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Metrical Characterization and Correlative Dependences between Basic Measurements of Mandible Bone

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The aim of the present work is to make detailed metrical characterization of the mandible in bone material of individuals from both genders and to determine the correlations between investigated features. The research includes 128 mandibles of adults. The methods of Martin—Saller and Y. Yordanov are applied. In the present paper the data about 8 basic features of mandible bone are discussed — 6 linear and 2 angular. The evidences are statistically processed by variation and correlation analyses. The absolute metrical differences between both genders are with priority for males concerning all linear features, while for both angles it is for females. The mandible front width and the profile angle vary within wide limits concerning each bone. The correlative dependences between linear features of the mandible bone are positive. It is established that with the increment of the projection length and the ramus measurements, both angular features decrease.

Key words: mandible bone, metrical characterization, sexual differences, correlation analysis.

Introduction

The anatomical knowledge about facial-jaw region of the cranium is very detailed, although the facial skeleton continues to be an object of comprehensive investigations in different scientific fields. The mandible being a hard basis of the lower part of the face determines its shape to a large degree [9].The detailed metrical characterization of mandible bone could be applied in the objective determination of the possible operative correction magnitude concerning inborn and inherited sagital, vertical, transversal and combined mandible deformations [10]. From the literature review we established that in Bulgaria the purposeful anthropological investigations of the mandible in bone material are not enough and they are available only for individuals from the male gender [6].

The **aim** of the present work is to make detailed metrical characterization of the mandible in bone material of individuals from both genders and to determine the correlative dependences between investigated features.

Material and Methods

The presented data are result from metrical study, which includes 128 mandible bones of adults divided into two gender groups (each group subsumes 64 bones). The bone material

is from the collections of the Institute of Experimental Morphology and Anthropology with Museum — Bulgarian Academy of Sciences. The sex is determined by the methods of Martin — Saller [2], and the age — according to the methods of Valois (see ref. Yordanov [7]). The measurements are made by the methods of Martin — Saller [2] and Y. Yordanov [7]. The following instruments are used: small sliding compasses, goniometer, mandibulometer, Mollison's stand used for the orientation of the skull in the Frankfurt's plane. In the present paper data about 8 basic features of the mandible bone are discussed: mandible angle width and front width, projection length, height of the symphysis, height and smallest width of the ramus, mandibular and profile angle (angle of the chin).

By mathematic-statistical computing the following variation-statistical characteristics are calculated: mean value $\bar{x}$, standard deviation SD, error of mean value SEM, variation coefficient V, minimal and maximal value. Correlation analysis is applied as well. The correlative dependence is calculated by Pearson's coefficient. The strength of correlation's subordination is assessed by the empiric rules of Kalinov [8]:

Calculated value of r		Interpretation of the correlation
from 0.00 to 0.30	(from −0.30 to 0.00)	Very low positive (negative)
from 0.31 to 0.50	(from −0.50 to −0.31)	Low positive (negative)
from 0.51 to 0.70	(from −0.70 to −0.51)	Moderate positive (negative)
from 0.71 to 0.90	(from −0.90 to −0.71)	High positive (negative)
from 0.91 to 1.00	(from −1.00 to −0.91)	Very high positive (negative)

Concerning separate features, the valuation of sexual differences is made by the absolute metrical differences and their relative share, as well as by their standardization according to the Index of relative inter-group differences of Wolanski [4]. This index is applied to determine the sexual differences and is called Index of Sexual Differences (ISD). Its values submit the sexual differences to the Relative Index Units (IU).

$$ISD = 2\times\left[\left(\bar{x}_{males} - \bar{x}_{females}\right)\times 100\right] / \left(\bar{x}_{males} + \bar{x}_{females}\right).$$

The values of ISD, which are equal to zero, show absence of sexual differences; the positive values display relative priority for males, and the negative ones — for females.

The t-criterion of Student at $P \leq 0.05$ is used to determine the authenticity of the established sexual differences.

Results and Discussion

Linear and angular features of the mandible bone (Table 1, Fig. 1, 2)

Mandible angle width (measurement 66 by Martin—Saller) — the mean value of mandible angle width for male individuals is 100,12±0,81 mm, and for female ones — 95,88±0,79 mm. This size ranges from 86,0 mm to 113,5 mm in males and from 85,0 mm to 113,0 mm in females, i.e. the limits' variability of mandible angle width are very close concerning the individuals from both genders, although the mean value for males is 4,24 mm greater (4,42%), and the difference is statistically significant ($t = 3,75$).

