Measurement of Hyoid Bone Morphometric Parameters for Sex Prediction in Iranian Population

Siamak Soltani[1], Azadeh Memarian[2], Kamran Aghakhani[1], Behzad Ghazanfaripoor[1,3]

[1] Department of Forensic Medicine, School of Medicine, Iran University of Medical Sciences, Tehran, Iran
[2] Department of Forensic Medicine, School of Medicine, Mazandaran University of Medical Sciences, Mazandaran, Iran
[3] Legal Medicine Research Center, Legal Medicine Organization, Tehran, Iran

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Abstract- Anatomical and anthropological study of hyoid bones could be used in the sex prediction from skeletal remains. The aim of this study is to examine the morphometrical parameters of the hyoid bone individuals of the Iranian population. The study was carried out on 248 hyoid bones taken from cadavers Referred to Kahrizak Legal Medicine Center in 2020. Four anthropometric indices of hyoid bone were studied and have been associated with the sex and height of the individuals. The study included 179 (72.2%) males and 69 (27.8%) female cases. No significant difference was observed between the two gender groups in terms of age (P=0.678). The indexes of hyoid bones measured were compared between male and female genders, and the results show that the transverse distance between the tubercle of the greater horn, the Anterior/posterior dimension of the body, the distance between the upper and lower margin of the body in the middle (height) and the maximum depth of concavity on the posterior surface of the body, was associated with the sex determination (P<0.001). The four hyoid bone indexes measured in this study were higher in males compared with females, which indicates that hyoid bone morphometry can be used for sex determination in the Iranian population.

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Keywords: Hyoid bone; Morphometric indices; Sex determination; Anthropology

Introduction

Anthropometric indices include a set of parameters that are influenced by characteristics such as gender, age, and race (1). These indexes must be measured separately in each population. Because racial and ethnic differences affect them and reduce the possibility of their generalization (2-7).

Gender assessment is very important in forensic medicine and anthropological studies. Anatomical and radiological researches in estimating the development and connections of skeletal bones are one of the methods of sex determination (8).

To date, Studies have been carried out on different bones, such as the sternum, clavicle, femur, radius, ulna, scapula, for obtaining the sex of an individual (9). Furthermore, many researchers have shown that the morphometric study of hyoid bone is another helpful way for sex estimation (10). The hyoid bone is "U" shaped and it is not joined with other skeletal bones. It consists of a central part called body and a pair of cornua, the greater and the lesser cornua. The ends of the greater horns are connected by ligaments to the thyroid cartilage of the larynx, and the lesser horns are attached to the temporal styloid process (11). In several studies, the morphometric parameters of hyoid bone are analyzed and their relationship for sex determination have been characterized in different populations (12). Okasi *et al*., studied on 372 hyoid bones of Iranian people using CT images and measured nine anthropometric indices of hyoid bone. They found a significant difference between male and female cadavers in seven indexes including the diameter of the hyoid body, the length of the hyoid body, the vertical length of the greater horns of the hyoid bone, the length of the right greater horn, the length of the left greater horn, the angle between the right greater horn and

Corresponding Author: B. Ghazanfaripoor
Department of Forensic Medicine, School of Medicine, Iran University of Medical Sciences, Tehran, Iran
Tel: +98 9133400906, Fax: +98 8338322056, E-mail address: behzad.gp1362@gmail.com

the body, the angle between the left greater horn and the body (P<0.05) (13). In the present study, the other four hyoid indexes have been measured in some males and females of Iranian people, and the results can illustrate the potential of these indexes in sex prediction.

Materials and Methods

This cross-sectional study was carried out on Iranian cadavers referred to the autopsy hall of the Forensic Medicine Center of Kahrizak, Tehran, during 6 months (from October 2019 to March 2020). All 248 individuals were in the age range of 18 to 80 years old of Iranian people with a reliable identity certificate. The hyoid bone of the cases was carefully removed by a forensic medicine specialist, and the cases with positive signs of trauma or pressure on the neck, hyoid bone fracture, or dislocation of the joint between the body and the horn were excluded from the study. In this study, four anthropometric indices of the hyoid bone (including the transverse distance between the tubercle of the greater horn, the Anterior/posterior dimension of the body (in the middle), the distance between the upper and lower margin of the body in the middle (height) and the maximum depth of concavity on the posterior surface of the body (in the middle)) were measured, and they were shown in Figure 1.

All the parameters were recorded by Vernier Calipers, measuring scale (1-14 in mm). Furthermore, the sex, height, and age of individuals were collected and have been compared with the indices. After data collection, the results of the study were presented separately in two sections: descriptive statistics and analytical statistics. In order to explain qualitative data, frequency and percentage were used, and to describe quantitative data, mean and standard deviation were used. The data analysis was performed using SPSS statistical software version 24, and comparisons were performed using the variable logistic regression test with the Step method, and the diagnostic sensitivity of the four indicators was determined, and the significance level was 0.05.

