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Anatomical and Radiological-Morphometric Evaluation of the Head of Humerus and Glenoid Fossa in Healthy Individuals

Evaluación Anatómica y Radiológica-Morfométrica de la Cabeza Humeral y Cavidad Glenoidea en Individuos Sanos

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SUMMARY: The study aimed to evaluate the humeri and glenoid cavity anatomically and radiologically, from a morphometric perspective, in healthy Turkish individuals, and to determine reference values specific to the Turkish population by analyzing the possible relationships between these structures and the effects of demographic variables. A total of 190 healthy individuals (80 males, 110 females) between the ages of 20 and 60 years with available Computed Tomography images were examined. Possible relationships between the morphometry of the caput humeri and glenoid cavity in healthy Turkish individuals were evaluated, and morphometric measurements of these structures were also correlated with demographic variables. Frontal humeri diameter, humeri length, humeri inclination, humeri radius, sagittal humeri diameter, axial humeri diameter, glenoidalis height, glenoidalis Mid-Width, glenoidalis superior width, glenoidalis inferior width, glenoidalis radius of curvature, critical shoulder angle, glenoidalis inclination, and glenoidalis version were measured. Morphometric measurements of the glenoid cavity and caput humeri demonstrated significant correlations with demographic variables. When the scapula and related structures were evaluated across age groups, significant age-related changes were observed in the following parameters: humeri inclination, humeri diameter in the axial plane, glenoidalis inclination, radius of curvature of the glenoid cavity, and critical shoulder angle ($p<0.05$). Significant sex-related differences were observed in humeral and glenoid cavity measurements, except for caput humeri inclination, critical shoulder angle, and glenoid cavity version, with higher values in males, whereas axial configuration parameters showed no significant difference between sexes ($p>0.05$). The results of the study contribute to the normative measurements of these anatomical structures and can be used as reference data in clinical practice, particularly in shoulder surgery and prosthetic planning. Careful analysis of parameters such as scapular inclination and scapulothoracic angle, when assessing the spatial orientation of the glenoid, has been given to be critical for improving surgical outcomes.

KEY WORDS: Scapula; Glenoid version; Shoulder critical angle.

INTRODUCTION

The shoulder joint (glenohumeral joint) is a ball-and-socket synovial joint formed by the articulation of the humerus and glenoid cavity. It is one of the structures with the largest range of motion in the body (Tüzün *et al*., 1997). This joint enables multidirectional upper limb movements, such as flexion, extension, abduction, adduction, and internal and external rotation (Karaduman *et al*., 2017). However, this wide range of motion also brings with it the risk of structural instability. For this reason, the stability of the shoulder joint is provided not only by the bony structures but also by the holistic support of the surrounding connective tissue elements and muscle groups (Dere, 2018).

The two main structures that form the joint—the humeri and glenoid cavity—play a decisive role in both mechanical adaptation and biomechanical performance. The geometric relationship between the spherical structure of the humeri and the depth and orientation of the glenoid cavity directly affects joint stability (Iannotti *et al*., 1992). The shallower and smaller size of the glenoid cavity compared to the humerus is a factor that increases the risk of dislocation, especially in extreme arm positions (Burkhart & De Beer, 2000). For this reason, the morphometric properties of these two structures are critical parameters not only for anatomical information but also in applied fields such as traumatology,

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orthopedics, rehabilitation, and prosthetic design (Iannotti *et al*., 1992).

Several studies in the literature have emphasized that the morphological characteristics of the humeri and glenoid cavity exhibit significant variation among individuals and ethnic groups (Gandhi *et al*., 2015). However, the data obtained in these studies generally pertain to Western societies or different ethnic groups. Systematic and comprehensive morphometric studies conducted on healthy individuals specific to the Turkish population are quite limited (Sarı *et al*., 2020; Karademir & Aslan, 2022). This complicates both decision-making processes in clinical practice and the individual planning of prosthesis and implant designs. In this context, this study aimed to analyze the anatomical variations and proportional relationships between the humeri and glenoid cavities of healthy Turkish individuals by performing morphometric measurements on radiological images. Furthermore, the aim was to evaluate the effects of demographic variables such as age and sex on morphometric measurements, to assess their applicability in clinical and surgical practice, and to determine reference values specific to the Turkish population.

