

Scientific Foundations

Relation Between Anthropometric and Cephalometric Measurements and Proportions of the Face of Healthy Young White Adult Men and Women

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The specific aim of this study was to determine the differences between 6 anthropometric (taken from the surface) and cephalometric (taken from x-rays) measurements and 12 proportion indices formed by the measurements obtained from the face of 51 healthy Caucasoid young adult males and females. The z-score analysis revealed negligible differences in frequency of normal values, in surface measurements 97.4% (298 of 306) versus 96.7% (296 of 306) in cephalometric ones. The optimal normal measurements dominated, in males in 76.8% and in females in 80.8%. The mean values of the 6 linear measurements, taken from the surface and the cephalogram of the face were in equal number similar and significantly dissimilar in both sexes (Table 1). Comparison of the mean anthropometric and cephalometric proportion indices did not show significant differences in the two sexes (Table 2). For males 50% of the 12 proportions the indices were similar and 50% were significantly different. For females the frequency of similar proportions was seen in 33.3% and in 66.7% moderately-severely differing, statistically not significant. The z-score analysis identified subnormal measure-

ments on the facial surface in 2.6% (8 of 306) and in cephalometric ones in 3.3% (10 of 306). The subnormal measurements of mild and moderate degree disclosed on the skeleton were not detected on the surface and some of the severely subnormal ones became mild-moderate on the skin surface. The study showed that the vertical anthropometric and cephalometric measurements in the facial profile were in highly significant percentage normal when compared with their normative data established for healthy populations. Generally, the cephalometric normal measurements were smaller than those of the anthropometric ones, some of them significantly. The significant differences between the proportions on the surface and skeleton in healthy subjects advice to be cautious in clinical practice, to judge the morphological changes of the face separately on the surface and on the skeleton of the patient.

Key Words: Anthropometry, cephalometry, differences between facial measurements and proportions in healthy young adults

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In clinical practice the quantitative evaluation of the morphology of the facial surface is determined by anthropometric methods using soft tissue landmarks and that on the skeleton by cephalometry. Studies comparing the results of both examination methods are sparse in the medical literature and devoted to demonstrating the relationship between the two methods in patient populations only.¹

Table 1. Anthropometric and Cephalometric Measurements in Males and Females

Males (25)						Females (26)					
		Measurement	Mean (mm)	SD				Measurement	Mean (mm)	SD	
1	A	n-gn	128.0	6.2	SIG	A	n-gn	120.9	6.8		SIG
	C	N-ME	122.2	6.2	(MOD)	C	N-ME	116.2	6.7		(M)
2	A	n-sto	80.3	4.7	NS	A	n-sto	76.7	4.7		NS
	C	N-SD	83.2	6.8		C	N-SD	78.2	6.2		
3	A	sn-gn	75.3	5.0	SIG	A	sn-gn	70.4	6.0		SIG
	C	SN ₁ -ME	69.0	4.7	(SEV)	C	SN ₁ -ME	64.7	6.0		(MOD)
4	A	sto-gn	48.2	5.0	SIG	A	sto-gn	45.3	4.3		SIG
	C	ID-ME	42.5	4.1	(SEV)	C	ID-ME	38.3	5.0		(SEV)
5	A	n-sn	53.8	4.3	NS	A	n-sn	51.5	3.5		NS
	C	N-SN ₁	53.8	4.3		C	N-SN ₁	51.4	3.3		
6	A	sn-sto	26.5	3.2	NS	A	sn-sto	25.4	2.7		NS
	C	SN ₁ -SD	26.1	3.1		C	SN ₁ -SD	27.7	5.8		

A, Anthropometric; C, Cephalometric; mm, millimeters; SD, Standard Deviation; NS, not significant; SIG, significant; mild (M) ($p = 0.04-0.01$); moderate (MOD) ($p = 0.009-0.0002$); severe (SEV) ($p \leq 0.0001$).

