural and somatic growth patterns that are different.[28,29] Also, the anterior limit of the cranial base (as denoted by Nasion) is part of the frontal bone,[30,31] and this bone increases in thickness by

TableVI
Vertical Relationships
(* denotes level of significance for sexual dimorphism)

		6		9		12		14		16		18	
		X	SD	X	SD	X	SD	X	SD	X	SD	X	SD
MALES	Y Axis	91.9ns	2.3	91.4ns	2.8	91.5ns	2.6	91.2*	2.4	91.7ns	2.7	91.9ns	2.9
	MPA	25.4ns	3.1	23.8ns	3.2	24.4ns	3.7	24.5ns	3.7	22.8ns	4.5	22.3ns	4.4
	UAFH	44.7ns	2.1	49.3ns	2.1	52.5ns	2.2	55.8***	2.0	58.2***	2.3	59.3***	2.5
	LAFH	57.0ns	3.0	60.0ns	3.5	63.0ns	3.5	65.5ns	3.8	68.3*	4.2	70.3**	4.7
FEMALES	Y Axis	91.5ns	2.1	91.0ns	2.4	91.2ns	2.6	93.6*	2.9	93.0ns	2.3	91.4ns	2.7
	MPA	25.9ns	2.9	24.5ns	3.3	24.3ns	3.0	22.4ns	4.1	22.5ns	3.7	22.5ns	3.5
	UAFH	43.6ns	2.5	48.2ns	2.6	51.7ns	2.5	52.0***	2.0	53.1***	2.1	53.9***	2.1
	LAFH	58.4ns	2.7	58.6ns	2.8	61.4ns	4.5	64.3ns	4.8	64.8*	4.3	65.7**	4.5

ns= Not significant
* Significant at the 0.05 level of confidence
** Significant at the 0.01 level of confidence
*** Significant at the 0.001 level of confidence

