OPEN ACCESS Freely available online

Anthropology

Research Article

Sternal Morphometric Parameters Are More Depended Upon Stature than Sex: An Investigation in an Iranian Population

Mehrdad Ghorbanlou[1], Fatemeh Moradi[2], Mina Eftekharzadeh[1,3], Hamid Reza Asgari[1*]

[1]Department of Anatomy, School of Medicine, Iran University of Medical Sciences, Tehran, Iran; [2]Department of Anatomy, School of Medicine, Zanjan University of Medical Sciences, Zanjan, Iran; [3]Department of Anatomy, Neuroscience Research Center, Iran University of Medical Sciences, Tehran, Iran

ABSTRACT

Gender and stature prediction of human remains is crucial in anthropological and forensic sciences. This study investigated stature dependency of sternal morphometric parameters in an Iranian population. Chest CT scans of 100 patients (male=58, female=42) were investigated in thirteen stature-based groups in a retrospective study for sternal morphometric parameters including length, width, and thickness of manubrium, body, and xiphoid process. Also, derived parameters such as combined length of manubrium and body (MBL), sternal area and volume, and manubrium, body and sternal indices were evaluated. Differences among groups and stature dependency were investigated by one way analysis of variance and linear regression tests. Most significant differences were evident in manubrium width, body length, combined length of manubrium and body, and sternum area and volume between groups with higher stature (>180 cm) and groups with lower stature (<169 cm). Correlation studies revealed a multiple five variable linear regression model predicting stature with high prediction rate (r^2=0.62). Evaluations among male and female participants of same height revealed there are few significant differences in sternal body thickness, MBL, and sternal area. Results of this investigation revealed that although sternal parameters are significantly different in male and female, this difference is greatly depended upon stature not sex.

Keywords: Stature; Sternum; Anthropology; Forensic medicine

INTRODUCTION

To be aware of gender and stature of human remains is of significant importance in anthropological and bio-archaeological investigations [1]. For this purpose, various methods have been suggested in the literature, in most of which the long bones such as femur and humerus are measured [2,3]. In case of not finding any long bone, or when the skeletal remains are damaged or not intact, researchers provide other methods for stature and gender estimation including measuring other bones such as scapula, sacrum, bones of hands and feet, vertebral column, skull, and sternum [4-9].

The need for stature estimation from osteometric analysis in every part of the world seems crucial, since various factors affect the stature such as genetic, and environmental factors, ethnic origin, and etc. [10,11]. It is evident in the literature that the size of each bone of the body is in a proportional relationship with the individual stature [12].

Morphometric studies of sternum are of significant importance in the literature and it is analyzed in various populations; sternum parameters have been applied for sex discrimination and stature prediction [13-15]. In this study we investigated the sternal morphometric parameters in relation to stature and sex and provided a stature prediction formula in an Iranian population.

Correspondence to: Hamid Reza Asgari, Department of Anatomy, School of Medicine, Iran University of Medical Sciences, Tehran, Iran; E-mail: hamidrezaasgari99@gmail.com

Received: 29-Jul-2023, Manuscript No. ANTP-23-25856; **Editor assigned:** 01-Aug-2023, PreQC No. ANTP-23-25856 (PQ); **Reviewed:** 16-Aug-2023, QC No. ANTP-23-25856; **Revised:** 23-Dec-2024, Manuscript No. ANTP-23-25856 (R); **Published:** 30-Dec-2024, DOI: 10.35248/2332-0915.24.12.253

Citation: Ghorbanlou M, Moradi F, Eftekharzadeh M, Asgari HR (2024) Sternal Morphometric Parameters Are More Depended Upon Stature than Sex: An Investigation in an Iranian Population. Anthropology. 12:253.

MATERIALS AND METHODS

Patients and computed tomography

This cross-sectional retrospective study was conducted after institutional review board approval (IR.IUMS.FMD.REC. 1400.011). In a retrospective study, 100 chest CT scans were investigated for one year (2020 to 2021) in medical imaging center of Dr. Shariati hospital, Mahdasht, Alborz, Iran. The patients were divided into 13 groups based on their heights and gender including male groups: Group 1 (160-164 cm), group 2 (165-169 cm), group 3 (170-174 cm), group 4 (175-179 cm), group 5 (180-184 cm), group 6 (185-189 cm), group 7 (190-194 cm), group 8 (195-199), and female groups including: group 9 (150-154 cm), group 10 (155-159 cm), group 11 (160-164 cm), group 12 (165-169 cm), and group 13 (170-174 cm) (Table 1 and Figure 1).