MATERIAL AND METHOD

Study Design

A total of 190 healthy individuals aged between 20 and 60, who were admitted to Adana Medline Hospital and Izmir Bozyaka Training and Research Hospital for various reasons between 2020 and 2025 and had Computed Tomography Images, were included in the study. Among the 190 participants in the study, 80 were male, and 110 were female. Permission was received from the Çukurova University Non-Interventional Clinical Research Ethics Committee for this study (01.09.2023, 136/46).

Exclusion criteria

· Having a history of neuromuscular or neurological disease
· Having a history of trauma, surgery, or chronic pain in the shoulder joint
· Being diagnosed with rheumatoid arthritis or a similar autoimmune disease
· Having congenital anomalies of the shoulder region
· Having systemic diseases of the musculoskeletal system
· CT images with poor image quality and anatomical structures that could not be clearly distinguished

Inclusion criteria

· Being aged 18 and over
· Not having a fracture or underlying pathology of the shoulder joint
· Applying to the emergency room
· Having no fractures or underlying pathologies
· Having pain involving the upper limb
· Being over the age of 18

Scan parameters

Thoracic CT images were obtained using a 64-slice Optima CT660 scanner (GE Healthcare, Milwaukee, WI, USA). A GE Volume Viewer 4.6 (GE Healthcare) workstation was used for image analysis. For all examinations, the field of view (FOV) was 46.8 cm, the tube voltage was 100 kV, and the tube current was 249 mA. Images were acquired with an axial slice thickness of 2.5 mm, and retrospective reconstruction was performed in the axial, frontal, and sagittal planes with a slice thickness of 0.625 mm.

Measurements

CT image analyses were performed by three observers [observer 1, a radiologist (RB), observer 2, a radiologist (BC), and observer 3, an anatomist (BO). All measurements except the critical shoulder angle were calculated in millimeters (mm), and the critical shoulder angle measurement was calculated in degrees **(˚)** using the imaging analysis program (RadiAnt Dicom Viewer).

Morphometric measurements were performed using thoracic CT images obtained in different planes. Frontal CT images included the following: Caput Humeri Diameter (CHDfp), Caput Humeri Heigth (CHH), Caput Humeri Inclination (CHI), Caput Humeri Radius (CHR), Glenoidal Cavity Radius of Curvature (GCROC), Glenoidal Cavity Inclination (GCI), and Critical Shoulder Angle (CSA) (Figs. 1 to 5). Axial CT images included the following in the axial plane: Caput Humeri Diameter (CHDap), Glenoid Cavity Version (CGV), and Glenoid Axial Configuration (Figs. 6 and 7). The Sagittal Caput Humeri Diameter (CHDsp) was determined from the CT sections in the sagittal plane, and the Cavitas Glenoidalis Height (CGH), Cavitas Glenoidalis Mid-Width (CGMW), Cavitas Glenoidalis Upper Width (CGGUW), and Cavitas Glenoidalis Lower Width (CGGAG) of the glenoid cavity were also measured by structuring oblique coronal and oblique sagittal CT sections (Figs. 8 and 9). The subjects included in the study were evaluated considering both sex and age parameters (20-29 years were considered Decade 1; 30-39 years were considered Decade 2; 40-49 years were considered Decade 3; and 50 years and above were considered Decade 4).