The aim of the study was to 1. determine the differences between the anthropometric and cephalometric measurements of the face, 2. establish the differences between the anthropometric and cephalometric proportion indices of the face, and 3. determine the differences between the anthropometric and cephalometric facial proportions in healthy young caucasoid adult males and females.

MATERIALS AND METHODS

The study group consisted of 51 Caucasoid (Hungarian) healthy young adult males ($N = 25$) and females ($N = 26$), 18 to 25 years of age.

The examination was focused on the vertical projective linear anthropometric² and cephalometric³ measurements of the facial profile. Six anthropometric measurements were made up of the face height (n-gn), upper face height (n-sto), lower face height (sn-gn), mandible height (sto-gn), nose height (n-sn) and the upper lip height (sn-sto) (Fig 1A). From these six anthropometric measurements, 12 anthropometric proportion indices were formed: n-sto/n-gn, sn-gn/n-gn, sto-gn/n-gn, sto-gn/n-sto, sto-gn/sn-gn, n-sn/n-gn, n-sn/n-sto, sn-sto/n-gn, sn-sto/n-sto, sn-sto/sto-gn, sn-sto/n-sn and sn-sto/sn-gn (Fig 2A).⁴

The six cephalometric measurements obtained in norma lateralis³ corresponding to the anthropometric measurements were, the N-ME, N-SD, SN₁-ME, ID-ME, N-SN₁ and SN₁-SD (Fig 1B), creating 12 cephalometric proportion indices: N-SD/N-ME, SN₁-ME/N-ME, ID-ME/N-ME, ID-ME/N-SD, ID-ME/SN₁-ME, N-SN₁/N-ME, N-SN₁/N-SD, SN₁-SD/N-ME, SN₁-SD/N-SD, SN₁-SD/ID-ME, SN₁-SD/N-SN₁, SN₁-SD/SN₁-ME (Fig 2B).

Both the cephalometric and anthropometric measurements were taken by one of the authors (MB) using standard examination techniques.⁵ The findings were converted to z-scores using anthropometric and respectively cephalometric normative data established for Hungarian healthy subjects 18 to 25 years of age (Budai, unpublished data).

STATISTICAL ANALYSIS

Terminology

Based on anthropometric category and z-score range, the z-scores were classified into descriptive categories as follows^{5,6}:

Normal values:

optimal -1.00 to $+1.00$

borderline -1.00 to -2.00 or $+1.00$ to $+2.00$

Abnormal values:

mild to moderately subnormal -2.01 to -3.00

Severely subnormal -3.01 to -9.99

Mild to moderately supernormal $+2.01$ to $+3.00$

Severely supernormal $+3.01$ to $+9.99$

In this classification system, z-scores within the range of -2.00 to $+2.00$ were considered normal and those within -1.00 and $+1.00$ as optimal. Scores less than -2.00 or greater than $+2.00$ from the mean were defined as abnormal, either subnormal or supernormal, respectively.

The frequency (expressed as a percentage) of each of these categories was compared with that of the normal distribution, using Student *t* test [the level of significance was mild (M) ($p = 0.04-0.01$),

Table 2. Sex-Related Differences Between Anthropometric and Cephalometric Proportion Indices