Table 1: Study groups and height distribution among male and female.

Male height groups	Rate of distribution: n (%)	Mean ± SD
1: 160-164 cm	6 (10.34%)	160.67 ± 1.15
2: 165-169 cm	7 (12.06%)	167.25 ± 1.5
3: 170-174 cm	8 (13.79%)	171.2 ± 1.64
4: 175-179 cm	10 (17.24%)	177.14 ± 1.77
5: 180-184 cm	9 (15.51%)	181.67 ± 1.5
6: 185-189 cm	7 (12.07%)	186.5 ± 0.57
7: 190-194 cm	6 (10.34%)	190.67 ± 0.57
8: 195-199 cm	5 (8.62%)	196.33 ± 1.53
Total	58	178.40 ± 10.16
Female height groups	**Rate of distribution**	**Mean ± SD**
9: 150-154 cm	8 (19.05%)	150.8 ± 1.78
10: 155-159 cm	5 (11.90%)	157.33 ± 0.58
11: 160-164 cm	12 (28.57%)	161.22 ± 1.4
12: 165-169 cm	9 (21.42%)	167 ± 1.9
13: 170-174 cm	8 (19.05%)	172 ± 0.9
Total	42	161.86 ± 6.85

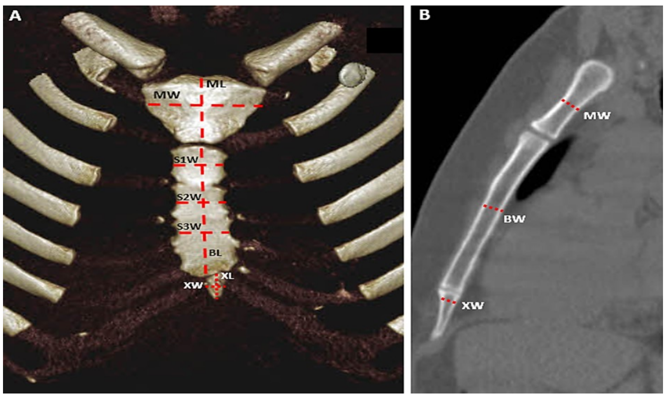

Figure 1: Measurements of sternal parameters. A. Three dimensional reconstruction of sternum on which ML (Manubrium Lngth), MW (Manubrium Width), BL (Body Length), S1W (Sternebra 1 Width), S2W (Sternebra 2 Width), S3W (Sternebra 3 Width), XL (Xiphoid Length), and XW (Xiphoid Width) are demonstrated; B. Sagittal reconstruction of sternum on which MT (Manubrium Thickness), BT (Body Thickness), and XT (Xiphoid Thickness) are demonstrated

Multi-detector computed tomography scan was used in this study (Hitachi-Supria 16/32 with 51 kW power, 75 cm gantry bore, 180 cm scan range, 5 Mega Hit Unit (MHU) X ray tube, and 0.675 mm minimum slice thickness) [16].

Prior to entering the study, medical history of patients were considered and those with congenital, traumatic, and surgical sternal defects were excluded from the study. In order to minimize motion artifacts, patients were asked to stay still and hold their breath in deep inspiration. CT scans of the chest with 7 mm thickness and 5 mm interval were acquired. Images were reconstructed with thickness and interval of 1.25 mm in desired planes for accuracy. Internal software of CT device was used to measure sternal parameters [17,18].

Morphometric parameters of sternum

Morphometric parameters of sternum consist of manubrium, body, xiphoid process, and other derived parameters.

Manubrium parameters

Include manubrium length (ML-the distance between suprasternal notch and manubriosternal joint is measured), manubrium thickness (MT-the middle thickness of manubrium in a sagittally reconstructed image was measured), and manubrium width (MW-the distance between the two points on the middle of the first rib facet on both sides of manubrium is measured).