Mandible front width (measurement 67 by Martin—Saller) — the average for male individuals is 45,12±0,32 mm, and for female ones — 44,53±0,31 mm. This size ranges

T a b l e 1. Biostatical characterization of the absolute mandible measurements and sexual differences

Features	Males							Females							Sexual differences		
	n		SD	SEM	V	min	max	*n*	*x*	SD	SEM	V	min	max	Absolute difference	t-test	ISD
Mandible angle width	**58**	100.12	6.18	0.81	6.17	86.0	113.5	**56**	95.88	5.92	0.79	6.18	85.0	113.0	4.24	3.75*	4.33
Mandible front width	**60**	45.12	2.49	0.32	5.52	40.0	54.0	**64**	44.53	2.51	0.31	5.64	40.0	53.0	0.59	1.32	1.32
Mandible length-projection	**64**	87.47	4.66	0.58	5.32	79.0	98.0	**64**	82.36	4.36	0.54	5.29	71.5	91.0	5.11	6.41*	6.02
Mandible height of the symphysis	**64**	32.69	2.83	0.35	8.66	28.0	39.0	**64**	29.23	3.30	0.41	11.29	20.0	35.0	3.46	6.37*	11.18
Mandible height of the ramus	**64**	64.23	4.38	0.55	6.83	52.0	73.5	**64**	56.94	5.02	0.63	8.82	46.5	69.5	7.29	8.75*	12.03
Mandible smallest width of the ramus	**64**	31.66	2.69	0.34	8.48	24.5	37.5	**64**	29.49	2.46	0.31	8.32	24.0	34.0	2.17	4.76*	7.08
Mandibular angle	**64**	120.51	5.83	0.73	4.83	106.0	134.5	**64**	125.53	6.81	0.85	5.42	109.5	141.5	-5.02	4.48*	-4.08
Profile angle of the mandible	**64**	85.48	5.94	0.74	6.95	68.0	99.0	**64**	86.19	7.47	0.93	8.67	65.0	106.0	-0.71	0.59	-0.82