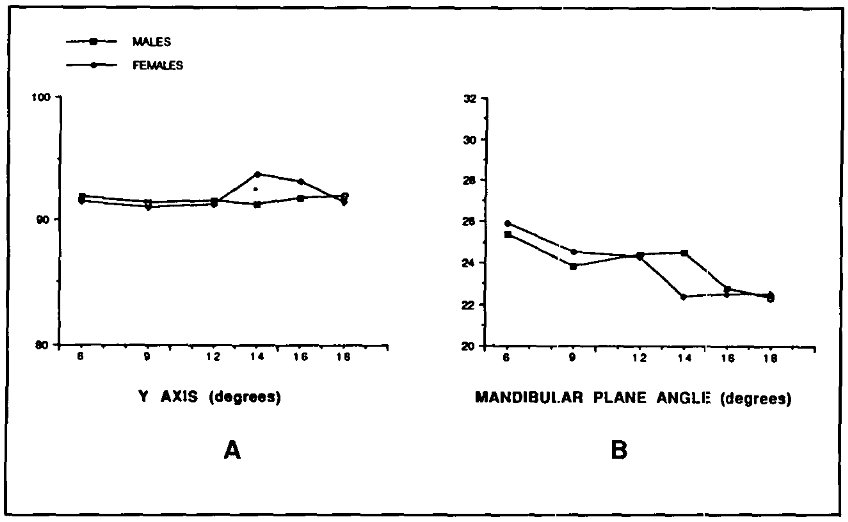

Figure 6A-B

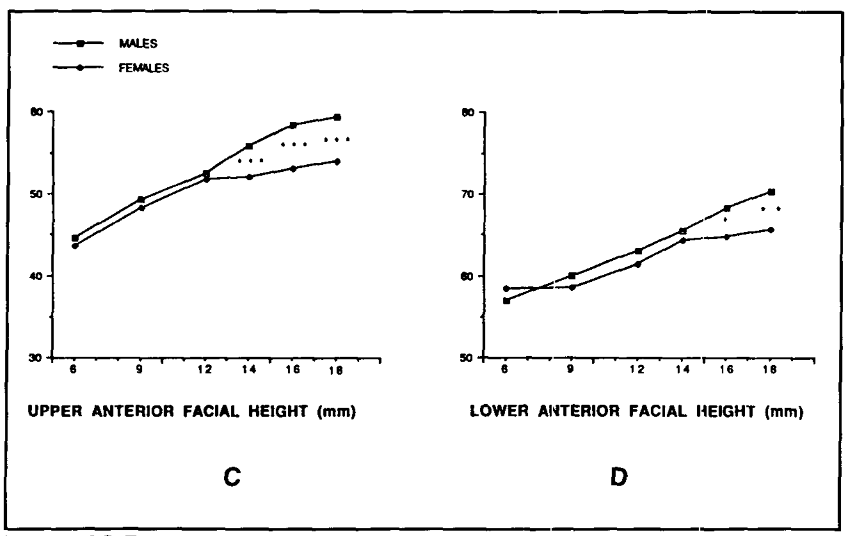

Figure 6C-D

Figure 6A-D
Vertical evaluation
A: Y axis B: FMA C: UAFH D: LAFH.

surface deposition during life, accompanied by increasing pneumatization of the frontal sinus particularly during adolescence.[32] In addition, the region of the frontal sinus, as pointed out by Broadbent and co-workers,[4] is simply larger, on average, in males than in females. These factors could influence the position of Nasion.

The cranial base angle was similar for both sexes. These findings agree with those of Lewis and Roche[27] and Sinclair and Little.[7] The small decrease of approximately two degrees noted in both sexes is in agreement with Lewis and Roche;[27] however, Björk and Palling[10] reported a seven degree increase between the ages of 12 and 20 years in boys.

The sagittal position of the maxilla did not present sexual dimorphism; however, there were minimal differences at 6 and 18 years. Similar findings also were noted by other investigators.[3,7,33,34] With growth, the maxilla maintained a constant relationship and presented a coordinated forward displacement relative to the the cranial base. As the latter was sexually dimorphic in length, one would expect a similar dimorphism in the effective maxillary length. This was not evident in the early years but was present at 9 years and from 14 years onward, at which time females reached their approximate final size while males continued to grow.

The sagittal position of the mandible was similar to that of the maxilla in its lack of sexually dimorphic features. The tendency for protrusion noted between 6 and 18 yrs (e.g., 2.5° increase in SNB angle and 4 mm increase in Pg-N Perp) has been mentioned in the literature by many others.[3,7,33-36] The effective length of the mandible kept pace with that of the maxilla as sexual dimorphism occurred at or about the same time in both jaws (14 years). This also was observed by Björk and Helm[37] and Björk and Skieller.[12] They pointed out that the rate of increase of the mandibular length presents a large growth spurt in the pubertal period, particularly in males. Buschang and co-workers[38] speculated that sexual dimorphism in mandibular size favoring males could be temporarily confounded in early years by the earlier growth spurt of females.

Nanda[2] stated that the horizontal growth observed in females probably was due to the earlier onset of the pubertal growth spurt during which time more horizontal than vertical growth may be expected. Both the mandibular plane angle and facial height measurements corroborated this finding. There was a 2° decrease in this angle between the ages 12 and 14 and overall, during the study period, this angle decreased about 3°, a finding noted by others.[3,7,33,34,39] Finally, the small nonsignificant changes observed in the incisal region were in agreement with Sinclair and Little.[7]

The upper and the lower anterior facial height measurements demonstrated dimorphism at 14 years. This was expected as the adolescent growth spurt in boys peaks at this time.[31] Additionally, male facial growth is more substantial during adolescence, with dimensional increases up to 25%.[40]

Conclusions

The purpose of this mixed longitudinal study was to quantitatively report the presence of sexual dimorphism in a sample of caucasian individuals of mostly Northern European ancestry and undefined ethnic origins, previously characterized as having excellent occlusions and balanced facial proportions (from a subjective assesment). Serial lateral cephalograms of 51 subjects were obtained from the Bolton-Brush Study at ages 6, 9, 12, 14, 16 and 18 years. At each age, the records of 16 males and 16 females were selected. The following conclusions were drawn:

1. The anterior cranial base was larger in males. The posterior cranial base did not show sexual dimorphism until age of 16. The cranial base angle was similar for both sexes.
2. There was no sexual dimorphism found in the maxillary and mandibular sagittal positions. The effective lengths of the maxilla and mandible were similar in both sexes up to 14 years; thereafter in females this length remained relatively constant while in males it increased.
3. The direction of facial growth was similar for both sexes, with a tendency towards a more horizontal growth pattern in females.
4. Sexual dimorphism was not evident in the dentoalveolar measures at any age.

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