

# Cephalometric Floating Norms for Czech Adults

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**Abstract:** The purpose of this study was to establish floating cephalometric norms for the description of the individual skeletal pattern in Czech adults. Floating norms provide a method of analysis that uses the variability of the associations among suitable cephalometric measures, on the basis of the regression model combining both sagittal and vertical skeletal parameters. Harmony box is a simple and useful tool for diagnostics of orthodontic anomalies according to individual cephalometric norms. 118 subjects, 53 male and 65 female, from Czech population were selected. The method of multiple regression analysis was used to determine interdependence among five cephalometric variables of the sample. Linear regression equations with corresponding  $r^2$  and standard error of the estimate (SE) were then illustrated as the harmony box. The results construct a harmony box based on correlated cephalometric variables. The multiple regression analysis of the data is graphically illustrated as a harmony schema which divides harmony box in three zones according to the type of the face – prognathic, orthognathic and retrognathic. The cephalometric floating norms describing the individual craniofacial pattern among Czech adults were established based on five correlated variables in the form of a harmony box.

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**Introduction**

The need for lateral cephalometric analysis in orthodontic diagnosis and treatment planning is well established. The goal of cephalometric analysis is to estimate the relationship, vertically and horizontally of the jaws to the cranial base and to each other, the relationships of the teeth to their supporting bone, and the effect of the teeth on the profile (Wahl, 2006). The principle is that the radiographic measurements of each patient are compared with normative values. After Broadbent (1931) and Hofrath (1931) who simultaneously published methods used to obtain standardized head radiographs in 1931, numerous cephalometric analyses related to standardized norms were developed. Orthodontists use the values of those measurements or norms for their diagnosis, treatment, and assessment of orthodontic treatment outcomes (Proffit et al., 1992; Tahir et al., 1997; Alcalde et al., 1998).

The criteria of the samples for the cephalometric norms were estimated for untreated subjects of same ethnic group with well balanced face and normal occlusion. These measurements with their standard deviations provided guidelines for orthodontic diagnosis and treatment planning. The conventional cephalometric analysis doesn't take into account the possible interdependence among the cephalometric variables and compare each cephalometric value of the patient with an appropriate normative value separately. However, the appropriate application

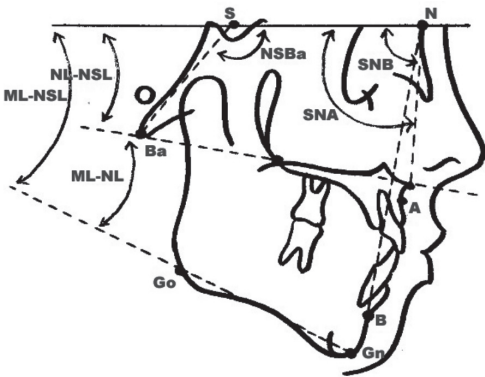


Figure 1 – Cephalometric points with corresponding angular variables.

	SNA	NL-NSL	NSBa	ML-NSL	SNB	ML-NL
Retrognath	62		141	43	64	28
	63			42	65	
	64	14	140	41	66	27
	65	●		40	67	●
	66	13	139	39	68	26
	67	●	138	38	69	●
	68	12		37	70	25
	69	●	137	36	71	●
	70	11	136	35	72	24
	71	●		34	73	●
	72	10	135	33	74	23
	73	●	134	32	75	●
	74	9	133	31	76	22
75	●		30	77	●	
76	8	132	29	78	21	
77	●	131	28	79	●	
78	7		27	80	20	
79	●	130	26	81	●	
80	6	129	25	82	19	
81	●	128	24	83	●	
82	5	127	23	84	18	
83	●	126	22	85	●	
84	4	125	21	86	17	
85	●	124	20	87	●	
86	3	123	19	88	16	
87	●	122	18	89	●	
88	2	121	17	90	14	
89	●		16	91	●	
90	1		15	92	13	
91	●		14	93	●	
92				94	●	
93				95	13	
94				96	●	
95				97	●	
96						
97						
98						
99						
100						
101						
102						
103						

Figure 2 – Segner-Hasund harmony box.