Body of sternum parameters

Consist of body length (BL-the distance between manubriosternal to xiphisternal joint, is measured), body thickness (BT-the middle thickness of the body parallel to manubriosternal joint is measured), width of body is measured in three points: Width of first sternebra (S1W-the distance between the two points on the middle of the second and third rib facet on both sides of first sternebra is measured), width of second sternebra (S2W-the distance between the two points on the middle of third and fourth rib facet on both sides of second sternebra is measured), width of third sternebra (S3W-the distance between the two points on the middle of fourth and fifth rib facet on both sides of third sternebra is measured).

Xiphoid process parameters

Include xiphoid length (XL-the distance between xiphisternal joint to the end of xiphoid process), xiphoid thickness (XT-maximum thickness was measured in sagittally reconstructed image), and xiphoid width (XW-maximum width of the process is measured in a coronally reconstructed image).

Derived parameters

Parameters including combined length of sternum (MBL), sternum area (SA=((ML+BL) × (MW+S1W+S3W)/3)), sternum volume (SV=SA × (MT+BT)/2), manubrium index (MI=MW/ML × 100), body index (BI=S1W/S3W × 100), and sternum index (SI=ML/BL × 100) were investigated (Figure 2).

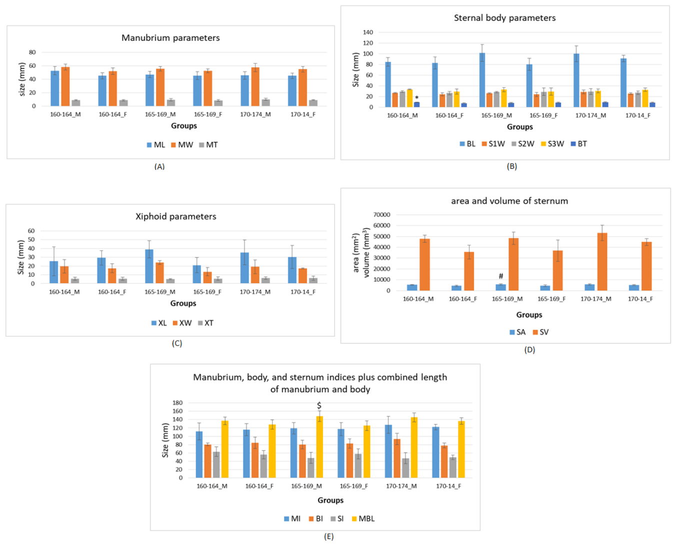

Figure 2: Comparison of sternal parameters in male and female with same heights. A. Manubrium parameters; B. Body parameters, *group1 *vs.* group 11 (P=0.05); C. Xiphoid parameters; D. Area and Volume of sternum, #group 2 *vs.* group 12 (P=0.03); E. Manubrium, body, and sternum indices plus combined length of manubrium and body, $ group 2 *vs.* group 12 (P=0.04).

Statistical analysis

Normal distribution of data was investigated by Kolmogorov–Smirnov test. Differences of mean between groups was analyzed by one way Analysis of Variance (ANOVA) and the post-hoc Tukey test. Linear regression was performed to clarify sternal parameters' correlation with height, then, in order to identify the stature dependency of sternum parameters, a five variable (mostly correlated with height) Multiple Linear Regression (MLR) was performed. Statistical analyses were performed by SPSS 16.0 statistical software (SPSS, Inc., Chicago, IL), and $P \leq 0.05$ was considered significant. Data were reported as mean ± standard deviation.

RESULTS

Manubrium, body, and xiphoid parameters of sternum

Among manubrium parameters MW in groups 4, 5, 6, 7, and 8 were significantly higher compared to groups 9, and 10 ($P \leq 0.05$); a significant increase of MT in groups 7, and 8 compared to groups 9, and 10 was also evident ($P \leq 0.03$); but no significant difference was evident in ML among groups. Among body parameters, BL is significantly increased in groups 5, 6, 7, and 8 compared to group 9 ($P \leq 0.05$), and S1W was significantly higher in groups 7 and 8 compared to group 9 ($P \leq 0.01$), however no significant changes were evident in S2W and S3W parameters. Body thickness was also significantly increased in groups 7, and 8 compared to groups 9, 10, and 11 ($P \leq 0.04$). No significant changes was evident in xiphoid process parameters among groups (Table 1).

