DETERMINATION OF SEX BASED ON THE SHAPE AND SIZE OF THE HYOID BONE IN THE POPULATION OF BOSNIA AND HERZEGOVINA

SHORT TITLE: SEXUAL DIMORPHISM OF THE HYOID BONE

Elvira Talović[1]*, Alma Voljevica[1]

[1] Department of Anatomy, Faculty of Medicine, University of Sarajevo, Sarajevo, Bosnia and Hercegovina

*Corresponding author

Elvira Talović
Department of Anatomy,
Faculty of Medicine,
University of Sarajevo,
Čekaluša 90, 71000 Sarajevo,
Bosnia and Hercegovina
e-mail: elvira.talovic@mf.unsa.ba
Phone: + 387 33 665 949/506

ABSTRACT

The hyoid bone is typically a „U" shaped bone present in the anterior aspect of neck at the level of the fourth cervical vertebra, located between the mandible and thyroid cartilage. This bone displays morphological and morphometric characteristics that can assist in determination of age, sex and race of an individual.

Aim: Therefore, the present study aimed to investigate the morphological and morphometric parameters of the hyoid bone in the Bosnian and Hercegovina population.

Material and methods: Sixty adult human hyoid bones (32 male and 28 female) were used as material in this study. The morphological analysis included the macroscopic identification of the shape of the hyoid bones, and the morphometric analysis included the measurement of eight parameters using a standard digital vernier caliper keeping the bone on flat surface in anatomical position.

Results: In this study, 40.6 % of hyoid bones were „U" shaped and 59.4 % were „V" shaped in males, whereas in the female specimens, 64.3 % of hyoid bones were „U" shaped and 35.7 % „V" shaped. Values obtained for all eight parameters of hyoid bone were higher in males compared to females.

Conclusion: All parameters used in the present study confirmed sexual dimorphism in hyoid bone. Hence, hyoid bone can be considered in forensic investigations or anthropological studies to determine the sex of an individual.

Key Words: hyoid bone, shape, morphometry, sexual dimorphism

Introduction

Determination of sex is the first and crucial step in the process of identifying human remains in forensic casework [1,2]. Determining sex on the basis of human skeletal remains is a century-old problem, especially if sex needs to be determined using isolated bones. Different bones have different degrees of accuracy in sexing the adult from the skeletal remains. The degree of accuracy is 100% in complete skeleton, 95% for the pelvis, 90% for the skull, 98% for the pelvis and skull together, 80% for long bones [3]. Previous research has shown that morphological and morphometric analysis of the hyoid bone can also be a useful technique in determining sex skeleton [4].

Hyoid bone is a „U" shaped bone and part of viscerocranium placed between the tongue root and thyroid cartilage to which it is connected by thyrohyoid membrane. It is placed at the level of the fourth cervical vertebra and articulates with surrounding structures via muscles (suprahyoid and infrahyoid muscle groups) and ligaments (stylohyoid ligaments). It is also called an unsocial bone as it doesn't form any joint directly with other bones. It consists of a central part called body and a pair of cornua, and the greater and the smaller cornu [5]. Initially, it is a cartilaginous tissue which by age increasing gradually turns to bone [6-9]. The hyoid bone plays an important role in speaking, swallowing, preventing the reflux and maintaining the airway [6].

The present study aims to determine the sex of an individual based on the morphology and morphometric characteristic of the hyoid bone in the Bosnian and Hercegovina population.

Materials and Methods

Sixty adult human hyoid bones (32 male and 28 female) were used as material in this study. The hyoid bones of known sex and age (57±19), without visible gross pathology, deformities or traumatic lesions were included in the study, were taken from the osteological collection of the Department of Human Anatomy, Faculty of Medicine, University of Sarajevo. The hyoid bones were subjected to morphological and morphometric analysis.

Morphology of the hyoid bone

The shapes of hyoid bones were macroscopically noted and classified according to the system described by Deepak et al. as either „U" or hyperbolic shaped or „V" or parabolic shaped [10].

The shape of the hyoid bone, where the width is equal to or less than the length is noted as hyperbolic or „U" shaped, and the shape of the hyoid bone where the width is greater than the length is noted as parabolic or „V" shaped.

Morphometry of the hyoid bone

Morphometric measurements were performed using digital vernier calipers 0-1000 mm, 0.05 mm, Metric 530-502 (Mitutoyo Corporation, Japan), with a margin of error of 0.01 mm. All the measurements were repeated three times and the mean was taken for further analysis. Furthermore, the measurements were recorded by the same person to minimize the errors in methodology.

