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Sex Determination from Scapula by Volume Rendering Technique Using in Turkish Population

Determinación del Sexo a partir de la Escápula Mediante la Técnica de Representación de Volumen Utilizada en la Población Turca

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SUMMARY: The aim of this study is to measure the significant parameters on scapula at computed tomography images and to determine the effects of these parameters for sex determination. The second aim is to find the most effective single and combined parameters to use for sex determination using scapula in Turkish population. In this study, morphometric measurements of scapula on the computed tomography images of 60 male and 60 females were evaluated and their impacts on sex determination were examined via stepwise logistic regression analysis. 10 parameters and 6 indexes calculated via using these parameters were measured. Scapular breadth of the right scapulae (86.7%), maximum scapular length of the left scapulae (85%), scapular breadth of all scapulae (80%) were found to be the most effective single parameters. Combination of the scapular breadth and maximum scapular length were 85%, 90%, 86.7% effective in sex determination on the right scapulae, on the left scapulae and on all of the scapulae, respectively. We believe that the results of this study will contribute to sex determination studies using the scapula in Turkish population for anatomist, anthropologist and forensic scientists.

KEY WORDS: Scapula; Sex determination; Morphometry; Anatomy; Computed tomography.

INTRODUCTION

Scapula is a short, flat and triangular bone and it is located between the 2nd and 7th costae at the posterior aspect of the thorax (Standring, 2015). Identification of the corpses in mass graves that emerged due to terrorist attacks, natural disasters and for any reason is important for anthropological studies (Debnath *et al*., 2018). For this purpose, some methods such as fingerprint, recognition from the photography, DNA analysis and pre-mortem and post-mortem dental radiographs are used (Ali *et al*., 2018). In forensic anthropology instead of these methods, less complicated, less technologically costly and useful morphological and metric methods are generally favored to identify the features of the skeleton (Baraybar, 2008). The morphological method is a subjective method based on observation, depending on observer's experience. The metric method, on the other hand, is an objective method that tries to predict which sex a bone belongs to, it is based on equations and morphometric methods using statistical analysis. Four features are used as anthropological data at biological identification: race, sex, stature and age at death (Krishan *et al*., 2016). First of all, sex determination is used for identification, because the stature and age at death are generally sex related features (Özer *et al*., 2006).

The skull and pelvis have been commonly used for sex determination in the literature because of their high accuracy rates. Apart from these bones, other skeletal components are used for sex determination, recently (Krishan *et al*., 2016).

Scapula is a dimorphic bone (Torimitsu *et al*., 2016; El Morsi *et al*., 2017), it is more resistant to fracture than long bones, and no morphological changes are seen after the bone completes its development (Giurazza *et al*., 2013).

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In the literature, sex determination studies were performed using scapula at different populations and scapula was found as high effective in sex determination (Torimitsu *et al*., 2016; Zhang *et al*., 2016; El Morsi *et al*., 2017; Omar *et al*., 2019a). Skeletal components may have different morphometric features among populations depending on geographic, genetic and environmental factors (Patriquin *et al*., 2005). Therefore, parameters used for sex determination should be specific to population (Spradley *et al*., 2008). Different methods have been used for determining sex using scapula: measurements on the dry bones (Özer *et al*., 2006; Koukiasa *et al*., 2017; Gara, 2019), digital photography (Macaluso, 2011), computed tomography (Torimitsu *et al*., 2016; Zhang *et al*., 2016; El Morsi *et al*., 2017; Debnath *et al*., 2018; Omar *et al*., 2019a,b) and magnetic resonance imaging (Atamtürk *et al*., 2019). According to literature, there are a few studies using scapula for sex determination in Turkish population (Özer *et al*., 2006; Atamtürk *et al*., 2019; Er *et al*., 2020).

The aim of this study is to measure the significant parameters on scapula at computed tomography images and to determine the effects of these parameters for sex determination. The second aim is to find the most effective single and combined parameters to use for sex determination using scapula in Turkish population.