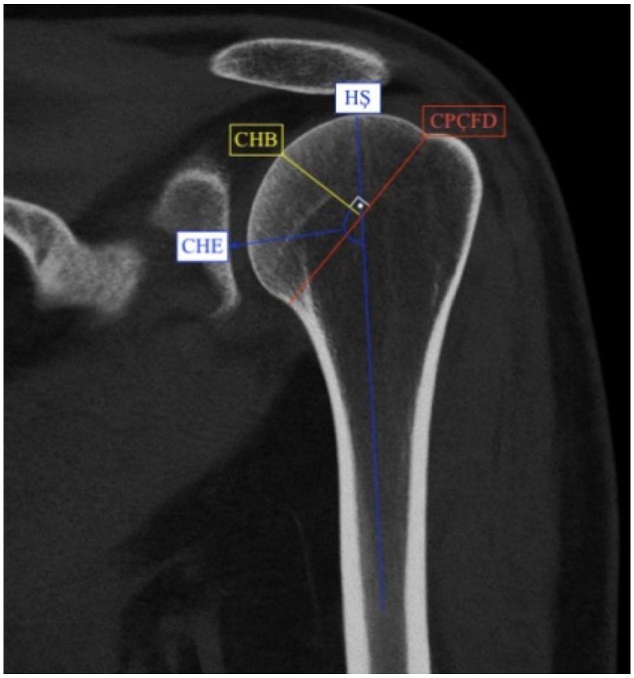

Fig. 1. CHDFP: Caput humeri diameter frontal plane, CHL: Caput humeri heigth, CHI: Caput humeri inclination.

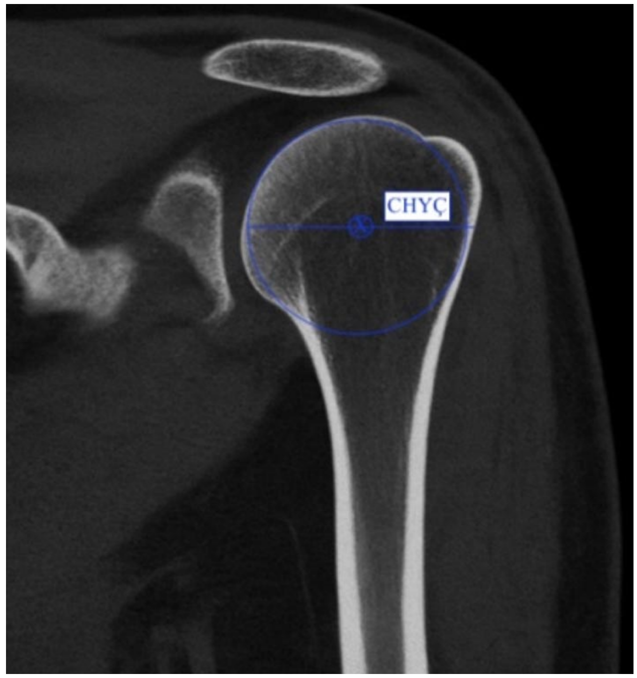

Fig. 2. CHR: Caput humeri radius.

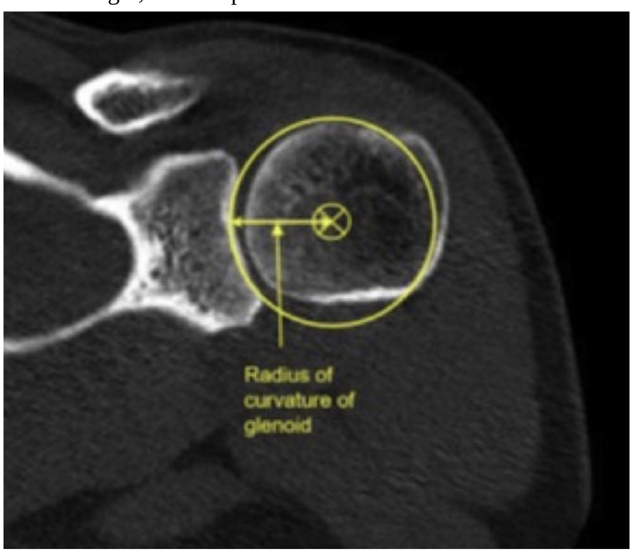

Fig. 3. GCROC: Glenoid cavity radius of curvature (Sahu *et al.*, 2020).