of any cephalometric analysis must be used with norms derived from populations similar to the orthodontic patients with regard to ethnic group, gender, and age (Athanasίου, 1997). The cephalometric norms don't have to represent a real situation in craniofacial skeletal system but they are necessary to evaluate a measured diagnostic value. Solow (1966) in his study "The pattern of the craniofacial associations" demonstrated significant correlations between sagittal and vertical cephalometric variables, leading to the concept of "craniofacial pattern". This implies that even though all cephalometric values of a patient lie beyond one standard deviation (SD) from the population, they still may be considered acceptable if they maintain a certain correlation with each other (Sevilla-Naranjilla and Rudzki-Janson, 2009). Hasund et al. (1974) first described combinations of acceptable values for different facial types. Finally, a comprehensive analysis for the assessment of individual craniofacial patterns was performed by Segner (1989) and Segner and Hasund (1994), who constructed floating norms for the description of sagittal and vertical skeletal relationships in a sample of European adults. The method is based on the correlations among the following craniofacial measurements: SNA, SNB, NL-NSL, ML-NSL, and NSBa (Figure 1). Interdependence between two cephalometric variables is described by linear correlation coefficient "r" (Segner and Hasund, 1994).

The concept of harmony box was established by Segner (1989) and Segner and Hasund (1994) and at present is widely used its improved form as a Segner-Hasund harmony box (Segner and Hasund, 1998) (Figure 2). The linear regression analysis was used to construct a harmony schema, which contained the cephalometric floating norms of the five correlated variables. The harmony box is divided into three zones – retrognathic, orthognathic, and prognathic zones – depending on the ANB value of the subject. Angle ANB represents the anteroposterior relationship of the maxilla with the mandible (Zwemer, 1998).

The cephalometric variables are illustrated graphically and their values are arranged in five columns. A horizontal line connecting the values of these cephalometric variables inside the box represents the harmony line of the subject. A straight horizontal line suggests that the face is harmonious, and the facial type is determined according to the zone where the cephalometric values of the subject fall. For every horizontal harmony line, a range of accepted variability is allowed, which is derived from the standard error of the estimate (SE) of the multiple regression analysis and is represented by the harmony schema (Sevilla-Naranjilla and Rudzki-Janson, 2009).

The harmony schema varies by the different population group. When the cephalometric values of the subject lie inside the harmony schema for appropriate population group (the value maintains a certain correlation with each other according to SD) the skeletal pattern of the subject may be considered harmonious. By this means the harmony schema determines a facial type. Any value that lies outside the schema is a parameter that causes disharmony to the face. The face is considered to be disharmonious (Sevilla-Naranjilla and Rudzki-Janson,

2009). The floating norms are nowadays a valuable diagnostic tool in orthodontics. In 1998 Franchi, Baccetti, and McNamara established a floating norms for North American adults. Ngarmprasertchai (2002) and Mahaini (2005) provided floating norms for Thais and Syrians. Tollaro and co-workers (1996) established floating norms for the southern European children with full deciduous dentition. In 2009 Sevilla-Naranjilla and Rudzki-Janson presented floating norms for Filipinos. The purpose of this study was to establish floating norms for the description of the individual skeletal pattern in Czech adults.

### Material and Methods

The sample comprised Caucasian 118 subjects aged 18–45 (mean 26.3 years, SD 7.2 years), 53 males (mean age 26.1 years, SD 8.3 years) and 65 females (mean age 26.4 years, SD 6.1 years) from Czech Republic. The selection criteria for the study were: well-balanced profile, ideal or near-ideal occlusion (Class I molar relationship, Class I canine relationship) and no previous orthodontic treatment. Lateral cephalograms were taken in centric occlusion with lips in repose and natural head position.

Cephalometric points were digitized and the five cephalometric angular measurements were obtained using the PC Dent program (version 3.0.2). These angular measurements were: SNA (maxillary prognathism), SNB (mandibular prognathism), NL-NSL (maxillary inclination relative to the cranial base), ML-NSL (mandibular inclination relative to the cranial base), and NSBa (cranial base angle). The method error was determined by retracing and measuring 10 randomly selected radiographs again, which generated an average error of less than 0.4 degree.

### Statistical analysis

The statistical examination for the measured data comprised: calculation of Pearson's correlation coefficients, bivariate linear regression analysis and multiple linear regression analysis.