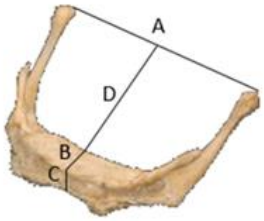

Figure 1. The measured Hyoid parameters: A, the transverse distance between the tubercle of the greater horn; B, the Anterior/posterior dimension of the body (in the middle); C, the distance between the upper and lower margin of the body in the middle (height); D, maximum depth of concavity on the posterior surface of the body (in the middle)

Results

In the current study, 179 (72.2%) males and 69 (27.8%) female cases were included. The average age was 44 years in the male group and 43 years in the female group. The description of the age and height of the cases in relation to gender is shown in Table 1.

The average age was 42.75±13.54 years in the male group and 43.57±14.74 years in the female group. No significant difference was observed between the two groups in terms of age (P=0.678). Furthermore, the average height of individuals was 173.24±4.64 cm in the male group and 162.61±5.27 cm in the female group. It shows a significant difference between the genders (P<0.001).

Table 1. Comparison of demographic characteristics between sexes

Characterization	Sex (frequency)	Mean	SD	Minimum	Maximum	*P*
Age (year)	Male (179)	42.75	13.54	18	80	0.678
	Female (69)	43.57	14.74	25	67	
Height (cm)	Male (179)	173.24	4.64	160	185	<0.001
	Female (69)	162.61	5.27	155	180	

The indexes measured in this study were compared between males and females. The results showed a significant difference between male and female cases in all four indices (P<0.001). The results are illustrated in Table 2. By the way, the mean of each parameter in males and females was close together.

To find the independent sex predictors among measured variables and also adjust for height, Logistic regression analysis was applied (Table 3). Multivariate Logistic Regression analysis revealed that all the parameters, in addition to height, were independent sex predictors. Regards to regression coefficients (B), Among all the parameters, the anterior/posterior dimension of the body in the middle and the maximum depth of concavity

on the posterior surface of the body were the best factors for estimating the gender.

Table 2. Characteristics of measured dimensions of hyoid bones specified by sex

Hyoid Index	Sex	Mean	IQR	Minimum	Maximum	*P*
Transverse distance between Tubercle of the greater horn	Male	36.58	33.60 – 39.70	20.83	46.71	<0.001
	Female	32.76	30.41 – 35.35	22.16	43.12	
Anterior/posterior dimension of the body in the middle	Male	11.98	11.29 – 12.79	7.60	15.52	<0.001
	Female	10.32	9.15 – 11.85	6.22	13.08	
Distance between the upper and lower margin of (height)	Male	8.91	8.20 – 9.83	4.81	13.40	<0.001
	Female	8.10	7.37 – 8.70	5.91	10.26	
Maximum depth of concavity on the posterior surface of the body	Male	32.7	30.21 – 34.18	32.07	37.66	<0.001
	Female	29.67	28.07 – 31.25	24.70	33.49	

IQR=Interquartile Range

Table 3. Logistic regression analysis to select variable's ability to estimate the sex

Hyoid Index	Univariate analysis			Multivariate analysis		
	B	Crude Odd's ratio	CI 95%	B	Adjusted Odd's ratio	CI 95%
Transverse distance between tubercle of the greater horn	0.229	1.257	1.15 –1.36	-0.104	0.901	0.78 – 1.03
Anterior/posterior dimension of the body in the middle	0.802	2.229	1.75 – 2.82	0.456	1.578	1.03 – 2.41
Distance between the upper and lower margin of the body (height)	0.574	1.775	1.36 –2.30	-0.088	0.916	0.57 – 1.46
Maximum depth of concavity on the posterior surface of the body	0.403	1.496	1.30 –1.71	0.309	1.362	1.05 – 1.75
Height	0.337	1.400	1.29 – 1.51	0.318	1.375	1.25 – 1.50

(R square= 0.67, *P* <0.001, CI= confidence interval for Odd's ratio, Mean values are representative of bilateral measures, regardless of side)