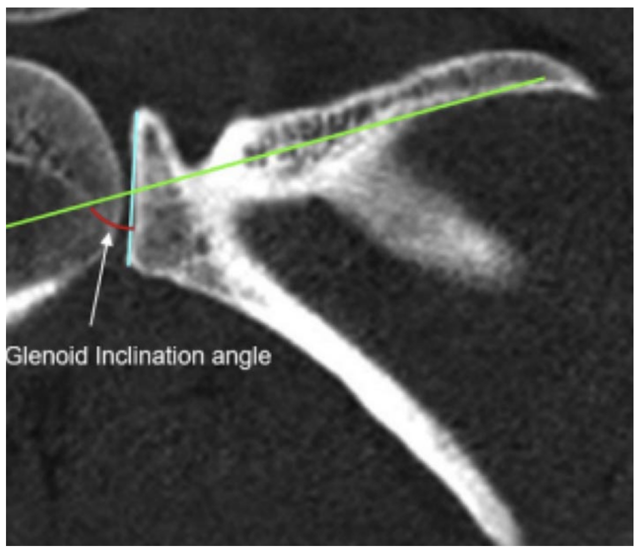

Fig. 4. GCI: Cavity glenoidalis inclination (Sahu *et al.*, 2020).

Statistical analysis

The SPSS 21.0 software was used to analyze measurements taken on 190 healthy individuals included in the study. In all statistical analyses, a p-value of less than 0.05 was considered statistically significant. The Kolmogorov-Smirnov test was used to determine whether the study was parametric or non-parametric. Based on the analysis of measurements, the following statistical methods were applied. P-values for data and means were analyzed using ANOVA, while the chi-square test was used for categorical classifications such as sex.

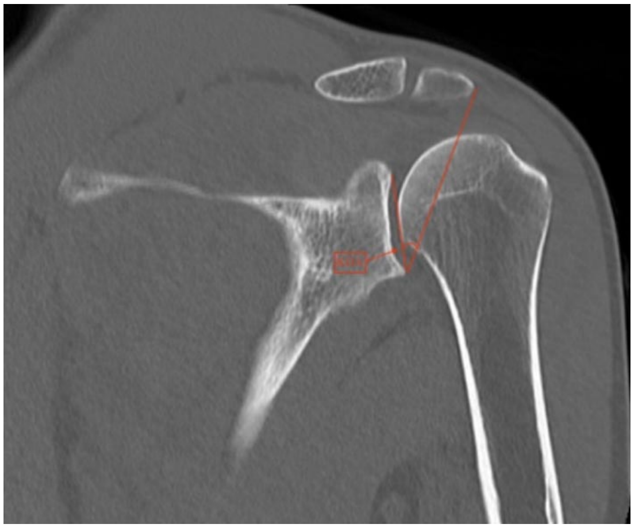

Fig. 5. CSA: Critical shoulder angle.

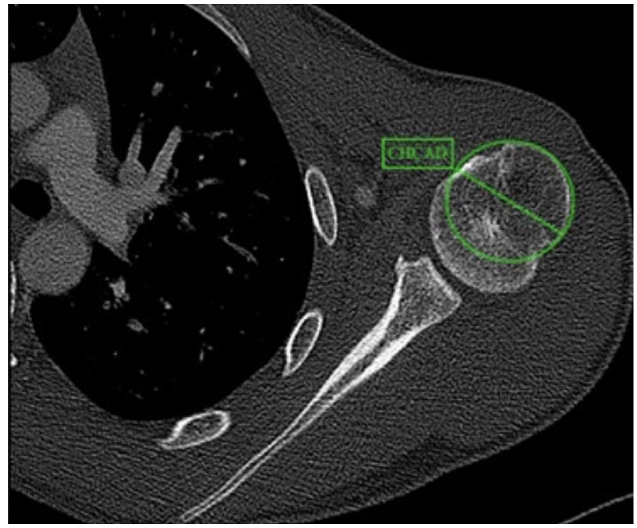

Fig. 6. CHDap: Caput humerus diameter in the axial plane.