Derived sternum parameters

MBL was significantly depended upon stature showing higher amounts in groups 4, 5, 6, 7, and 8 compared to groups 9, 10, 11, and 12 ($P \leq 0.02$). SA and SV indicated a same pattern of difference among groups showing significant increase in groups 4, 5, 6, 7, and 8 compared to groups 9, 10, 11, and 12 ($P \leq 0.02$). Other derived parameters including MI, BI, and SI showed no significant difference among groups.

Linear regression analysis

If we consider sternal parameters as variables depending upon height, linear regression analysis illustrates a significant positive correlation between height and ML, MW, MT, BL, S1W, BT, XL, XW, MBL, SI, SA, and SV parameters. Among these parameters, the most significant ones which are highly depended upon height are MW ($r=0.61$, $P=0.000$), BL ($r=0.66$, $P=0.000$), MBL ($r=0.74$, $P=0.000$), SA ($r=0.74$, $P=0.000$), and SV ($r=0.76$, $P=0.000$). Variations in MW, BL, MBL, SA, and SV can be estimated by height by 37, 43, 54, 55, and 57%, respectively (Table 2). Multiple Linear Regression Model (MLRM) to predict height in males ($r=0.68$, $P=0.003$), females ($r=0.67$, $P=0.01$), and total ($r=0.79$, $P=0.002$) from five significant sternum parameters of MW, BL, MBL, SA, and SV indicates 46, 45, and 62% of variations in height can be explained by these five sternal parameters, respectively (Tables 3 and 4).

Table 2: Sternal parameters.

Parameter	Groups												
	1	2	3	4	5	6	7	8	9	10	11	12	13
ML (mm)	52.66 ± 6.37	46.97 ± 4.7	45.5 ± 5.42	54.51 ± 6.07	49.88 ± 6.06	51.57 ± 3.36	54.6 ± 4.85	54.06 ± 3.22	47.98 ± 5.9	43.7 ± 2.4	45.18 ± 4.59	45.35 ± 5.94	45.08 ± 4.26
MW (mm)	57.93 ± 4.35	55.6 ± 3.47	57.3 ± 6.09	57.32 ± 2.94	61.2 ± 6.39*	61.02 ± 3.6*	61.3 ± 1.2*	59.43 ± 0.68*	50.86 ± 3.99	47.36 ± 2.2	51.83 ± 4.88	52.43 ± 2.77	54.9 ± 4.18
MT (mm)	8.83 ± 0.75	9.35 ± 1.9	10.02 ± 1.41	9.91 ± 1.51	10.2 ± 1.49	9.67 ± 1.75	12 ± 0.72*	11.46 ± 1.5*	8.28 ± 1.88	7.13 ± 1.05	8.58 ± 1.06	8.26 ± 1.21	8.98 ± 0.62
BL (mm)	84.43 ± 8.04	101.65 ± 15.89	99.92 ± 15.03	96.62 ± 20.27	104.47 ± 12.26*	100.45 ± 10.38	109.67 ± 5.15*	110.37 ± 4.55*	68.76 ± 7.31	75.96 ± 6.11	82.92 ± 11.35	80.08 ± 11.33	91.24 ± 6.01
S1W (mm)	26.63 ± 1.07	26 ± 1.11	28.36 ± 3.78	27.88 ± 2.01	26.81 ± 2.91	29.05 ± 1.97	31.46 ± 2.37*	32.66 ± 2.1*	27.8 ± 10.04	19.26 ± 0.4	23.97 ± 2.71	23.71 ± 3.89	25.26 ± 1.86
S2W (mm)	29.03 ± 1.51	28.37 ± 1.25	29.08 ± 5.31	31.32 ± 4.8	28.95 ± 3.11	30.47 ± 1.37	33.3 ± 2.86	36.36 ± 1.15	34.86 ± 14.15	22.45 ± 0.5	26.28 ± 3.31	28.73 ± 7.03	27.02 ± 3.13
S3W (mm)	33.2 ± 0.45	32.8 ± 3.96	30.54 ± 3.45	33.37 ± 2.53	31.53 ± 3.72	33.05 ± 2.58	37.33 ± 1.69	40.46 ± 1.1	37.32 ± 13.31	26.6 ± 1	29.06 ± 8.11	29.23 ± 8.69	32.58 ± 13.16
BT (mm)	8.96 ± 0.3^{a}	7.7 ± 1.16	8.94 ± 0.87	8.78 ± 1.56	8.26 ± 1.53	9.72 ± 2.09	10.86 ± 0.85*	9.9 ± 0.65*	7.26 ± 0.67	6.96 ± 0.45	7.27 ± 0.74^{a}	8.23 ± 0.96	8.56 ± 0.53
XL (mm)	25.5 ± 16.49	39.06 ± 9.81	35.54 ± 14.16	39.57 ± 16.32	30.38 ± 13.92	29.05 ± 2.84	33.5 ± 8.93	34.5 ± 12.45	15.26 ± 6.41	27.2 ± 1	29.28 ± 8.11	20.98 ± 8.69	30.1 ± 13.16
XW (mm)	19.76 ± 7.67	24.03 ± 2.05	19.08 ± 7.74	19.08 ± 5.36	19.75 ± 9.37	19.82 ± 5.97	21.6 ± 6.15	21.2 ± 3.01	15.5 ± 6.57	11.8 ± 0.5	17.42 ± 5.19	13.55 ± 4.56	17.2 ± 0.53
XT (mm)	5.56 ± 1.87	5.1 ± 0.52	6.22 ± 1.31	5.81 ± 1.23	6.09 ± 1.56	6.35 ± 2.07	6.83 ± 0.73	5.76 ± 0.86	5.56 ± 0.95	5.1 ± 1.25	6.22 ± 1.79	5.81 ± 2.02	6.09 ± 2.45
MBL (mm)	137.1 ± 8.83	148.62 ± 12.88^{b}	145.42 ± 10.69	151.14 ± 19.33	154.35 ± 12.2$^{*\#}$	152.02 ± 8.6$^{*\#}$	164.27 ± 9.8$^{*\#}$	164.43 ± 1.4$^{*\#}$	116.74 ± 3.89	119.67 ± 8.51	128.11 ± 11.12	125.43 ± 11.55^{b}	136.31 ± 7.98
MI (mm)	111.62 ± 20.76	119.27 ± 13.82	127.45 ± 20.58	106.49 ± 15.49	123.36 ± 11	118.68 ± 10.31	112.93 ± 11.14	110.23 ± 7.68	107.01 ± 13.32	108.79 ± 10.97	115.68 ± 14.78	117.25 ± 16	122.07 ± 6.3