The following morphometric measurements were taken on each hyoid bone and keeping the bone on flat surface in anatomical position (Figure 1):

a. Length of right greater cornua (distance between junction of right lesser cornua and body to the tip of right greater cornua)
b. Length of left greater cornua (distance between junction of right lesser cornua and body to the tip of right greater cornua)
c. Breadth or width of hyoid (distance between the distal ends of greater cornua)
d. Length of hyoid (distance between a line through the distal ends of the greater cornua and center of hyoid body)
e. Minimum transverse distance between bases of lesser cornua
f. Width (side to side length) of the body in the midline
g. Distance between the upper and lower margins of the body (height)
h. Thickness (antero-posterior) of body in the middle

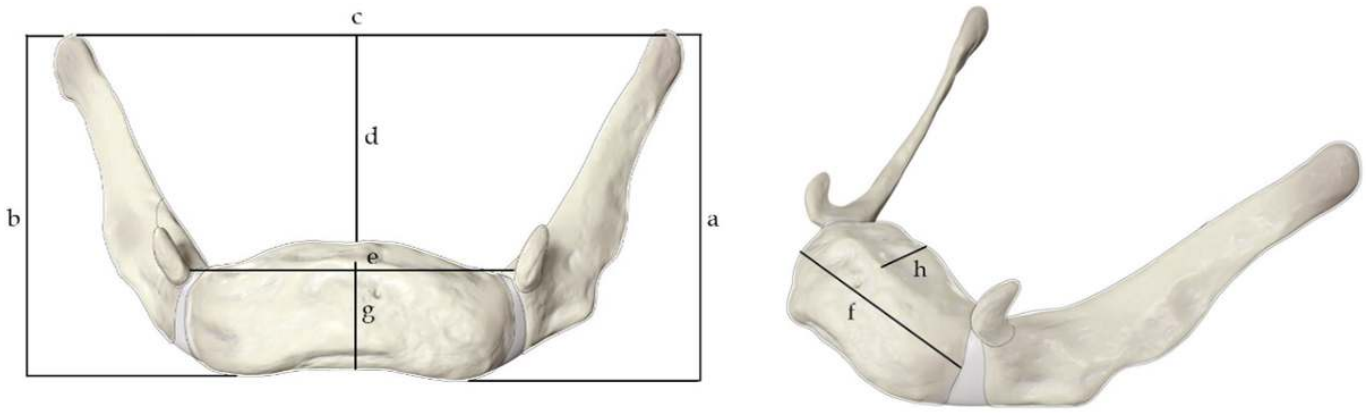

Figure 1. Diagram showing parameters (a to g) taken on each hyoid bone.

Statistical Analysis

All parameters were tabulated and statistically analyzed as mean, standard deviation and range using SPSS version 19 (SPSS Inc., Chicago, IL, USA), and data were compiled in Microsoft Excel 2020 (Microsoft Corp., Redmond, WA, USA). The chi-square test and the T-test were utilized to determine if there were any statistical significance differences. A P-value less than 0.05 was accepted as the level of statistical significance for this study.

Results

Morphology of the hyoid bone

This study examined 60 hyoid bones, the „U" shaped hyoid bone more prevalent than the „V" shaped hyoid bone, with an incidence of 51,7 % and 49,3 %, respectively. The present study documented that 40,6 % and 59,4 % of the males had a „U" shaped and „V" shaped hyoid bones, respectively. However, „U" shaped hyoid bone was most prevalent among the females in this study, with an incidence of 64,3 %, while the remaining 35,7 % of female hyoid bones was „V" shaped. This study found a statistically significant relationship between the shape of the hyoid bone and sex, with a p-value of 0.027. The results were collectively shown in Table 1.

Morphometry of the hyoid bone

By analyzing our study all the above eight parameters of the hyoid bone were more in males than females which are either highly significant ($p < 0.001$) or significant ($p < 0.005$). The mean and standard deviation of all parameters were calculated and tabulated in Table 2.

Shape	Male (n=32)	Female (n=28)	Total (n=60)	P - value
U - shaped	13 (40.6%)	18 (64.3%)	31 (51.7%)	0.027
V - shaped	19 (59.4%)	10 (35.7%)	29 (49.3%)	

Table 1. Frequency of shapes of hyoid bone for sex

SN	Anthropometric parameters	Males (N= 32)		Females (N=28)		p-value
		Mean ± SD	Range	Mean ± SD	Range	
a	Length of right greater cornua (distance between junction of right lesser cornua and body to the tip of right greater cornua)	31.31±2.65	29.75-37.6	28.78±2.71	23.89-29.25	P<0.005
b	Length of left greater cornua (distance between junction of left lesser cornua and body to the tip of left greater cornua)	31.69±2.61	27.49-37.65	28.30±2.55	23.63-33.00	P<0.001
c	Breadth or width of hyoid (distance between the distal ends of greater cornua)	37.45±6.90	23.66-51.59	33.19±5.19	20.37±41.50	P<0.001
d	Length of hyoid (distance between a line through the distal ends of the greater cornua and center of hyoid body)	35.85±2.93	17.68–47.43	31.95±2.88	26.01–37.22	P<0.001
e	Minimum transverse distance between bases of lesser cornua	19.04±3.40	13.03-27.20	18.62±2.77	12.57-23.20	P<0.001
f	Width (side to side length) of the body in the midline	23.75 ±2.49	18.20–28.70	20.39 ± 2.12	13.20–24.70	P<0.001
g	Distance between the upper and lower margins of the body (height)	11.58±1.43	9.25-15.09	10.26±1.06	8.75-12	P<0.001
h	Thickness (antero-posterior) of body in the middle	6.29 ±1.84	4.75-9.25	5.63 ±0.97	4.4-8.25	P<0.001