MATERIAL AND METHOD

Data collecting: In this retrospective study, 60 male and 60 female scapulae were examined in Department of Radiology, Ufuk University, Ankara, Turkey. The study was performed between December 2019 and March 2021. The ethical approval of the study was obtained from the Ethical Committee of Hacettepe University (number: GO 19/1132, date: December 3, 2019). The ages of the patients that were included in the study were between 18-82 years (mean: 49.8±16.01). The exclusion criteria for the patients include shoulder injury, implants, osteoporosis, trauma, and structural defects of the scapula and also patients under 18 years old were excluded.

Table I. Measurements and their descriptions.

Measurement	Description
Scapular breadth (SB)	The distance between the midpoint of the posterior margin of the glenoid fossa (glenoid cavity) and the point where the spine of the scapula intersects the medial border of the scapula (Koukiasa *et al*., 2017) (F-G)
Maximum scapular length (MSL)	The distance between the highest point of the superior angle and the lowest point of the inferior angle of the scapula (White *et al*., 2011) (B-C)
Supraspinous line length (SSLL)	The distance between the point where the spine of the scapula intersects the medial border and the superior angle (White *et al*., 2011) (B-G)
Infraspinous line length (ISLL)	The distance between the point where the spine of the scapula intersects the medial border and the inferior angle (White *et al*., 2011) (C-G)
Length of superior border of root (LSBR)	The distance between the apex of the root of the spine of the scapula and the point where the superior border of root intersects the medial border of the scapula (I-D)
Length of inferior border of root (LIBR)	The distance between the apex of the root and the point where the inferior border of the root intersects the medial border of the scapula (I-E)
Root-spine superior length (RSSL)	The distance between the point where the superior border of the root intersects the medial border and the point where the spine intersects the medial border of the scapula (G-D)
Root-spine inferior length (RSIL)	The distance between the point where the inferior border of the root intersects the medial border of the scapula and the point where the spine intersects the medial border of the scapula (G-E)
Medial angle (MA)	The angle between the line from the most medial point of the medial border to the superior angle and the line from the most medial point of the medial border to the inferior angle of the scapula (Oladipo *et al*., 2015)(The angle between HB and HC lines)
Spinal axis angle (SAA)	The angle between the line from the superior angle to the point where the spine intersects the medial border and the line from the inferior angle to the point where the spine intersects the medial border of the scapula (The angle between GB and GC lines)
Scapular index (SI)	(SB/MSL)*100 (White *et al*., 2011)
Supraspinous index (SSI)	(SB/SSLL)*100
Infraspinous index (ISI)	(SB/ISLL)*100 (Dwight, 1887)
Root-spine index (RSI)	(RSSL/RSIL)*100
Root index (RI)	(LSBR/LIBR)*100
Supra-infra scapular index (SISI)	(SSLL/ISLL)*100 (Rissech & Black, 2007)

Scanning technique: The study was performed by using 16 slice CT scanner (General Electric LightSpeed 16, Milwaukee, ABD). The images were taken between the upper margins of the clavicles and the diaphragm as the patient's arms were raised above the head during inspiratory breath-hold. Computed tomography scan was performed with the following parameters: 300 mAs, 120 kVp, 0.9 pitch, 5 mm slice thickness and 1.25 mm reconstruction increment. Images were selected from the Picture Archieving and Communication System (PACS). All images were transferred to the workstation (Advantage Workstation 4.6, GE Healthcare, Sun Microsystems, ABD) and 2D tomography images were reconstructed to 3D images by volume rendering (post processing) technique. Two anatomists and a radiology specialist positioned the scapulae for the measurements on antero-posterior view and the radiology specialist measured all of the measurements 3 times for intraobserver reliability. Axis of the spine of the scapula was determined and used as a landmark before the measurements.

Measurements: (Table I, Figs. 1 and 2).