BI (mm)	80.22 ± 3.4	80.17 ± 10.61	93.4 ± 13.76	84.01 ± 9.61	85.47 ± 8.2	88.6 ± 12.43	84.36 ± 6.83	80.67 ± 2.99	74.99 ± 7.94	72.46 ± 1.24	84 ± 13.69	82.61 ± 11.22	77.81 ± 6.03
SI (mm)	62.9 ± 11.39	47.7 ± 13.33	47.06 ± 13.43	59.03 ± 15.53	48.38 ± 8.75	51.99 ± 8.79	49.73 ± 2.36	49.12 ± 4.94	71.03 ± 15.3	57.6 ± 1.46	55.56 ± 10.19	57.77 ± 11.92	49.54 ± 5.36
SA (mm^2)	5381.4 ± 376.6	5678.8 ± 659.4^{c}	5629.9 ± 599.5	5987.5 ± 904.8	6152.9 ± 760.6$^{*\#}$	6235.4 ± 311.2$^{*\#}$	7122.3 ± 41$^{*\#}$	7267.3 ± 274.5$^{*\#}$	4519.7 ± 1037.7	3712.2 ± 120.5	4483.9 ± 610.6	4421.4 ± 768.6^{c}	5130.9 ± 485.1
SV (mm^3)	47839.1 ± 3271.7	48326.2 ± 5734.6	53324.4 ± 7181.4	56601.3 ± 14826.4	57108.7 ± 11659.3$^{*\#}$	60709.9 ± 13244.6$^{*\#}$	81571.4 ± 9507.6$^{*\#}$	77854.4 ± 11640.4$^{*\#}$	36055.5 ± 14116.8	26231.6 ± 3636.8	35613.4 ± 6286.1	36912.4 ± 9806.9	44856.2 ± 3119.2

Note: *vs F1,2 (P≤0.05), $^{\#}$vs F3,4 (P≤0.05); ^{a}vs F3 (P=0.05), ^{b}vs F4, ^{c}vs F5; ML (Manubrium Length), MW (Manubrium Width), MT (Manubrium Thickness), BL (Body Length), S1W (Sternebra 1 Width), S2W (Sternebra 2 Width), S3W (Sternebra 3 Width), BT (Body Thickness), XL (Xiphoid Length), XW (Xiphoid Width), XT (Xiphoid Thickness), MBL (Manubrium and Body Length), SA (Sternal Area), SV (Sternal Volume), MI (Manubrium Index), BI (Body Index), SI (Sternum Index)

Table 3: Linear regression results (independent variable is height; sternal parameters are considered dependent variables).