<i>Anthropometric proportions</i>	<i>Sex</i>	<i>Mean</i>	<i>SD</i>	<i>t-test</i>	<i>Cephalometric proportions</i>	<i>Sex</i>	<i>Mean</i>	<i>SD</i>	<i>t-test</i>
n-sto/n-gn	M	62.8	3.8	NS	N-SD/N-ME	M	68.1	4.9	NS
	F	63.5	2.4			F	67.3	4.1	
sn-gn/n-gn	M	58.8	2.9	NS	SN ₁ -ME/N-ME	M	56.5	3.2	NS
	F	58.2	3.1			F	55.7	3.2	
sto-gn/n-gn	M	37.6	3.1	NS	ID-ME/N-ME	M	34.8	3.2	NS
	F	37.5	2.7			F	32.9	3.2	
sto-gn/n-sto	M	60.4	8.4	NS	ID-ME/N-SD	M	51.5	6.9	NS
	F	59.2	5.2			F	49.2	6.9	
sto-gn/sn-gn	M	65.9	5.7	NS	ID-ME/SN ₁ -ME	M	61.6	4.3	NS
	F	64.4	3.1			F	59.2	5.5	
n-sn/n-gn	M	42.1	3.3	NS	N-SN ₁ /N-ME	M	44.1	2.9	NS
	F	42.6	2.6			F	44.3	2.5	
n-sn/n-sto	M	67.0	3.7	NS	N-SN ₁ /N-SD	M	65.0	5.3	NS
	F	67.6	4.0			F	66.1	6.5	
sn-sto/n-gn	M	20.7	2.6	NS	SN ₁ -SD/N-ME	M	24.1	2.9	NS
	F	21.3	1.9			F	22.9	2.6	
sn-sto/n-sto	M	32.8	3.6	NS	SN ₁ -SD/N-SD	M	35.6	4.9	NS
	F	32.2	3.3			F	34.1	4.2	
sn-sto/sn-gn	M	54.8	8.7	NS	SN ₁ -SD/ID-ME	M	69.8	9.8	NS
	F	52.7	11.1			F	70.4	11.2	
sn-sto/n-sn	M	48.9	8.1	NS	SN ₁ -D/N-SN ₁	M	55.1	8.5	NS
	F	50.0	7.2			F	52.1	8.1	
sn-sto/sn-gn	M	35.2	4.1	NS	SN ₁ -SD/SN ₁ -ME	M	42.7	4.5	NS
	F	36.2	3.4			F	41.1	3.8	

M, males; F, females; NS, not significant.

moderate (MOD) ($p = 0.009-0.0002$) or severe (SEV) ($p \leq 0.0001$)², as well as the method of Standard Error of Difference (SED).⁷

RESULTS

Overall, the z-score analysis revealed normal anthropometric measurements in 97.4% (298 of 306) and normal cephalometric measurements in 96.7% (296 of 306). Within the 298 anthropometric and 296 cephalometric normal measurements the percentage of the optimal values was only slightly higher on the facial skeleton (76.4%) than on the facial surface (75.8%). H = Borderline normal values on the surface of the face were slightly more frequent (24.2%), than on the skeleton (23.6%).

In sexes the optimal measurements in females were slightly significantly more frequent (80.8% of 151) than in males (70.7% of 147). In contrast, the percentage of borderline-normal values in males was slightly significantly greater (29.3% of 147) than in females (19.2% of 151) (in both sexes the SED was 9.8, and the difference 10.1). The number of abnormal measurements (10)⁸ was equally divided between males and females.

The comparison of the cephalometric abnormal measurements to the anthropometric abnormal measurements revealed slightly more improvements than setbacks. The severely subnormal cephalometric upper face height (N-SD) appeared moderate on the surface, the moderately supernormal lower alveolar height (ID-ME), nose height (N-SN₁), as well as the moderately subnormal upper alveolar height (SN₁-SD) did not show up on the surface of the face, in males. For females, the severely subnormal cephalometric upper face height (N-SD) became moderate on the surface. Nose heights (N-SN₁) exhibiting moderately subnormal variation from the cephalogram were not observed on the surface of the face. In contrast, the normal cephalometric upper alveolar height (SN₁-SD) was associated with a severely supernormal upper lip height (sn-sto).