– Priority for females
* $P \leq 0.05$

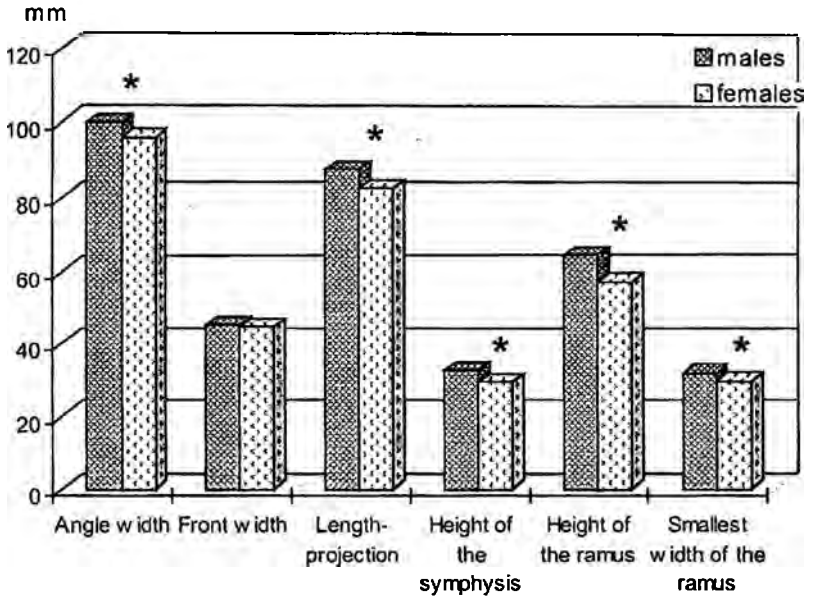

Fig. 1. Mean values of the linear features
* $P \leq 0.05$

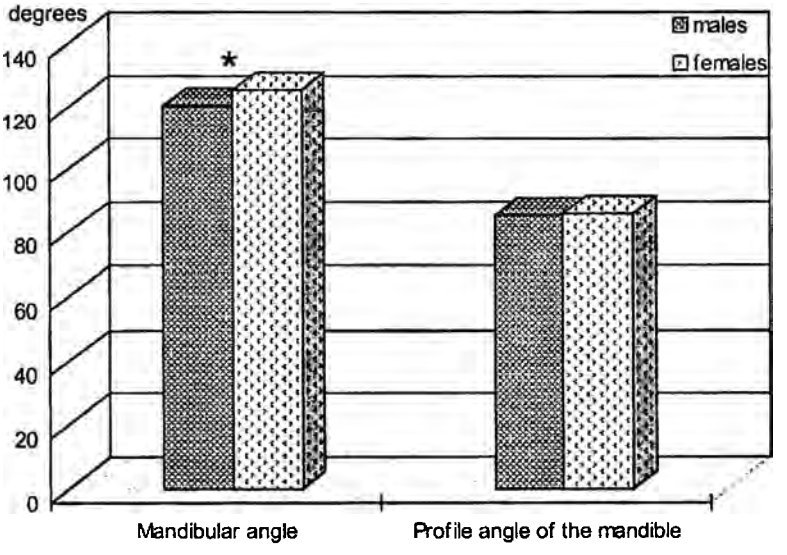

Fig. 2. Mean values of the angular features
* $P \leq 0.05$

from 40,0 mm to 54,0 mm for the males and from 40,0 mm до 53,0 mm for the females. It is obviously that the mean values, as well as the extent minimum-maximum are very close for the individuals from both genders and in contrast to the previous feature there is no statistical significance in this case ($t = 1,32$). This could be explained probably with the fact that mandible front width (respectively the position of foramen mentale) vary within broad limits in each individual and do not depend on his sexual appurtenance.

Mandible length – projection (measurement 68 by Martin–Saller) – the mean value of this feature for male individuals is 87,47±0,58 mm, and for female ones it is vastly lower - 82,36±0,54 mm. For males the average is 5,11 mm greater (6,20%), the difference being statistically significant ($t = 6,41$). The projection length varies from 79,0 mm to 98,0 mm in males, and from 71,5 mm to 91,0 mm in females.

Chin height – mandible height of the symphysis (measurement 69 by Martin–Saller) – the mean value of this mandible feature in individuals from the male gender is 32,69±0,35 mm, and in the female ones – 29,23±0,41 mm, as for the males the average is 3,46 mm greater (11,84%) and the difference is statistically significant ($t = 6,37$). The mandible height of the symphysis ranges from 28,0 mm to 39,0 mm in males and from 20,0 mm to 35,0 mm in females.

Mandible height of the ramus (measurement 70 by Martin–Saller) – the mean value in male gender is 64,23±0,55 mm, and in female one – 56,94±0,63 mm. The difference between both genders is 7,29 mm (12,80%), being the greatest compared to all the rest features measured by us ($t = 8,75$). The mandible height of the ramus varies from 52,0 mm to 73,5 mm in males and from 46,5 mm to 69,5 mm in females.

Mandible smallest width of the ramus (measurement 71a by Martin–Saller) – the mean value for individuals from the male gender is 31,66±0,34 mm, and for the female gender is 29,49±0,31 mm. For the male individuals the average is 2,17 mm greater (7,36%), and the difference is statistically significant ($t = 4,76$). This measurement ranges from 24,5 mm to 37,5 mm in males and from 24,0 mm to 34,0 mm in females.

Mandibular angle (measurement 79 by Martin–Saller) – the mean value of this angle in individuals from the male gender is 120,51±0,73°, and for the female ones – 125,53±0,85°. The mandibular angle varies from 106,0° to 134,5° for the male gender and from 109,5° to 141,5° for the female one. As it is known from the literature [1, 2, 5, 6, 7, 9, 10], our data also show greater value of the mandibular angle for individuals from the female gender, and the difference 5,02° (4,00%) is statistically significant ($t = 4,48$).

Profile angle of the mandible (measurement 79(1) by Martin–Saller) – concerning this angle the means for both genders are very close. The average for the male individuals is 85,48±0,74°, and for the female ones – 86,19±0,93°, as the difference 0,71° (0,82%) is in favour of the females but it is not statistically significant ($t = 0,59$). This fact gives us reason to suppose that the mandible front width, as well as the profile angle show a large individual variability. The variation limits of this angle change from 68,0° to 99,0° in the male individuals and from 65,0° to 106,0° for the female ones.