Dependent variables	r	B	r^2	p-value	Formula
ML	0.39	15.35	0.152	0.002	ML: 15.35+0.19 (height)
MW	0.61	7.59	0.37	0	MW: 7.59+0.28 (height)
MT	0.58	-4.54	0.34	0	MT: -4.54+0.08 (height)
BL	0.66	-61.79	0.43	0	BL: -61.79+0.9 (height)
S1W	0.43	-0.58	0.18	0	S1W: -0.58+0.16 (height)
S2W	0.21	11.85	0.04	0.09	S2W: 11.85+0.10 (height)
S3W	0.23	13.32	0.05	0.06	S3W: 13.32+0.11 (height)
BT	0.57	-3	0.32	0	BT: -2.99+0.07 (height)
XL	0.32	-25.33	0.1	0.01	XL: -25.33+0.32 (height)
XW	0.28	-5.25	0.08	0.03	XW: -5.25+0.14 (height)
XT	0.2	1.6	0.04	0.12	XT: 1.60+0.02 (height)
MBL	0.74	-46.43	0.54	0	MBL: -46.43+1.1 (height)
MI	0.09	96	0.01	0.44	MI: 96+0.12 (height)
BI	0.21	51.23	0.05	0.09	BI: 51.23+0.18 (height)
SI	0.35	116.09	0.13	0.004	SI: 116.02–0.36 (height)

SA	0.74	-6371.8	0.55	0	SA: -6371.8–68.82 (height)
SV	0.76	-128624	0.57	0	SV: -128623.5+1038.6 (height)

Note: *indicates significant correlation to height; _ underlined parameters demonstrate correlation of >0.6; ML: Manubrium Length; MW: Manubrium Width; MT: Manubrium Thickness; BL: Body Length; S1W: Sternebra 1 Width; S2W: Sternebra 2 Width; S3W: Sternebra 3 Width; BT: Body Thickness; XL: Xiphoid Length; XW: Xiphoid Width; XT: Xiphoid Thickness; MBL: Manubrium And Body Length; SA: Sternal Area; SV: Sternal Volume; MI: Manubrium Index; BI: Body Index; SI: Sternum Index; r: Pearson's correlation coefficient; B: Model coefficient; r^2: Square of Pearson's correlation coefficient.

Table 4: Multiple linear regression for estimation of height from 5 independent variables of MW, BL, MBL, SA, and SV.

Dependent variable		r	B	r^2	p-value
Male	Height	0.68	172.9	0.46	0.003
	Formula	Height: 172.90–0.35 (MW)–0.41 (BL)-0.31 (MBL)+0.011 (SA)+0 (SV)			
Female	Height	0.67	111.66	0.45	0.01
	Formula	Height: 111.66+0.82 (MW)+0.36 (BL)+0.07 (MBL)-0.011 (SA)+0.001 (SV)			
Total	Height	0.79	100.42	0.62	0.002
	Formula	Height: 100.42+0.46 (MW)–0.13 (BL)+0.4 (MBL)–0.004 (SA)+0 (SV)			

Note: r: Pearson's correlation coefficient; B: Model coefficient; r^2: Square of Pearson's correlation coefficient; MW: Manubrium Width; BL: Body Length; MBL: Manubrium and Body Length; SA: Sternal Area; SV: Sternal Volume.

Stature dependency of sternal morphometric parameters

In order to clarify that sternum parameters are depended upon gender or height, male and female patients of the same height were analyzed. Male groups of 1, 2, and 3 have the same height as female groups of 11, 12, and 13. Majority of the parameters were not significantly different among the group, however significant differences were only evident in BT (group 1 *vs.* group 11, P=0.05), MBL (group 2 *vs.* group 12, P=0.03), and SA (group 2 *vs.* group 12, P=0.04).