A high percentage of optimal normal anthropometric and cephalometric measurements were observed in both sexes. In males, the lower face height on the surface reached 80% (20 of 25), in females, the upper face and the upper lip heights 80.8% (21 of 26). The SN₁-SD cephalometric measurement, counterpart of the upper lip height (sn-sto), revealed in 88% (22 of 25) optimal values in males and in females the

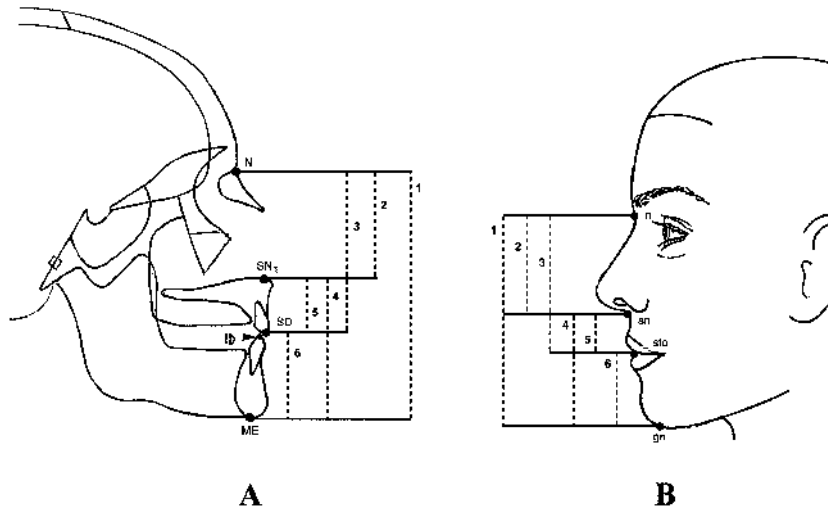


Fig 1 Cephalometric (A) and anthropometric (B) measurements of the face. (A) 1. Face height (N-ME); 2. Nose height (N-SN₁); 3. Upper face height (N-SD); 4. Lower face height (SN₁-ME); 5. Upper alveolar height (SN₁-SD); 6. Lower alveolar height (ID-ME). (B) 1. Face height (n-gn); 2. Nose height (n-sn); 3. Upper face height (n-sto); 4. Lower face height (sn-gn); 5. Upper lip height (sn-sto); 6. mandible height (sto-gn).

N-SN₁ (height of the nose) and the height of the upper face (N-SD), both in 84.6% (22 of 26). The cephalometric face height (N-ME) was significantly smaller than the anthropometric one (n-gn), in males, moderately and mildly in females.

Difference Between Anthropometric and Cephalometric Measurements in Both Sexes

The cephalometric upper face (N-SD), nose (N-SN₁) and upper lip (SN₁-SD) heights did not differ significantly from their anthropometric counterparts (n-sto, n-sn and sn-sto). The cephalometric face height (N-ME) was significantly smaller than on the surface, moderately in males, less so in females. The cephalometric lower face height (SN₁-ME) of males was severely and in females moderately smaller compared with the anthropometric findings (sn-gn). The lower alveolar height (ID-ME) was in both sexes severely significantly smaller than the corresponding anthropometric measurement (sto-gn) (Table 1).

Comparison of Anthropometric and Cephalometric Proportion Indices in Men and Women

For males and females all 12 cephalometric indices were smaller than the anthropometric ones. In males, the difference in 2 indices was not significant, 10 were significant: 4 mild, 2 moderate and 4 of severe degree. In females, 3 of the 12 indices did not show significant difference. Of the 9 significantly differing ones 1 was mild, 3 moderate and 5 of severe degree.

The relation of the nose height to the upper face height (n-sn/n-sto) in both sexes and examination

methods was almost identical. The anthropometric mandible-lower face height index (sto-gn/sn-gn) in males did not differ significantly from the cephalometric one (ID-ME/SN₁-ME), but in females it was moderately significantly smaller. In females the non-significantly differing anthropometric sn-sto/n-sto and the cephalometric SN₁-SD/N-SD indices in males the cephalometric index was mildly significantly greater. Similar results were found in the relationship of the upper lip-nose heights (sn-sto/n-sn versus SN₁-SD/N-SN₁).