Statistical analysis: Statistical analysis was performed using SPSS version 20.0 (IBM Corporation, Armonk, NY, USA). Quantitative variables were described as mean; standard deviation; minimum and maximum. One-way ANOVA test was used to analyze any differences in measurements between the right and left scapulae and any differences in measurements between sexes. Stepwise logistic regression analysis was used to generate equations for sex determination. P-value lower than 0.05 was considered significant at a 95% confidence interval. Intraobserver reliability was calculated by coefficient of variation (CV) analysis.

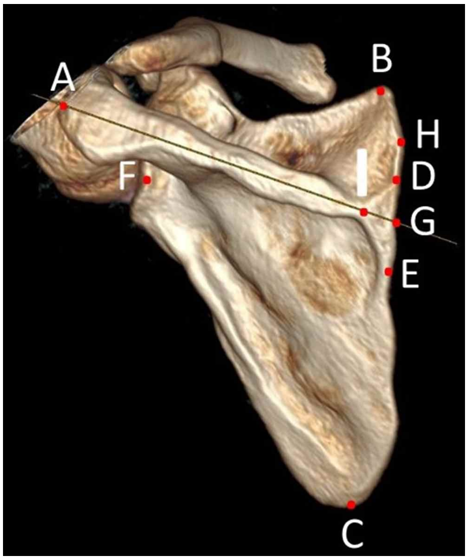

Fig. 1. Reference points. A: the point where the spine intersects the most lateral side, B: the highest point of the superior angle, C: the lowest point of the inferior angle, D: The point where the upper margin of the root intersects the medial margin, E: The point where the lower margin of the root intersects the medial margin, F: midpoint of the posterior margin of glenoid cavity, G: the point where the spine intersects the medial margin, H: the most medial point of the medial margin, I: apex of the root where the upper and lower margins of root intersect

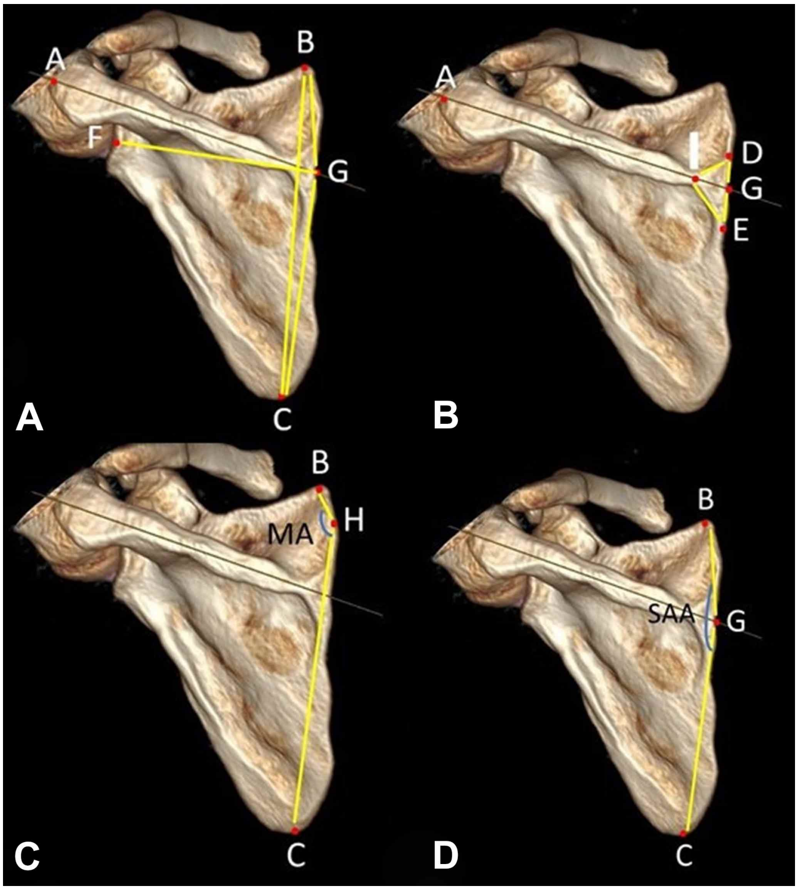

Fig. 2. Demonstration of the measurements. a) SB: scapular breadth (F-G), MSL: maximum scapular length (B-C), SSLL: supraspinous line length (B-G), ISLL: infraspinous line length(C-G). b) LSBR: length of superior margin of root (I-D), LIBR: length of inferior margin of root (I-E), RSSL: root-spine superior length (G-D), RSIL: root-spine inferior length (G-E). c) MA: medial angle (between H-B and H-C). d) SAA: spinal axis angle (between G-B and G-C).