DISCUSSION

This study investigated stature and gender dependency of sternal morphometric parameters. The participants (n=100) included male (n=58) and female (n=42) at different height groups covering from 150-174 cm in females, and 160-199 cm in males. Each height group consisted of at least 5 participants to provide a fairly reliable data. Various sternal morphometric parameters were evaluated among the study groups revealing significant differences of MW, MT, BL, S1W, BT, MBL, SA, and SV among groups. Significant differences of previously mentioned parameters were evident between male height groups of >180 cm and female height groups of <169 cm. Regression studies indicated a significant correlation between stature and sternum morphometric parameters in which MW, BL, MBL, SA, and SV are correlated with height with a Pearson's correlation coefficient of >0.6. As a result, a five variable formula predicting height was developed in which height could be estimated with a Pearson's correlation coefficient of 0.79. Further investigation revealed stature dependency of sternal morphometric parameters since male and female groups of the same height (male groups of 1, 2, and 3, and female groups of 11, 12, and 13) demonstrated only few significant differences in BT, MBL, and SA.

As it is mentioned in the literature, there are numerous osteometric studies predicting the gender or stature from body remaining [19]. Our previous studies, demonstrated there was a significant difference between morphometric parameters of Iranian male and female sternum and costal cartilages, regardless of stature. However, in this study it is demonstrated that sternal morphometric parameters are a function of stature rather than sex.

Several studies have specifically investigated the significance of sternal parameters in predicting gender and stature [20]. In Yonguc study, sternal length was positively correlated with stature and the combined length of manubrium and body was the highest positively correlated parameter with stature (r^2>0.52) and an MLRM predicting stature from manubrium length and combined length of manubrium and body of sternum reported high positive correlation with stature (r2>0.64) . Zhang also reported a positive correlation between sternal length (r>0.45) and height suggesting sternum length as a reliable parameter for predicting stature. In our study, not only there are positive correlation between BL (r^2:0.43) and MBL (r^2:0.54), and height, but also other parameters such as MW (r^2:0.37), SA (r^2:0.55), and SV (r^2:0.57) were positively correlated with height. And a five variable MLRM provided the highest prediction rate (r^2:0.62). Table 5 provides a literature review on dependency of stature on sternum parameters using linear regression model.

Table 5: Stature estimation by regression analysis using sternum parameters in different populations.

Study sample	Sex	Regression	r	r^2
South India	Male	Simple linear	0.63	_
	Female	–		_
	Total	–		_
South India	Male	–		
	Female	Simple linear	0.63	0.4
	Total			
Northwest India	Male	Multiple linear		0.16
	Female	Simple linear	0.32	0.1
	Total			
Portugal	Male	Simple linear	0.33	0.11
	Female	–	–	–
	Total			
Spain	Male	Simple linear	0.39	–
	Female	Simple linear	0.46	–
	Total	–	–	–
Turkey	Male	Simple linear	0.72	0.52
	Female	Simple linear	0.74	0.54
	Total	–	–	–
Western China	Male	Simple linear	0.45	–
	Female	Simple linear	0.54	–
	Total	–	–	–
Central India	Male	Simple linear	0.55	0.3

	Female	–	–	–
	Total	–	–	–
Mysore India	Male	Quadratic	0.93	0.86
	Female	Quadratic	0.9	0.81
	Total	Simple linear	0.89	0.79
Thailand	Male	Simple linear	0.76	0.57
	Female	Simple linear	0.45	0.19
	Total	Simple linear	0.46	0.2
Our study	Male	Multiple linear	0.68	0.46
	Female	Multiple linear	0.67	0.45
	Total	Multiple linear	0.79	0.62

CONCLUSION

Authors could not find any study in the literature in which males and females of the same height were compared in sternal parameters, thus a new investigation is provided in this study by comparing various sternal parameters in males and females with the same height. Results of this investigation revealed that although sternal parameters are significantly different in male and female, this difference is greatly depended upon stature not gender. Since female patients' height is generally less than male patients' height in a random population as it was true in our study (mean of male height=178.40 ± 10.16, and mean of female height=161.86 ± 6.85, and) female patients' sternal parameters (except BI and SI) are less than male patients'.

ACKNOWLEDGEMENT

This study was funded by a grant from Iran University of Medical Sciences (IUMS) (Number: 99-03-04-19259). Our deep gratitude goes to staff and supervisor (Mr. Habib Rostami) of medical imaging center of Shariati hospital, Mahdasht, Alborz, Iran.