The sexual determination is very important for the study of bone material. The results obtained in the present investigation show that there are distinct sexual differences in sizes and shape of mandible bone, as these distinctions are most marked for the height of the ramus and of the symphysis. These differences are more pronounced in the ramus than in the body of the mandible. Nicholson and Harvati [3] in their publication cite authors, who have investigated sexual differences of the mandible (Morant et al., 1936; Martin, 1936; Hrdlička, 1940; De Villiers, 1968; Hunter and Garn, 1972; Humphrey et al., 1999). It is worth noting that the features with most substantial distinctions between male and female mandibles are identical in our research and in the studies of the authors, mentioned above (viz. the height of the ramus and of the symphysis).

Correlations between the investigated features of the mandible bone

The results from the correlation analysis have showed differences in the correlations' degree and directions in both genders.

Correlative coefficients between investigated features of the mandible bone in males – the values of the correlative coefficients are given in Table 2. Highest correlative dependence (but from moderate degree by Kalinov [8]) is established between the projection mandible length and the smallest width of the ramus ($r = 0,586$), as the relation is direct (directly proportional), i.e. when one feature's value increases the other value increases, too. The subordination is low positive between the mandible front width and the projection length ($r = 0,434$), as well as between the height of the symphysis and the profile angle ($r = 0,311$). It makes an impression that the relation is reverse (inversely proportional) between the height of the ramus and the mandibular angle ($r = -0,496$), as well as between the projection mandible length and the profile angle ($r = -0,400$). It gives us reason to suppose that by the increase of the linear measurements of the mandible, which is typical for the male individuals, the angular measurements decrease. The correlation dependence between rests of the features is very low and it would not be discussed.

Correlative coefficients between investigated features of the mandible bone in females — the values of the correlative coefficients are given in Table 3. Highest correlative dependence was established between the height of the ramus and the mandibular angle ($r = -0,542$), and the relation is inversely proportional, as it is in the male gender. The subordination is low positive between the mandible length and the smallest width of the ramus ($r = 0,499$), between the height of the symphysis and the profile angle ($r = 0,452$), between the mandible front width and the projection length ($r = 0,364$), between the smallest width and the height of the ramus ($r = 0,348$), between the mandible angle width and the mandibular angle ($r = 0,315$), as well as between both investigated angular features ($r = 0,335$). It makes an impression once again that the relation is reverse between the projection mandible length and both angles, and between the smallest width of the ramus and the mandibular angle. The correlation dependence between rests of the features is from a very low degree.

The comparison between correlative coefficients values in both genders showed lack of statistically significant differences.

Conclusion

1. All linear features, as a natural biological regularity, have higher absolute values of the mandible bones in male individualsing, while the both measured angles are with priority for females.

2. The mandible front width and the profile angle vary within broad limits concerning each individual and these features do not depend on the individuals' sexual appurtenance.

3. The results from correlation analysis show that the correlative dependences between linear features of the mandible bone are positive. It is established that by the increase of the projection length and the ramus measurements, both angular features decrease, i.e. the subordination between these measurements is inversely proportional.

T a b l e 2. Correlative coefficients between investigated features of the mandible bone in males

Features	Mandible angle width	Mandible front width	Mandible length-projection	Mandible height of the symphysis	Mandible height of the ramus	Mandible smallest width of the ramus	Mandibular angle	Profile angle of the mandible
Mandible angle width	1	0.146	0.181	0.173	0.179	0.272	0.268	-0.043
Mandible front width		1	0.434	0.055	0.157	0.239	0.016	-0.093
Mandible length-projection			1	0.142	0.239	0.586	-0.254	-0.400
Mandible height of the symphysis				1	0.221	0.218	0.108	0.311
Mandible height of the ramus					1	0.298	-0.496	-0.217
Mandible smallest width of the ramus						1	-0.215	-0.272
Mandibular angle							1	0.228
Profile angle of the mandible								1

T a b l e 3. Correlative coefficients between investigated features of the mandible bone in females

Features	Mandible angle width	Mandible front width	Mandible length-projection	Mandible height of the symphysis	Mandible height of the ramus	Mandible smallest width of the ramus	Mandibular angle	Profile angle of the mandible
Mandible angle width	1	0.251	-0.151	0.131	0.106	0.149	0.315	-0.033
Mandible front width		1	0.364	0.198	0.166	0.298	0.003	0.058
Mandible length-projection			1	-0.108	0.134	0.499	-0.444	-0.390
Mandible height of the symphysis				1	0.166	-0.057	0.183	0.452
Mandible height of the ramus					1	0.348	-0.542	-0.168
Mandible smallest width of the ramus						1	-0.412	-0.126
Mandibular angle							1	0.335
Profile angle of the mandible								1

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