Discussion

One of the most important issues in forensic medicine is determining the identity of individuals, especially gender. This is especially important when the body is burned or severely damaged. In these cases, evolutionary changes in the bones of the body can be used to determine age or sex. In these cases, evolutionary changes in the bones can be used to determine age or sex. Hyoid bone has some applications in forensic medicine; for example, in hyoid fractures, cases of hanging or neck injuries can be detected (14). In addition, the hyoid bone may be helpful in sex prediction. In this study, 248 bodies sent to Kahrizak Forensic Medicine Anatomy Hall were studied, and the variables of age, height, sex and 4 morphometric indices of the hyoid bone, including the transverse distance between large tubercles, the anterior-posterior distance of the body (in the middle), distance Between the upper and lower margins of the body (in the middle) and the maximum depth of concavity of the posterior surface of the body (in the middle) were measured. The results of the present study showed that there is a significant difference between the measured indices of the hyoid bone in males and females, and a statistically significant correlation between the results of all 4 indicators and the height factor of individuals was observed. These findings are consistent with the results obtained in the study of Mukhopadhyay *et al*., which showed that the hyoid bone is wider and longer in men than women and this difference is statistically significant (15). In another study, Miller *et al*. reported the hyoid bone is significantly larger in men than in women, and some of the bone sizes were significantly different between the sexes (16). In the study of Kim et al., morphometric factors of Hyoid bone were examined, and the results revealed that the accuracy of discriminant function using three measurements, including the length of the distance from the midpoint of the left side of the hyoid body to the midpoint of the right side of the hyoid body, Length of the distance from the narrowest segment of the greater horn to a point equidistant between the distal and proximal ends of the greater horn, and maximum width of the proximal end of the greater horn was 88.2% (10). In another study, Okasi *et al*. investigated that the best indicator of sex is the length of the large horn of the hyoid bone, which has 81.7% accuracy for discriminant analysis (13). However,

in another study, Reesink *et al*., concluded that although some hyoid bone sizes are significantly different between the sexes, the discriminant function of these parameters is not sufficient for definitely sex determination, and using additional parameters was proposed (17). In the present study, and in consistent with the results published by Reesink *et al*., (17), Although hyoid bone sizes were all statistically significantly different between men and women. However, due to the proximity of the average of these sizes in both sexes, they cannot be used as a separate criterion for determining gender. Rather, the study of other hyoid bone indices and the combination of their results with indices from other bones of the body is needed to design an efficient sex determination model.

References

1. Üzün I, Daregenli O, Sirin G, Müslümanoğlu O. Identification procedures as a part of death investigation in Turkey. Am J Forensic Med Pathol 2012;33:1-3.
2. Krishan K, Kanchan T, Menezes RG, Ghosh A, et al. Forensic anthropology casework—essential methodological considerations in stature estimation. J Forensic Nurs 2012;8:45-50.
3. Krishan K, Tanuj Kanchan, Abhilasha Sharma. Multiplication factor versus regression analysis in stature estimation from hand and foot dimensions. J Forensic Leg Med 2012;19:211-4.
4. Agarwal P, Singh A, Gupta R. Estimation of human stature by measurements of foot. Natl J Integr Res Med 2018;9:38-43.
5. Ozden H, Balci Y, Demirüstü C, Turgut A, Ertugrul M. Stature and sex estimate using foot and shoe dimensions. Forensic Sci Int 2005;147:181-4.
6. Jankauskas R. Forensic anthropology and mortuary archaeology in Lithuania. Anthropol Anz 2009;67:391-405.
7. Chumlea WC, Guo SS, Wholihan K, Cockram D, Kuczmarski RJ, Johnson CL. Stature prediction equations for elderly non-Hispanic white, non-Hispanic black, and Mexican-American persons developed from NHANES III data. J Am Diet Assoc 1998;98:137-42.
8. İşcan MY. Global forensic anthropology in the 21st century. Forensic Sci Int 2001;117:1-6.
9. Santhi Priya KD, Kumari A. Sexual dimorphism with the shape of hyoid bone. Int J Anat Res 2016;4:2183-86.
10. Kim DI, Lee UY, Park DK, Kim YS, Han KH, Kim KH, et al. Morphometrics of the hyoid bone for human sex determination from digital photographs. J Forensic Sci 2006;51:979-84.
11. AlJulaih GH, Menezes RG. Anatomy, head and neck, hyoid bone. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing, 2022.
12. Cameriere R, Zolotenkova GV, Kuznetsov IA, Scendoni R Pigolkin YI. Sex estimation based on the anthropometric measurements of thyroid cartilage using discriminant analysis. Egypt J Forensic Sci 2021;11:1-12.
13. Okasi A, Sadeghian MH, Behnoush B, Shakori Rad A. Sex identification by morphometric study of hyoid bone. Int J Med Toxicol Forensic Med 2018;8:145-50.
14. Balseven-Odabasi A, Yalcinozan E, Keten A, Akçan R, Tumer AR, Onan A, et al. Age and sex estimation by metric measurements and fusion of hyoid bone in a Turkish population. J Forensic Leg Med 2013;20:496-501.
15. Mukhopadhyay PP. Morphometric features and sexual dimorphism of adult hyoid bone: A population specific study with forensic implications. J Forensic Leg Med 2010;17:321-4.
16. Miller KW, Walker PL, O'Halloran RL. Age and sex-related variation in hyoid bone morphology. J Forensic Sci 1998;43:1138-43.
17. Reesink E, Van Immerseel AAH, Brand R, Bruintjes TJD. Sexual dimorphism of the hyoid bone? Int J Osteoarchaeology 1999;9:357-60.