Table 2. Statistical analysis of the studied parameters of hyoid bone in male and females

Study	Year	Male		Female	
		U - shape	V - shape	U - shape	V - shape
Leksan et al.	2005	45.7 %	48.6 %	42.8 %	34.3 %
Deepak et al.	2013	44.0 %	56.0 %	55.0 %	45.0 %
Shangase et al.	2019	35.0 %	65.0 %	70.0 %	30.0 %
Present study	2024	40.6%	59.4%	64.3%	35.7%

Table 3. Comparison of Shape of Hyoid Bone of Present Findings with Previous Workers

Discussion

In the identification process of a deceased person determining the sex, age and race of the deceased is of vital importance. Identification of an individual is of great importance in criminal investigations. Using the human pelvis or on the skull alone, sex can be determined with only 95% or 92% accuracy. Metric analysis of the hyoid bone can also be a useful technique in determining sex skeleton, which was proven by this presented study.

Morphology of the hyoid bone

This study reported that the „V" shape hyoid bone was most prevalent in males (59.4 %), while the „U" shape is most prevalent in females (64.3 %) (Table 1). The present study also recorded a statistically significant relationship between the shape of the hyoid bone and sex (p-value = 0.027). These findings correlate with previous studies by Leksan et al., Deepak et al. and Shangase at al. (Table 3) [11,10,12].

Morphometry of the hyoid bone

The male hyoid bones were found to be larger compared with female hyoid bone under all parameters. This finding was similar when compared with other studies (Table 4) [13, 14, 15, 16, 17, 18, 19]. Table 2 shows that the maximum sexual dimorphism was recorded for parameters c, d and f (width of hyoid bone, length of hyoid bone and width

Anthropometric parameters		Santhi Priya et al.	Kopuz et al.	Ramagalla et al.	Harjeeth et al.	Savitha et al.	Priya et al.	Amgain et al.	Present study
a	M	32.37 ± 2.12	25.61 ± 4.53		33.59 ± 2.76	31.58 ± 3.17	32.58±2.34	32.78±2.44	31.31±2.65
	F	28.42 ± 2.32	24.32 ± 4.11		29.79 ± 2.75	29.04 ± 3.32	28.43±2.34	28.89±2.47	28.78±2.71
b	M	32.58 ± 2.34	25.44 ± 4.50		33.90 ± 2.84	30.04 ± 3.25	32.37±2.12	32.67±2.48	31.69±2.61
	F	28.43 ± 2.34	24.79 ± 4.11		29.66 ± 2.38	27.78 ± 2.71	28.42±2.32	28.71±2.64	28.30±2.55
c	M	33.29±4.66	34.07 ± 4.19	33.13 ± 4.97	33.42 ± 3.38	37.41 ± 6.79	33.29±4.66	34.25±4.81	37.45±6.90
	F		31.88 ± 3.46	28.26 ± 2.73	27.65 ±3.08	35.69 ± 6.70	28.02±2.80	31.21±2.38	33.19±5.19
d	M	36.51 ± 2.72	28.30 ± 4.34		38.66 ± 3.29	35.15 ± 3.15			35.85±2.93
	F	1.92 ± 2.76	28.36 ± 4.73		34.05 ± 2.85	33.35 ± 5.85			31.95±2.88
e	M				24.45 ± 2.35		21.71±3.18	20.34±3.82	19.04±3.40
	F	28.02 ± 2.80			20.48 ±2.42		18.24±2.9	18.45±2.91	18.62±2.77
f	M				24.03 ± 2.36		23.24±3.07	22.51±3.73	23.75 ± 2.49
	F				20.29 ±1.55		20.0±1.47	20.27±1.75	20.39 ± 2.12
g	M				6.58 ± 1.88		6.14±1 .90	6.45±1.79	11.58±1.43
	F				5.10 ± 0.95		5.60±0.97	5.66±0.97	10.26±1.06
h	M	11.85 ± 1.53	15.35 ± 2.85	11.85 ± 1.55	11.04 ± 1.10	10.09 ± 1.40	11.85±1.53	12.18±1.38	6.29 ±1.84
	F	10.04 ± 1.01	14.16 ± 3.08	10.00 ± 1.07	9.47 ± 1.08	9.55 ± 1.03	10.04±1.01	11.21±1.15	5.63 ±0.97

Table 4. Comparison of present study with other studies

of the body in the midline) while parameters e and g (minimum transverse distance between bases of lesser cornua, distance between the upper and lower margins of the body) were least dimorphic among study population.

Conclusion

After studying different shapes of hyoid bone, the authors concluded that in males V-type and in females U-type of hyoid bone were the leading types. All the parameters considered in the present study were showing significant sexual dimorphism as male hyoid bones were much larger in size when compared to female hyoid bones. These parameters can be considered in forensic investigations for the sex determination of an individual.

Acknowledgement:

We thank all those who donated their bodies for scientific purposes and made it possible to conduct the present anatomical research.

Conflict of Interest:

The authors declare that they have no conflict of interest..

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