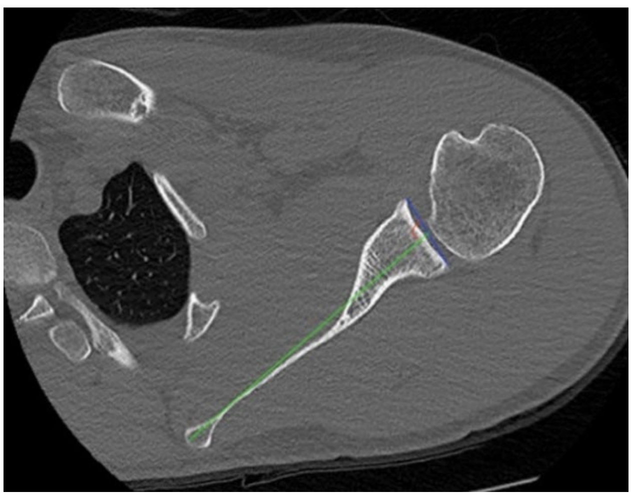

Fig. 7. GV: Glenoid version.

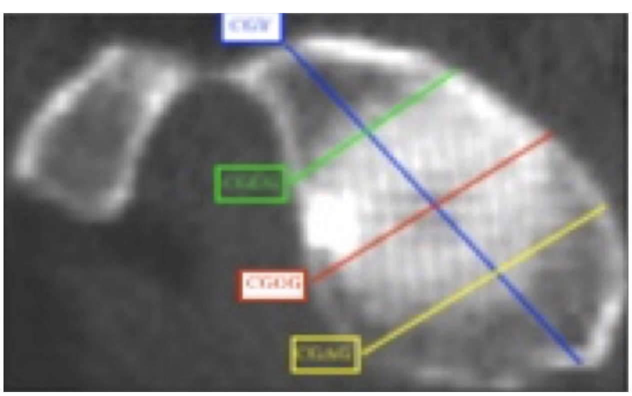

Fig. 9. CGH: Glenoid cavity height, CGGMW: Glenoid cavity mid-width, CGGUW: Glenoid cavity upper width, CGGLW: Glenoid cavity lower width.

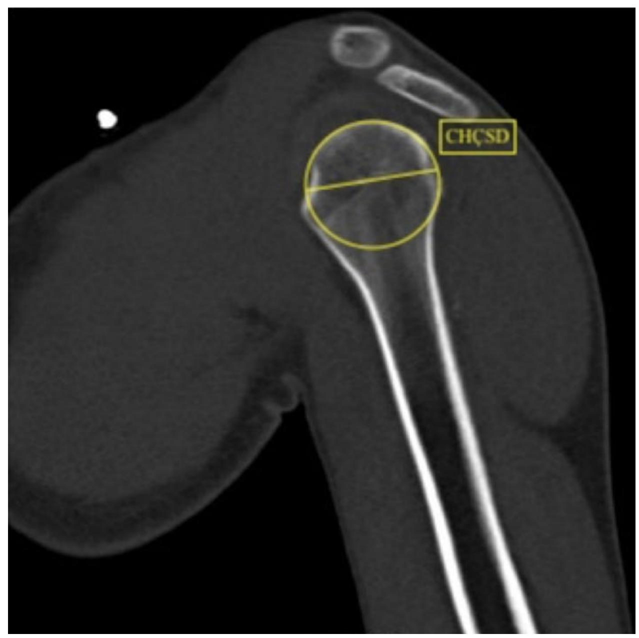

Fig. 8. CHDsp: Caput humerus diameter in the sagittal plane.

RESULTS

Among the 190 participants in the study, 80 were male, and 110 were female. The mean age of the male participants in the study was 36.98±10.01 years, while the mean age of the female participants was 37.42±8.39 years. No significant difference was found between the sexes in the age parameter (p=0.068).