Highly significant differences were observed in the cephalometric and anthropometric upper face-face height (N-SD/N-ME versus n-sto/n-gn) upper lip-mandible height (SN₁-SD/ID-ME versus sn-sto/sto-gn) and upper lip-lower face height (SN₁-SD/SN₁-ME versus sn-sto/sn-gn) relation, in both sexes. Highly significantly smaller cephalometric than anthropometric indices (ID-ME/N-ME versus sto-gn/n-gn) and (ID-ME/N-SD versus sto-gn/n-sto) of severe degree were found for females, but only moderately significant for males (Table 3).

Sex-Related Differences Between Anthropometric and Cephalometric Proportion Indices

Generally there was no significant difference between the mean values in the sexes. In 6 of 12 anthropometric proportion indices of slightly higher mean values were found for males, the other half in females. For the cephalometric proportion indices, in 75% (9 of 12) a slightly higher frequency of mean values was reported in males and in 25% (3 of 12) of females (in N-SN₁, N-ME, N-SN₁, N-SD) and (SN₁-SD/ID-ME) (Table 2).

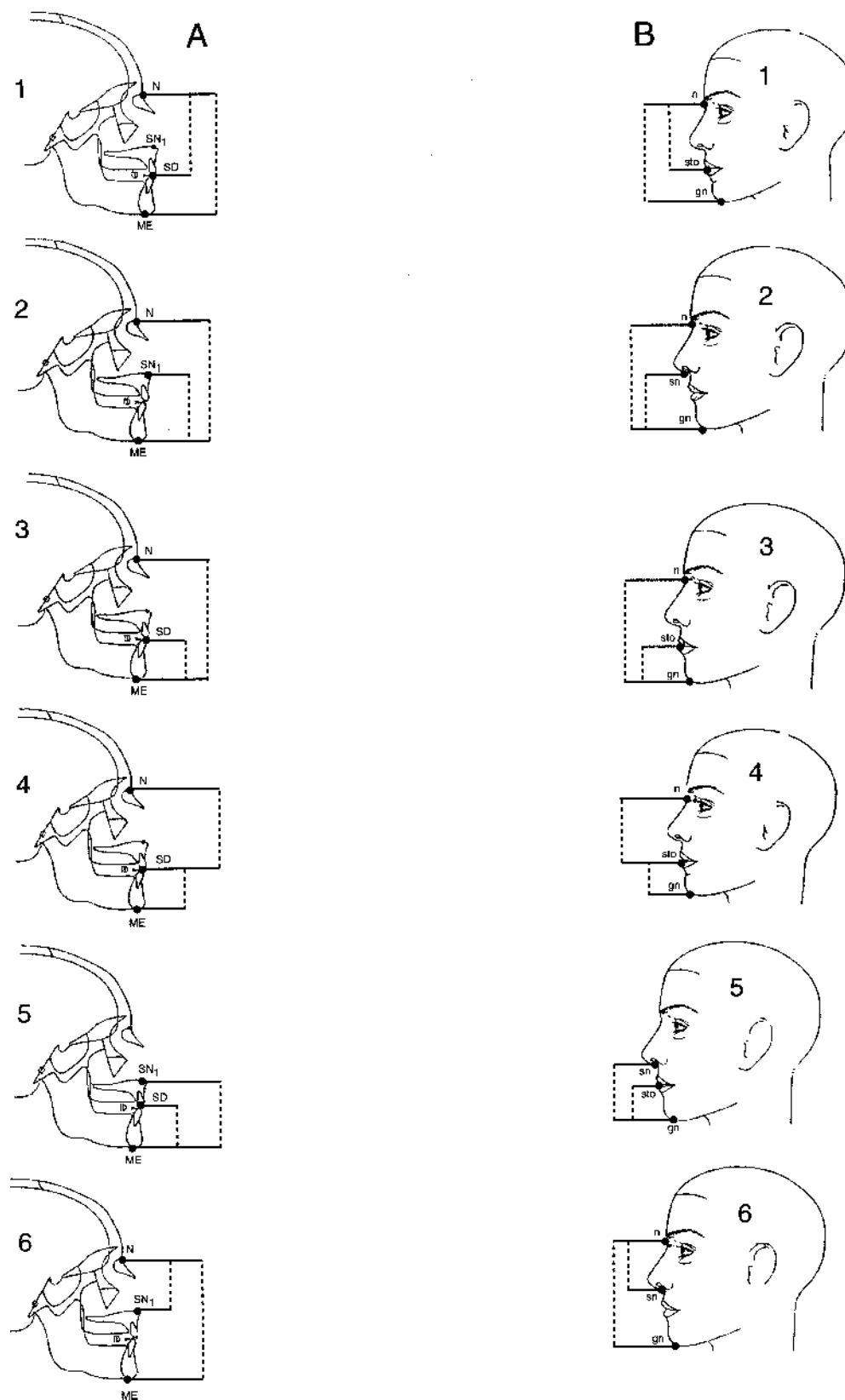


Fig 2 Cephalometric (A) and anthropometric (B) proportion indices. (A) 1. N-SD/M-ME; 2. SN₁-ME/N-ME; 3. ID-ME/N-ME; 4. ID-ME/N-SD; 5. ID-ME/SN₁-ME; 6. N-SN₁/N-ME. (B) 1. n-sto/n-gn; 2. sn-gn/n-gn; 3. sto-gn/n-gn; 4. sto-gn/n-sto; 5. sto-gn/sn-gn; 6. n-sn/n-gn.