RESULTS

The mean values of SB, MSL, SSLL, ISLL, LSBR, LIBR, RSSL, RSIL, MA and SAA were found higher in male than female, significantly. There was no statistically significant difference between male and female for index values. The descriptive statistical analysis results of the parameters and the indexes in male and female scapulae were summarized in Table II.

Significant differences between right and left side scapulae were found for mean values of SB, MA, SAA, SI and ISI. The results of the measurements for right and left scapulae were given in Table III.

The effects of the measured parameters on sex determination were evaluated by stepwise logistic regression analysis (Table IV). At the first step, SB of the right scapulae (86.7%), MSL of the left scapulae (85%), SB of all scapulae (80%) were found to be the most effective single parameters. At the second step, the combination of the SB and the MSL of the right scapulae (85%), left scapulae (90%) and all scapulae (86.7%) was found to be the most effective combination for sex determination from the scapulae. Except for the SB and MSL, no significant effects of the other parameters were found on sex determination.

Table II. Descriptive analysis of parameters for 60 males and 60 females.

Parameter	Sex	Mean±SD	Minimum-Maximum	p value
SB (mm)	M	106.79±6.26	91.7-119.4	<0.001*
	F	96.38±6.28	82.4-109.5	
MSL (mm)	M	159.13±12.20	135.0-183.6	<0.001*
	F		103.9-158.8	
SSLL (mm)	M	59.76±7.93	34.3-82.4	<0.001*
	F	51.88±6.02	38.1-65.8	
ISLL (mm)	M	104.81±11.09	81.2-134.5	<0.001*
	F	96.05±9.40	63.5-110.9	
LSBR (mm)	M	35.76±5.53	22.4-47.0	<0.001*
	F	30.13±6.65	14.2-48.1	
LIBR (mm)	M	49.38±10.32	28.4-77.0	0.002*
	F	43.52±9.98	21.1-69.4	
RSSL (mm)	M	33.94±5.79	18.8-49.3	<0.001*
	F	30.20±5.07	20.5-39.8	
RSIL (mm)	M	30.76±6.96	16.0-47.0	0.022*
	F	28.02±5.95	13.2-42.2	
MA (°)	M	144.62±9.67	108.2-161.0	0.016*
	F	140.40±9.38	117.51-158.5	
SAA (°)	M	150.97±10.31	109.81-170.6	0.036*
	F	147.38±8.54	126.3-163.3	
SI	M	67.43±5.76	54.9-79.8	0.412
	F	68.33±6.68	55.4-94.2	
SSI	M	181.37±22.60	129.7-267.3	0.120
	F	187.91±22.82	149.5-271.1	
ISI	M	102.94±12.00	76.2-137.7	0.548
	F	101.53±14.07	80.5-154.3	
RSI	M	113.92±23.75	79.0-166.3	0.628
	F	111.70±26.38	54.5-183.9	
RI	M	74.01±11.61	51.1-108.8	0.100
	F	70.35±12.37	47.2-108.2	
SISI	M	57.59±9.64	33.4-86.2	0.098
	F	54.71±9.28	35.3-76.2	

SD: standard deviation, SB: scapular breadth, MSL: maximum scapular length, SSLL: supraspinous line length, ISLL: infraspinous line length, LSBR: length of superior border of root, LIBR: length of inferior border of root, RSSL: root-spine superior length, RSIL: root-spine inferior length, MA: medial angle, SAA: spinal axis angle, SI: scapular index, SSI: supraspinous index, ISI: infraspinous index, RSI: root-spine index, RI: root index, SISI: supra-infra scapular index, M: male, F: female, * indicates that p value lower than 0.05

All of the measurement was repeated 3 times and the parameters with the least difference between the 3 measurements were found as MSL (CV=0.33±0.22) and ISLL (CV=0.45±0.34), while the most difference between each 3 measurement was determined in the parameters related to the root (LSBR (CV=2.50±2.44), LIBR (CV=2.14±2.29), RSSL (CV=1.92±1.76), RSIL (CV=2.34±2.43)).