### Results

Table 1 shows descriptive statistics for all of the five angular measurements with relevant standard deviation (SD). Table 2 describes correlation coefficients ( $r$ ) between the five cephalometric variables. Linear regressions with corresponding  $r^2$  and standard error of the estimate (SE) of Czech adults are shown in Table 3 and illustrated as the harmony box in Figure 3. The multiple correlation coefficients ( $r$ ), the adjusted  $r^2$  and the standard error of the estimate when one of the variables SNA, SNB, NL-NSL, ML-NSL, NSBa is predicted from the other four by means of multiple regression analysis is graphically illustrated as harmony schema for Czech adults in Figure 4. The mean values of five variables inside the harmony schema form a harmony line (Figure 5).

**Table 1 – Descriptive statistics (n=118)**

Variables	Mean	SD	Min	Max
SNA	81.96	3.15	73.30	88.50
NL-NSL	7.60	2.89	0.80	16.10
NSBa	130.64	4.35	118.60	143.30
ML-NSL	29.74	4.71	13.60	40.90
SNB	79.72	3.28	70.90	86.90
ML-NL	22.12	4.39	10.50	32.20

**Table 2 – Linear correlation coefficients (r) between SNA, NL-NSL, NSBa, ML-NSL, and SNB of Czech adults (n=118)**

Variables	SNA	NL-NSL	NSBa	ML-NSL	SNB
SNA	1				
NL-NSL	-0.45*	1			
NSBa	-0.45*	0.4**	1		
ML-NSL	-0.37*	0.42**	0.21**	1	
SNB	0.84*	-0.55**	-0.42**	-0.56**	1

\*P&lt;0.01; \*\*P&lt;0.05

**Table 3 – Linear regressions with corresponding r<sup>2</sup> and standard error of the estimate (SE) of Czech adults (n=118)**

Variables	Regression equation	r <sup>2</sup>	SE
NL-NSL	= -0.411×SNA+41.308	0.20	2.60
NSBa	= -0.625×SNA+181.83	0.20	3.90
ML-NSL	= -0.547×SNA+74.547	0.13	4.40
SNB	= 0.876×SNA+7.965	0.71	1.78
SNA	= -0.327×NSBa+124.67	0.20	2.82
SNB	= -0.3171×NSBa+121.14	0.18	2.99
ML-NSL	= -0.804×SNB+93.795	0.31	3.92

	SNA	NL-SNL	NSBa	ML-NSL	SNB	ML-NL
Retrognath	62.0	15.8	143.1	40.7	62.2	25.0
	63.0	15.4	142.5	40.1	63.1	24.9
	64.0	15.0	141.9	39.6	64.0	24.7
	65.0	14.6	141.2	39.0	64.9	24.6
	66.0	14.2	140.6	38.5	65.7	24.4
	67.0	13.8	140.0	37.9	66.6	24.3
	68.0	13.3	139.4	37.4	67.5	24.2
	69.0	12.9	138.7	36.8	68.4	24.0
	70.0	12.5	138.1	36.3	69.2	23.9
	71.0	12.1	137.5	35.7	70.1	23.7
72.0	11.7	136.9	35.2	71.0	23.6	
73.0	11.3	136.2	34.6	71.9	23.4	
74.0	10.9	135.6	34.1	72.8	23.3	
75.0	10.5	135.0	33.5	73.6	23.1	
76.0	10.0	134.4	33.0	74.5	23.0	
77.0	9.6	133.7	32.5	75.4	22.8	
78.0	9.2	133.1	31.9	76.3	22.7	
79.0	8.8	132.5	31.4	77.1	22.6	
80.0	8.4	131.9	30.8	78.0	22.4	
81.0	8.0	131.2	30.3	78.9	22.3	
82.0	7.6	130.6	29.7	79.8	22.1	
83.0	7.2	130.0	29.2	80.6	22.0	
84.0	6.8	129.4	28.6	81.5	21.8	
85.0	6.3	128.7	28.1	82.4	21.7	
86.0	5.9	128.1	27.5	83.3	21.5	
87.0	5.5	127.5	27.0	84.1	21.4	
88.0	5.1	126.9	26.4	85.0	21.2	
89.0	4.7	126.2	25.9	85.9	21.1	
90.0	4.3	125.6	25.3	86.8	20.9	
91.0	3.9	125.0	24.8	87.6	20.8	
92.0	3.5	124.4	24.3	88.5	20.7	
93.0	3.1	123.8	23.7	89.4	20.5	
94.0	2.6	123.1	23.2	90.3	20.4	
95.0	2.2	122.5	22.6	91.1	20.2	
96.0	1.8	121.9	22.1	92.0	20.1	
97.0	1.4	121.3	21.5	92.9	19.9	
98.0	1.0	120.6	21.0	93.8	19.8	
99.0	0.6	120.0	20.4	94.6	19.6	
100.0	0.2	119.4	19.9	95.5	19.5	
101.0	-0.2	118.8	19.3	96.4	19.3	
102.0	-0.6	118.1	18.8	97.3	19.2	
103.0	-1.1	117.5	18.2	98.1	19.0	

Figure 3 – Harmony box for Czech adults.