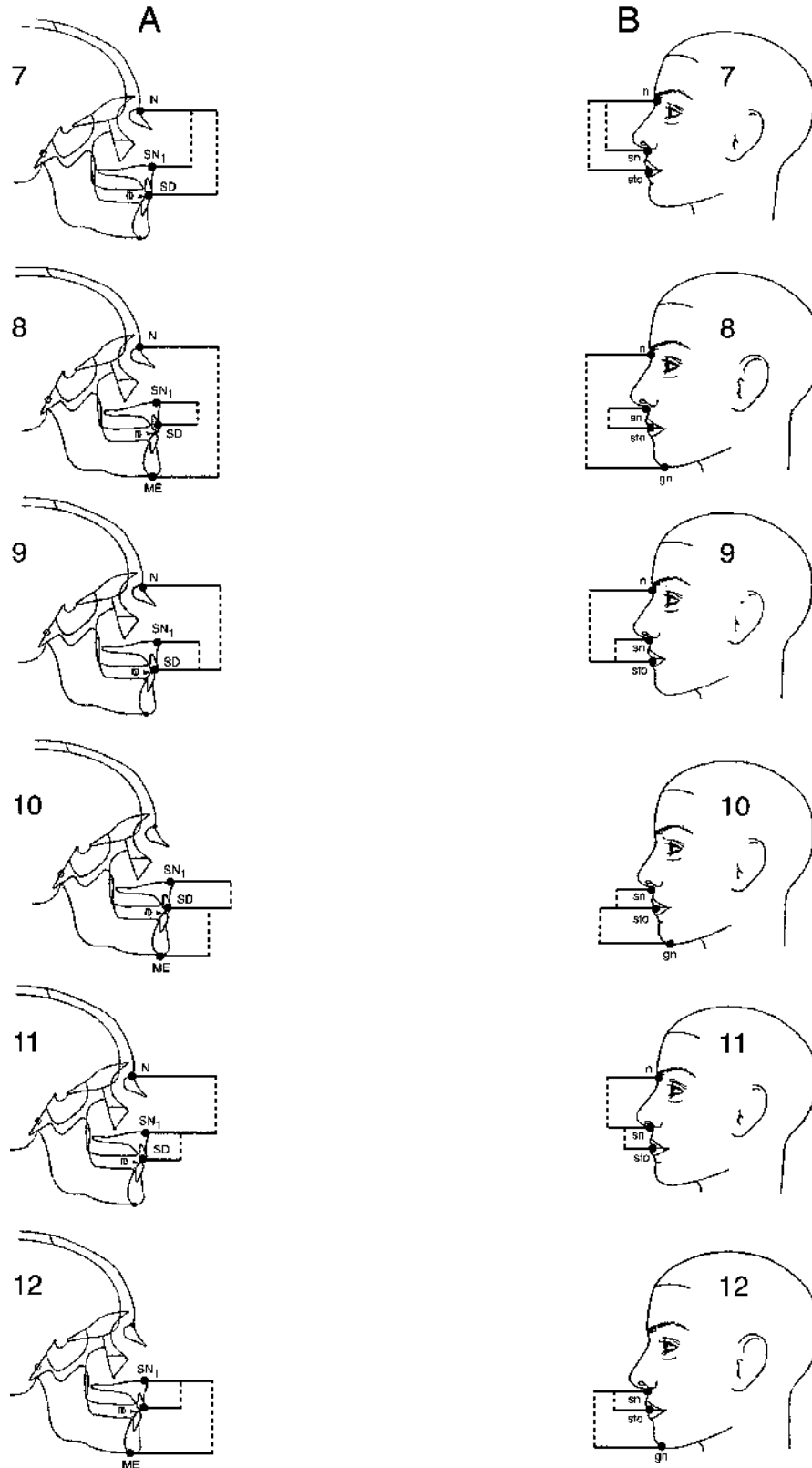


Fig 2 (continued) Cephalometric (A) and anthropometric (B) proportion indices. (A) 7. N-SN₁/N-SD; 8. SN₁-SD/N-ME; 9. SN₁-SD/N-SD; 10. SN₁-SD/ID-ME; 11. SN₁-SD/N-SN₁; 12. SN₁-SD/SN₁-ME. (B) 7. n-sn/n-sto; 8. sn-sto/n-gn; 9. sn-sto/n-sto; 10. sn-sto/sto-gn; 11. sn-sto/n-sn; 12. sn-sto/sn-gn.

Table 3. Comparison of Anthropometric and Cephalometric Proportion Indices in Males and Females

Males (25)					Females (26)				
		Index	Mean	SD			Index	Mean	SD
1	A	n-sto/n-gn	62.8	3.8	SIG	A	n-sto/n-gn	63.5	2.4
	C	N-SD/N-ME	68.1	4.9	(SEV)	C	N-SD/N-ME	67.3	4.1
2	A	sn-gn/n-gn	58.8	2.9	SIG	A	sn-gn/n-gn	58.2	3.1
	C	SN ₁ -ME/N-ME	56.5	3.2	(M)	C	SN ₁ -ME/N-ME	55.7	3.2
3	A	sto-gn/n-gn	37.6	3.1	SIG	A	sto-gn/n-gn	37.5	2.7
	C	ID-ME/N-ME	34.8	3.2	(MOD)	C	ID-ME/N-ME	32.9	3.2
4	A	sto-gn/n-sto	60.4	8.4	SIG	A	sto-ng/n-sto	59.2	5.2
	C	ID-ME/N-SD	51.5	6.9	(MOD)	C	ID-ME/N-SD	49.2	6.9