DISCUSSION

Thomas Dwight made the first study of scapula's role in sex determination in 1894. In his study, he measured the maximum scapular length and the glenoid cavity length. The maximum scapular length more than 170 mm was determined as male and the length shorter than 140 mm was determined as female. Intermediate values were remained at the unstable interval. Dwight claimed that the maximum scapular length was more accurate for sex determination (Dwight, 1887, 1894).

In 2009, Gretchen R. Dabbs applied Dwight's method to current population and he found that the determinations with less than 140 mm and more than 170 mm had high margin of accuracy, and there was a low margin of accuracy for the measurements between 140 and 170 mm. Therefore, he

Table III. Descriptive analysis of parameters for 60 right and 60 left scapulae.

Parameter	Side	Mean±SD	Minimum-Maximum	p value
SB (mm)	R	103.05±7.37	83.2-118.0	<0.01*
	L	100.11±8.67	82.4-119.4	
MSL (mm)	R	148.68±14.69	103.9-182.1	0.082
	L	152.16±13.04	122.0-183.6	
SSLL (mm)	R	56.21±8.38	38.5-82.4	0.548
	L	55.43±7.75	34.3-71.0	
ISLL (mm)	R	99.31±12.70	63.5-134.4	0.236
	L	101.55±9.30	80.8-134.5	
LSBR (mm)	R	33.51±7.15	14.2-48.1	0.313
	L	32.37±6.25	18.2-43.7	
LIBR (mm)	R	47.07±10.69	25.1-69.4	0.506
	L	45.83±10.41	21.1-77.0	
RSSL (mm)	R	31.95±6.13	20.5-49.3	0.810
	L	32.19±5.35	18.8-41.4	
RSIL (mm)	R	28.59±6.60	13.2-46.0	0.178
	L	30.19±6.54	17.4-47.0	
MA (º)	R	140.70±10.41	108.2-161.0	0.038*
	L	144.33±8.69	121.0-157.6	
SAA (º)	R	146.86±10.28	109.8-167.1	0.007*
	L	151.48±8.33	126.3-170.6	
SI	R	69.75±6.48	58.4-94.2	0.001*
	L	66.0±5.40	54.9-77.6	
SSI	R	186.19±22.63	129.7-248.6	0.46
	L	183.09±23.16	144.6-271.1	
ISI	R	105.27±14.35	80.9-154.3	0.01*
	L	99.20±10.88	76.2-126.9	
RSI	R	115.54±25.69	78.6-183.9	0.236
	L	110.09±24.24	54.5-166.3	
RI	R	72.31±12.25	47.2-108.2	0.902
	L	72.04±12.02	50.4-108.8	
SISI	R	57.43±10.81	35.9-86.2	0.139
	L	54.86±7.96	33.4-66.9	

SD: standard deviation, SB: scapular breadth, MSL: maximum scapular length, SSLL: supraspinous line length, ISLL: infraspinous line length, LSBR: length of superior border of root, LIBR: length of inferior border of root, RSSL: root-spine superior length, RSIL: root-spine inferior length, MA: medial angle, SAA: spinal axis angle, SI: scapular index, SSI: supraspinous index, ISI: infraspinous index, RSI: root-spine index, RI: root index, SISI: supra-infra scapular index, R: right, L: left, * indicates that p value lower than 0.05

emphasized the necessity of developing new formulas for current population (Dabbs, 2009). In this study, minimum and maximum values of the maximum scapular length at male and female were found 135.0 mm and 183.6 mm, 103.9 and 158.8, respectively. We conclude that maximum scapular length more than 158.8 mm was determined as male, and shorter than 135.0 mm was determined as female, and between the 135.0 mm-158.8 mm were remained at the unstable interval.