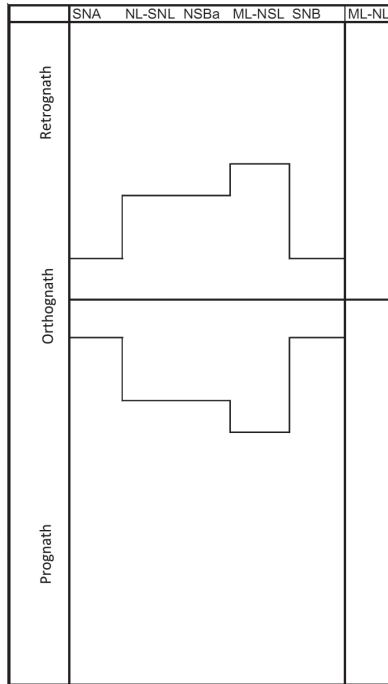


Figure 4 – Harmony schema for Czech adults.

	SNA	NL-SNL	NSBa	ML-NSL	SNB	ML-NL
Retrognath	62.0	15.8	143.1	40.7	62.2	25.0
	63.0	15.4	142.5	40.1	63.1	24.9
	64.0	15.0	141.9	39.6	64.0	24.7
	65.0	14.6	141.2	39.0	64.9	24.6
	66.0	14.2	140.6	38.5	65.7	24.4
	67.0	13.8	140.0	37.9	66.6	24.3
	68.0	13.3	139.4	37.4	67.5	24.2
	69.0	12.9	138.7	36.8	68.4	24.0
	70.0	12.5	138.1	36.3	69.2	23.9
	71.0	12.1	137.5	35.7	70.1	23.7
72.0	11.7	136.9	35.2	71.0	23.6	
73.0	11.3	136.2	34.6	71.9	23.4	
74.0	10.9	135.6	34.1	72.8	23.3	
75.0	10.5	135.0	33.5	73.6	23.1	
76.0	10.0	134.4	33.0	74.5	23.0	
77.0	9.6	133.7	32.5	75.4	22.8	
78.0	9.2	133.1	31.9	76.3	22.7	
79.0	8.8	132.5	31.4	77.1	22.6	
80.0	8.4	131.9	30.8	78.0	22.4	
81.0	8.0	131.2	30.3	78.9	22.3	
82.0	7.6	130.6	29.7	79.8	22.1	
83.0	7.2	130.0	29.2	80.6	22.0	
84.0	6.8	129.4	28.6	81.5	21.8	
85.0	6.3	128.7	28.1	82.4	21.7	
86.0	5.9	128.1	27.5	83.3	21.5	
87.0	5.5	127.5	27.0	84.1	21.4	
88.0	5.1	126.9	26.4	85.0	21.2	
89.0	4.7	126.2	25.9	85.9	21.1	
90.0	4.3	125.6	25.3	86.8	20.9	
91.0	3.9	125.0	24.8	87.6	20.8	
92.0	3.5	124.4	24.3	88.5	20.7	
93.0	3.1	123.8	23.7	89.4	20.5	
94.0	2.6	123.1	23.2	90.3	20.4	
95.0	2.2	122.5	22.6	91.1	20.2	
96.0	1.8	121.9	22.1	92.0	20.1	
97.0	1.4	121.3	21.5	92.9	19.9	
98.0	1.0	120.6	21.0	93.8	19.8	
99.0	0.6	120.0	20.4	94.6	19.6	
100.0	0.2	119.4	19.9	95.5	19.5	
101.0	-0.2	118.8	19.3	96.4	19.3	
102.0	-0.6	118.1	18.8	97.3	19.2	
103.0	-1.1	117.5	18.2	98.1	19.0	

Figure 5 – Harmonious combinations.