Six values for the humeral head and nine values for the glenoid cavity were measured. CHDfp 44.0016±3.97 (35.40-52.60) mm, CHH 16.72±1.82448 (12.90-21.70) mm, CHI 50.0189±5.81 (36.60-63.50) mm, CHR 44.4768±4.02

(36.50-54.80) mm, CHDsp 41.8868±4.08525 (18.10-51.50) mm, CHDap 41.4553±3.55264 (34.60-51.20) mm, CGH 40.3332±3.40 (32.20-49.00) mm, CGGOG 22.58±2.65 (17.40-27.80 mm, CGGUW 18.39±2.32 (13.30-29.0) mm, CGGLW 25.2155±2.67 (18.80-31.90) mm, GCROC 43.3679±5.28630 (31.30-58.80) mm, CSA was found to be 39.3589±4.57935 (24.90-52.90)°, GCI was found to be 82.1105±4.95603 (71.40-95.90) mm, and CGV was -3.27±4.03 (-12.50-9.50) mm. Morphometric comparison of these measurements in terms of sex is given in Table I. CHDfp, CHH, CHR, CHDsp, CHDap, CGH, CCGMW, CGGUW, CGGLW, GCROC, and CGV showed significant differences in males and females, and all values except CHI, CSA, and CGV were found to be higher in males than in females.

Table I. Morphometric comparison of scapula and related structures in terms of sex.

Measurements	**Sex**				
	Female		**Male**		**p**
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	
Caput Humeri Diameter Frontal Plane (CHDfp)	41.22	2.35	47.83	2.14	< 0.001
Total	44.0016±3.97 (35.40-52.60)				
Caput Humeri Height (CHH)	15.85	1.50	17.91	1.53	< 0.001
Total	16.72±1.82448 (12.90-21.70)				
Caput Humeri Inclination (CHI)	50.36	5.37	49.55	4.65	0.282
Total	50.0189±5.08 (36.60-63.50)				
Caput Humeri Radius (CHR)	42.11	2.97	47.73	2.83	< 0.001
Total	44.4768±4.02 (36.50-54.80)				
Caput Humerus Diameter in the sagittal plane (CHDsp)	39.68	2.52	44.92	3.89	< 0.001
Total	41.8868±4.08525 (18.10-51.50)				
Caput Humerus Diameter Axial Plane (CHDap)	39.06	2.22	44.75	2.10	< 0.001
Total	41.4553±3.55264 (34.60-51.20)				
Cavitas Glenoidalis Height (CGH)	38.05	1.99	43.48	2.21	< 0.001
Total	40.3332±3.40 (32.20-49.00)				
Cavitas Glenoidalis Mid-Width (CCG_{MW})	20.94	1.89	24.83	1.73	< 0.001
Total	22.58±2.65 (17.40-27.80)				
Glenoid Cavity Upper Width (CGG_{UW})	17.11	1.62	20.17	1.94	< 0.001
Total	18.39±2.32 (13.30-29.0)				
Glenoid Cavity Lower Width (CGG_{LW})	23.48	1.61	27.60	1.88	< 0.001
Total	25.2155±2.67 (18.80-31.90)				
Cavitas Glenoidalis Curvature Radius (GCROC)	41.67	4.79	45.70	5.07	< 0.001
Total	43.3679±5.28630 (31.30-58.80)				
Critical Shoulder Angle (CSA)	39.63	4.30	38.98	4.94	0.334
Total	39.3589±4.57935 (24.90-52.90)				
Cavitas Glenoidalis Inclination (GCI)	81.63	4.81	82.77	5.11	0.116
Total	82.1105±4.95603 (71.40-95.90)				
Cavitas Glenoidalis Version (CGV)	-2.64	4.12	-4.14	3.75	0.011
Total	-3.27±4.03 (-12.50-9.50)				

A morphometric comparison of axial configuration by sex is given in Table II, and no significant difference was found between sexes (p>0.05). A morphometric comparison of these measurements by age groups is given in Table III, and the CHI, CHDAP, GCI, GCROC, and CSA parameters changed significantly with age (p<0.05).

Table II. Morphometric comparison of axial configuration in terms of sex.