According to the literature, morphometry of root of scapula (LSBR, LIBR, RSSL, RSIL) was not measured, previously. Since the tendon of the trapezius muscle is attached to the root of the spine of the scapula (Standring, 2015), it was thought that the morphometry of this region could be different in male and female. In the parameters related to the root (LSBR, LIBR, RSSL, RSIL) were found higher in male than female, significantly but no significant effects of these parameters were found on sex determination in stepwise logistic regression analysis. In the literature, index parameters (SI, SSI, ISI, RSI, RI, SISI) have not been evaluated for sex determination in previous studies. In this study, no significant difference was found between male and female scapula for index parameters and no effects of these parameters were found on sex determination. Consequently, these parameters were not used previously for sex determination and this study showed that the effects of these parameters on sex determination not valuable and effective.

The medial margin of the scapula is attachment region for muscles (Standring, 2015). Depending on the pulling force of these muscles, it was thought that the medial angle and spinal axis angle could be different in male and female. The medial angle and the spinal axis angle were also not used in sex determination studies, previously. As a result of the measurements, the medial angle and the spinal axis angle were found higher in male than female, significantly, but their effects on sex determination were not found.

Considering the studies of sex determination from the scapula, the most effective single parameter was found as SB in the studies of El Morsi *et al.* (2017) in Egypt population, Omar *et al.*(2019a,b) in Malaysia population, Zhang *et al*. (2016) in China population, Vassallo *et al*. (2022) in Italy population and Reddy & Doshi (2017) in India population, while MSL was found the most effective single parameter in the studies of Torimitsu *et al*. (2016) in Japan population, Papaioannou etal.(2012) and Koukiasa *et al*. (2017) in Greece population. In this study, the most effective single parameter was found to be SB (86.7%) on the right scapulae and MSL (85%) on the left scapulae (Table V). If the scapula is found in fragmented or broken, sex of the scapula could estimate based on these single parameters. In this respect, it is important to know the most effective single parameters in sex determination. Comparing the literature with this study, it is seen that different parameters are effective in sex determination with different accuracy values in different populations, and combining parameters instead of using a single parameter has higher values in sex determination (Zhang *et al*., 2016;

Table IV. Stepwise logistic regression analysis of the scapular parameters.

Side	Step		B	Sig.	Exp (B)	95 % CI Exp (B) Lower	Upper	Accuracy (%)
Right	Step 1	SB	0.313	0.000	1.368	1.176	1.591	86.7
		Constant	-32.401	0.000	0.000			
	Step 2	SB	0.256	0.002	1.292	1.099	1.519	85
		MSL	0.130	0.008	1.139	1.035	1.253	
		Constant	-45.671	0.000	0.000			
Left	Step 1	MSL	0.191	0.000	1.211	1.101	1.331	85
		Constant	-28.926	0.000	0.000			
	Step 2	SB	0.200	0.008	1.222	1.055	1.415	90
		MSL	0.155	0.004	1.167	1.052	1.295	
		Constant	-43.382	0.000	0.000			
Total	Step 1	SB	0.256	0.000	1.292	1.182	1.412	80
		Constant	-26.093	0.000	0.000			
	Step 2	SB	0.220	0.000	1.246	1.125	1.382	86.7
		MSL	0.145	0.000	1.156	1.080	1.238	
		Constant	-44.079	0.000	0.000			

SB: scapular breadth, MSL: maximum scapular length

Table V. The most effective single and combined parameters in sex determination using scapula in previous studies.