CONFLICT OF INTEREST

Authors declare no conflict of interests.

REFERENCES

1. Yonguc GN, Kurtulus A, Bayazit O, Adiguzel E, Unal I, Demir S, et al. Estimation of stature and sex from sternal lengths: An autopsy study. Anat Sci Int. 2015;90:89-96.
2. Konigsberg LW, Hens SM, Jantz LM, Jungers WL. Stature estimation and calibration: Bayesian and maximum likelihood perspectives in physical anthropology. Am J Phys Anthropol. 1998;107(S27):65-92.
3. Krishan K, Kanchan T, Menezes RG, Ghosh A. Forensic anthropology casework-Essential methodological considerations in stature estimation. J Forensic Nurs. 2012;8(1):45-50.
4. Campobasso CP, Di Vella G, Introna F Jr. Using scapular measurements in regression formulae for the estimation of stature. Boll Soc Ital Biol Sper. 1998;74(7-8):75-82.
5. Pelin C, Duyar I, Kayahan EM, Zağyapan R, Ağildere AM, Erar A. Body height estimation based on dimensions of sacral and coccygeal vertebrae. J Forensic Sci. 2005;50(2):294-297.
6. Agnihotri AK, Agnihotri S, Jeebun N, Googoolye K. Prediction of stature using hand dimensions. J Forensic Leg Med. 2008;15(8): 479-482.
7. Agnihotri AK, Purwar B, Googoolye K, Agnihotri S, Jeebun N. Estimation of stature by foot length. J Forensic Leg Med. 2007;14(5): 279-283.
8. Nagesh KR, Kumar GP. Estimation of stature from vertebral column length in South Indians. Leg Med (Tokyo). 2006;8(5):269-272.
9. Sahni D, Sanjeev, Sharma P, Harjeet, Kaur G, Aggarwal A. Estimation of stature from facial measurements in Northwest Indians. Leg Med (Tokyo). 2010;12(1):23-27.
10. Ruff C. Variation in human body size and shape. Annu Rev Anthropol. 2002;31(1):211-232.
11. Silventoinen K, Kaprio J, Lahelma E, Koskenvuo M. Relative effect of genetic and environmental factors on body height: Differences across birth cohorts among Finnish men and women. Am J Public Health. 2000;90(4):627-630.
12. Singh J, Pathak RK, Chavali KH. Skeletal height estimation from regression analysis of sternal lengths in a Northwest Indian population of Chandigarh region: A postmortem study. Forensic Sci Int. 2011;206(1-3):211.e1-e8.
13. Yammine K, Assi C. Estimation of stature from sternal lengths. A correlation meta-analysis. Arch Med Sadowej Kryminol. 2017;67(3): 166-177.
14. Giurazza F, Del Vescovo R, Schena E, Battisti S, Cazzato RL, Grasso FR, et al. Determination of stature from skeletal and skull measurements by CT scan evaluation. Forensic Sci Int. 2012;222(1-3):398.e1-e9.

15. Zhang K, Luo YZ, Fan F, Zheng JQ, Yang M, Li T, et al. Stature estimation from sternum length using computed tomography-Volume rendering technique images of Western Chinese. J Forensic Leg Med. 2015;35:40-44.
16. Ghorbanlou M, Moradi F, Mehdizadeh M. Frequency, shape, and estimated volume of intracranial physiologic calcification in different age groups investigated by brain computed tomography scan: A retrospective study. Anat Cell Biol. 2022;55(1):63-71.
17. Ghorbanlou M, Moradi F. Azygos lobe: The prevalence, dimensions, and estimated volume of thirteen cases investigated by computed tomography. Anat Sci J. 2021;18(2):72-77.
18. Ghorbanlou M, Moradi F. Rib abnormalities investigated by computed tomography: A report on common and uncommon cases. Anat Sci J. 2022;19(1):27-32.
19. Chandrakanth HV, Kanchan T, Krishan K. Osteometric analysis for sexing of modern sternum-An autopsy study from South India. Leg Med (Tokyo). 2014;16(6):350-356.
20. Ekizoglu O, Hocaoglu E, Inci E, Bilgili MG, Solmaz D, Erdil I, et al. Sex estimation from sternal measurements using multidetector computed tomography. Medicine (Baltimore). 2014;93(27):e240.