5	A	sto-gn/sn-gn	65.9	5.7	NS	A	sto-gn/sn-gn	64.4	3.1
	C	ID-ME/SN ₁ -ME	61.6	4.3		C	ID-ME/SN ₁ -ME	59.2	5.5
6	A	n-sn/n-gn	42.1	3.3	SIG	A	n-sn/n-gn	42.6	2.6
	C	N-SN ₁ /N-ME	44.1	2.9	(M)	C	N-SN ₁ /N-ME	44.3	2.5
7	A	n-sn/n-sto	67.0	3.7	NS	A	n-sn/n-sto	67.6	4.0
	C	N-SN ₁ /N-SD	65.0	5.3		C	N-SN ₁ /N-SD	66.1	6.5
8	A	sn-sto/n-gn	20.7	2.6	SIG	A	sn-sto/n-gn	21.3	1.9
	C	SN ₁ -SD/N-ME	24.1	2.9	(SEV)	C	SN ₁ -SD/N-ME	22.9	2.6
9	A	sn-sto/n-sto	32.8	3.6	SIG	A	sn-sto/n-sto	32.2	3.3
	C	SN ₁ -SD/N-SD	35.6	4.9	(M)	C	SN ₁ -SD/N-SD	34.1	4.2
10	A	sn-sto/sto-gn	54.8	8.7	SIG	A	sn-sto/sto-gn	52.7	11.1
	C	SN ₁ -SD/ID-ME	69.8	9.8	(SEV)	C	SN ₁ -SD/ID-ME	70.4	11.2
11	A	sn-sto/n-sn	48.9	8.1	SIG	A	sn-sto/n-sn	50.0	7.2
	C	SN ₁ -SD/N-SN ₁	55.1	8.5	(M)	C	SN ₁ -SD/N-SN ₁	52.1	8.1
12	A	sn-sto/sn-gn	35.2	4.1	SIG	A	sn-sto/sn-gn	36.2	3.4
	C	SN ₁ -SD/SN ₁ -ME	42.7	4.5	(SEV)	C	SN ₁ -SD/SN ₁ -ME	41.1	3.8