Study	Method	Population	Sample size (N)	Single parameter	Accuracy rate (%)	Combined parameters	Accuracy rate (%)
El Morsi *et al.* (El Morsi *et al.*, 2017)	CT	Egypt	100 (50M, 50F)	MSL, SB (right)	82	MSL (right), MLSS (left)	88
Omar *et al.* (Omar et al.,2019a)	CT	Malaysia	132 (66M, 66F)	SB	90.9	SB, MSL	92.4
Omar *et al.* (Omar *et al.*, 2019b)	CT	Malaysia	200 (100M, 100F)	SB	90.6	SB, LSCL	93.1
Zhang *et al.* (Zhang *et al.*, 2016)	CT	China	414 (224M, 190F)	SB, LML	85.5	SB, LML, LSL	86.7
Torimitsu *et al.* *(Torimitsu et al.*, 2016)	CT	Japan	218 (109M, 109F)	MSL (left)	91.3	MSL, MLSS, GCMB (left)	94.5
Özer *et al*. (Özer *et al.*, 2006)	DB	Turkey	93 (47M, 46F)	MSB	94.8	MSB, MSL, GCMB, GCML	95
Di Vella *et al.* (Di Vella *et al.*, 1994)	DB	Italy	80 (40M, 40F)	MSB	91.25	MSB, MSL, MACL, MAL, GCML	95
Dabs (Dabbs, 2010)	DB	Egypt	27 (14M, 13F)	GCML	84.6	GCML, MSL, MLSS	88
Papaioannou *et al.* (Papaioannou *et al.*, 2012)	DB	Greece	147 (81M, 66F)	MSL	91.2	MLSS, GCMB	95.9
Reddy and Doshi (Reddy & Doshi, 2017)	DB	Indian	180 (100M, 80F)	SB	93.3	SB, MSL, GCMB, GCML	96.7
Gara (Gara, 2019)	DB	Indian	200 (52M, 148F)	GCMB	96	GCMB, MACL, SSLL	96
Koukiasa *et al.* (Koukiasa *et al.*, 2017)	DB	Greece	197 (107M, 90F)	MSL (left)	88.3	SB, MSL, GCMB, GCML (left)	92.9
Atamtürk *et al.* (Atamtürk *et al.*, 2019)	MRI	Turkey	204 (99M, 105F)	MLSS * ISLL	82.4	MAL, GCML, MLSS	90.5
Debnath *et al.* (Debnath *et al.*, 2018)	CT	Indian	186 (93M, 93F)			LSL, MSL, TSL	93.5
Er *et al*. (Er *et al.*, 2020)	CT	Turkey	152 (71 M, 81 F)	GCMB	92.1	MSL, SB, MLSS, GCMB, GCML, LBT, MAH, ISLL	96.7
Vassallo *et al*. (Vassallo *et a*l., 2022)	CT	Italy	180 (94 M, 86 F)	SB (left)	85	SB, MWAP (left)	92.6
Present study	CT	Turkey	120 (60M, 60F)	SB (right)	86.7	SB, MSL (left)	90

CT: computed tomography, MRI: magnetic resonance imagination, DB: dry bone, M: male, F: female, SB: scapular breath, MSL: maximum scapular length, MLSS: maximum length of the spine of scapula, LSCL: longitudinal scapula-coracoid length, LML: longitudinal maximum length, LSL: longitudinal scapular length, GCMB: glenoid cavity maximum breath, MSB: maximum scapular breath, GCML: glenoid cavity maximum length, MACL: maximum acromion-coracoid length, MAL: maximum acromion length, LC: lateral curvature, LBT: lateral border thickness, SSLL: supraspinous line length, ISLL: infraspinous line length, TSL: transvers scapular length, MAH: maximum acromion height, MWAP: maximum width of the acromion process

Omar *et al*., 2019a,b; Er *et al*., 2020) (Table V). Therefore, sex determination formulas should be developed specific to populations. The reason for using stepwise logistic regression analysis in this study is that discriminant function analysis makes more assumptions about the basic structure of the data. However, logistic regression analysis does not make assumptions like discriminant function analysis (Press & Wilson, 1978).