	SNA	NL-SNL	NSBa	ML-NSL	SNB	ML-NL
Retrognath	62.0	15.8	143.1	40.7	62.2	25.0
	63.0	15.4	142.5	40.1	63.1	24.9
	64.0	15.0	141.9	39.6	64.0	24.7
	65.0	14.6	141.2	39.0	64.9	24.6
	66.0	14.2	140.6	38.5	65.7	24.4
	67.0	13.8	140.0	37.9	66.6	24.3
	68.0	13.3	139.4	37.4	67.5	24.2
	69.0	12.9	138.7	36.8	68.4	24.0
	70.0	12.5	138.1	36.3	69.2	23.9
	71.0	12.1	137.5	35.7	70.1	23.7
72.0	11.7	136.9	35.2	71.0	23.6	
73.0	11.3	136.2	34.6	71.9	23.4	
74.0	10.9	135.6	34.1	72.8	23.3	
75.0	10.5	135.0	33.5	73.6	23.1	
76.0	10.0	134.4	33.0	74.5	23.0	
77.0	9.6	133.7	32.5	75.4	22.8	
78.0	9.2	133.1	31.9	76.3	22.7	
79.0	8.8	132.5	31.4	77.1	22.6	
80.0	8.4	131.9	30.8	78.0	22.4	
81.0	8.0	131.2	30.3	78.9	22.3	
82.0	7.6	130.6	29.7	79.8	22.1	
83.0	7.2	130.0	29.2	80.6	22.0	
84.0	6.8	129.4	28.6	81.5	21.8	
85.0	6.3	128.7	28.1	82.4	21.7	
86.0	5.9	128.1	27.5	83.3	21.5	
87.0	5.5	127.5	27.0	84.1	21.4	
88.0	5.1	126.9	26.4	85.0	21.2	
89.0	4.7	126.2	25.9	85.9	21.1	
90.0	4.3	125.6	25.3	86.8	20.9	
91.0	3.9	125.0	24.8	87.6	20.8	
92.0	3.5	124.4	24.3	88.5	20.7	
93.0	3.1	123.8	23.7	89.4	20.5	
94.0	2.6	123.1	23.2	90.3	20.4	
95.0	2.2	122.5	22.6	91.1	20.2	
96.0	1.8	121.9	22.1	92.0	20.1	
97.0	1.4	121.3	21.5	92.9	19.9	
98.0	1.0	120.6	21.0	93.8	19.8	
99.0	0.6	120.0	20.4	94.6	19.6	
100.0	0.2	119.4	19.9	95.5	19.5	
101.0	-0.2	118.8	19.3	96.4	19.3	
102.0	-0.6	118.1	18.8	97.3	19.2	
103.0	-1.1	117.5	18.2	98.1	19.0	

Figure 6 – Comparison Czech adults (connected line) with North American adults (dashed line).

## Discussion

The Segner-Hasund harmony box is a useful auxiliary diagnostic tool to determine craniofacial anomalies in orthodontics and maxillofacial surgery. The conventional cephalometric analysis compares the cephalometric measurements of the individual patient with the cephalometric norms of corresponding ethnic or population group. The craniofacial skeleton is not then considered as one unit with certain harmonic rules. As long as the cephalometric measurements of the subject lie inside the harmony schema (despite their absolute values) the skeletal pattern may be considered harmonious. A harmonious combination from a correlation point of view would not necessarily require the values to lie on a perfectly straight horizontal line (Segner, 1989).

According to three zones inside the box (prognathic, orthognathic and retrognathic) a type of face may be described as prognathic but still harmonious, orthognathic and harmonious and retrognathic and harmonious.

The harmony schema is constructed by computing the SE when one of the cephalometric variables is predicted from the other four by multiple regression analysis (Table 3). It represents the degree of variability allowed among the five correlated cephalometric measurements for describing a harmonious face. It could be shifted on the different zones of the harmony box to include all five cephalometric variables of a subject (Sevilla-Naranjilla and Rudzki-Janson, 2009). The individual floating norms are then different for every patient considering his individual morphology.

Figure 6 shows comparison of mean cephalometric values of the five correlated variables among the North American Caucasian adults. All variables lie inside the harmony schema for Czech adults and in the orthognathic zone of harmony box. The line connecting the values of North Americans is shifted downward. This means that the North Americans have more prognathic type of face in comparison with Czech adults but their craniofacial morphology is not largely different.

## Conclusion

Cephalometric floating norms describing individual skeletal pattern based on correlation of five cephalometric variables are established for the Czech Caucasian adults. Results are graphically illustrated as a Hasund harmony box and harmony schema.

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