A, Anthropometric; C, Cephalometric; SD, Standard deviation; NS, not significant; SIG, significant; M, mild ($p = 0.04-0.01$); MOD, moderate ($P = 0.009-0.0002$); SEV, severe ($p \leq 0.0001$).

DISCUSSION

It is well known that the physiognomy of the face is greatly influenced by the shape and size of the underlying skeleton.⁷ The importance of analyzing the differences between the anthropometric and cephalometric measurements was emphasized by orthodontists.⁸ The introduction of anthropometry as a method for objective determination of the morphological changes on the facial surface² offered the opportunity for quantitative evaluation in relation to the cephalometric findings in patients with facial anomalies.¹

Databases established in this study for measurements, both on the surface and the skeleton of the face of adult healthy subjects, make it possible to determine the quantitative differences between the measurements and the proportion indices obtained by the two examination methods. The z-score analysis of the measurements revealed an overwhelmingly high percentage of normal measurements, 96.7% on the surface and 94.4% on the skeleton of the face of the total 306 measurements.

The presence of smaller cephalometric than anthropometric measurements in the face has been observed in other studies.^{1,9} In contrast, subnormal cephalometric measurements were found in a slightly higher percentage in cephalometric (3.3%, 10 of 306) than in surface measurements (2.6%, 8 of 306).

The main focus of this study was to determine the differences between the anatomical level of landmarks in healthy subjects. The comparison of the anthropometric and cephalometric landmarks in patients with facial anomalies revealed justifiable problems.^{10,11} Using faces of healthy subjects provided the opportunity to examine the quantitative relationship between the anatomical level of anthropometric and cephalometric landmarks. The morphological position of the nasion (n) and gnathion (gn) surface landmarks appeared to be well balanced with their cephalometric counterparts (NASION, N and MENTON, ME).

Analysis of the data for the subnasale (sn) surface point revealed a slightly higher position than the cephalometric SUBNASALE (SN₁), but the SUPRADENTALE (SD) and the INFRADENTALE

(ID) cephalometric landmarks, considered to be closest to the location level of the stomion (sto) on the surface, revealed varied locations, hence were half responsible for the significant differences between the findings of the two examination methods. The frequency in the values of proportions showed even greater differences in females with 33.3% of similar and 66.7% of significantly dissimilar indices. In the significantly differing measurements and proportions the unstable location of the SD and ID landmarks was the main factor for creating the highly significant differences between the anthropometric and cephalometric measurements and proportions. The variations in location of the SUPRADENTALE (SD) and INFRADENTALE (ID) landmarks in healthy subjects proved to be a disturbing factor in quantitative evaluation of the linear measurements in the lower half of the facial skeleton. It may be assumed, that in patients with facial disfigurements in this area of the face the location of the cephalometric landmarks could be exposed to greater aberration from the normal, than in other areas of the facial skeleton.

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