According to the studies conducted on sex determination in the current Turkish population, Er *et al*., Atamtürk *et al*. (2019) and this study; combination of the MSL, SB, MLSS, GCMB, GCML, LBT, MAH, ISLL, combination of the MAL, GCML, MLSS, combination of the SB, ML were found to be the most effective parameters, respectively (Atamtürk *et al*., 2019; Er *et al*., 2020). Ozer *et al*. (2006) examined. 10-11th century Anatolian population and they found the combination of MSB, MSL, GCMB, GCML to be the most effective parameters on sex determination from the scapula (Table V). In these studies, the effects of different parameters on the scapula were examined and it is seen that different parameters could be effective on sex determination.

Significant differences were found between the mean values of SB, MA, and SAA between the right and left sides. It is thought that the reason for this may be related to whether the muscles attached to the medial margin of the scapula, use the right or left upper limb of the person more actively. In this study, right or left handedness of the patients were unknown. Because of that, effect of the handedness on the measurements were not evaluated.

There were morphometric differences between male and female scapulae. The reason may be the differences in the release of growth hormone in different populations depending on genetic and environmental factors (Capellini *et al*., 2010). It is also thought that there may be a difference in muscle activity between male and female (Torimitsu *et al*., 2016). The mean values of the SB and MSL were found higher in male than female in this study, similar as the studies of Omar *et al*. (2019a,b), Zhang *et al*. (2016) and Torimitsu *et al*. (2016). Also, similar with the studies of Dabbs & Moore-Jansen (2010) and Gara (2019), the mean values of the SSLL and ISLL were found more in male than female.

This study has some limitations. The handedness and stature of patients were unknown and effects of these features on the measurements were not evaluated and also this study was performed with 60 male and 60 female scapulae. Future studies would be useful with large sample size and different parameters that could advance the sex determination studies from scapula in Turkish population.

In conclusion, effects of the parameters on the sex determination from scapula were evaluated by stepwise logistic regression analysis. At the first step of analysis, SB of the right scapulae (86.7%), MSL of the left scapulae (85%), SB of all scapulae (80%) were found to be the most effective single parameters. At the second step, the combination of the SB and the MSL of the right scapulae (85%), left scapulae (90%) and all scapulae (86.7%) was found to be the most effective combination for sex determination. The morphometry of root was not studied previously in the literature and we found that measurements of the root were found higher in male than female, significantly. The roles of root, indexes, medial and spinal axis angle measurements in sex determination have not been previously evaluated and except for the SB and MSL, no significant effects of these parameters were found on sex determination. It is thought that the results of this study will contribute to sex determination studies from scapula in the Turkish population.

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ÜLKIR, M.; FARıMAZ, M.; ATAÇ, G. K.; KIRICI, Y.; KARAAGAOGLU, E. & ALDUR, M. Determinación del sexo a partir de la escápula mediante la técnica de representación de volumen utilizada en la población turca. *Int. J. Morphol., 41(2)*:569-576, 2023.

RESUMEN: El objetivo de este estudio fue medir los parámetros significativos en la escápula en imágenes de tomografía computarizada y determinar los efectos de estos parámetros para la determinación del sexo. El segundo objetivo fue encontrar los parámetros individuales y combinados más efectivos para determinar el sexo utilizando la escápula en la población turca. Se evaluaron las medidas morfométricas de la escápula en las imágenes de tomografía computarizada de 60 hombres y 60 mujeres y se examinó su impacto en la determinación del sexo mediante un análisis de regresión logística paso a paso. Se midieron 10 parámetros y 6 índices calculados mediante el uso de estos parámetros. El ancho escapular de la escápula derecha (86,7 %), la longitud escapular máxima de la escápula izquierda (85 %), el ancho escapular de todas las escápulas (80 %) resultaron ser los parámetros individuales más efectivos. La combinación del ancho escapular y la longitud máxima escapular fueron 85%, 90%, 86,7% efectivas en la determinación del sexo en la escápula derecha, en la escápula izquierda y en todas las escápulas, respectivamente. Creemos que los resultados de este estudio contribuirán a los estudios de determinación de sexo utilizando la escápula en la población turca para anatomistas, antropólogos y científicos forenses.

PALABRAS CLAVE: Escápula; Determinación de sexo; Morfometría; Anatomía; Tomografía computarizada.

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