Measurements		Sex		p
		Female	Male	
Axial configuration	1	1	1	0.666
	2	109	79	

Table III. Morphometric comparison of scapula and related structures in terms of age groups.

Measurements	Age groups				
	Decade 1 (n=42)	Decade 2 (n=74)	Decade 3 (n=58)	Decade 4 (n=16)	p
	Mean ± Standard Deviation	Mean ± Standard Deviation	Mean ± Standard Deviation	Mean ± Standard Deviation	
Frontal plane caput humeri diameter	44.81±4.01	43.72±3.82	43.88±4.02	43.62±4.51	0.516
Caput humeri height	17.12±2.08	16.55±1.78	16.58±1.69	16.88±1.83	0.384
Caput humeri inclination	51.02±5.02	48.91±4.87	49.63±4.95	53.93±4.66	**0.002**
Caput humeri radius	44.97±4.27	44.36±3.62	43.80±3.74	46.17±5.59	0.156
Sagittal caput humeri in the plane diameter	42.64±3.56	42.06±3.44	41.41±3.87	40.84±7.58	0.335
Axial plane of the caput humeri diameter	42.17±3.92	41.27±3.26	40.71±3.52	43.14±3.36	**0.042**
Cavitas glenoidalis height	40.44±3.04	40.28±3.32	40.11±3.47	41.11±4.50	0.768
Cavitas glenoidalis Mid-Width	22.93±2.62	22.50±2.92	22.43±2.29	22.57±2.82	0.804
Cavitas glenoidalis upper-width	18.71±2.42	18.34±2.66	18.27±1.86	18.21±1.97	0.786
Cavitas glenoidalis lower width	25.44±2.31	24.8223±2.85	25.29±2.31	26.16±3.66	0.268
Cavitas glenoidalis curvature radius	44.41±5.46	42.76±5.06	42.18±5.04	47.76±4.31	**0.001**
Critical shoulder angle	38.19±4.98	40.78±4.45	38.36±4.05	39.51±4.47	**0.005**
Cavitas glenoidalis inclination	82.45±4.80	82.77±4.93	80.31±4.57	84.68±5.16	**0.003**
Cavitas glenoidalis version	-2.97±4.20	-3.77±3.97	-2.74±3.86	-3.72±4.46	0.458

DISCUSSION

As the longest and thickest bone of the upper limb, the humerus is among the fundamental structures that form the articulatio humeri with the scapula and the articulatio cubiti with the radius (Standring, 2008; Arıncı & Elhan, 2025). Proximal humerus fractures account for the vast majority of humerus fractures (more than 75%), a condition that stems from the structural weakness of the surgical neck (collum chirurgicum) region of the bone (Hansen, 2014; Schumaier & Grawe, 2018). Evaluating the anatomical structures of the humerus, along with the muscular and neurovascular structures passing through this region, is of great importance in orthopedic and traumatic surgical planning (DeLude *et al*., 2007; Dey *et al*., 2018). Morphometric analyses are widely used today in both forensic medicine and anthropological studies and provide high accuracy in sex determination (Tellioglu & Karakaş, 2013). Because of its durability, the humerus can be protected against chemical and physical effects for long periods, making it a preferred bone in such studies (Frutos, 2005). In the present study, morphometric parameters of the humeri and glenoid cavity were examined in detail, and the measurements were evaluated for sex differences. Statistically significant differences were found in the vertical and transverse diameters of the humeri in males. Similarly, the superoinferior diameter of the glenoid cavity was measured larger in males than in females. These differences are important for the personalized design of shoulder joint prostheses and surgical applications. The results provide reference values for both clinical decision support systems and forensic medicine applications.

The caput humeri is a critical structure for the range of motion and joint stability of the shoulder joint. Morphometric differences in this region directly impact functional outcomes, particularly in surgical procedures such as prosthesis placement, fracture fixation, and rotator cuff repair (Pearl & Volk, 1996). When the results obtained regarding the measurements of the caput humeri were evaluated in the present study, it was found that the CHH measurements were especially compatible with the data obtained from the studies of Suroto *et al*. (2022), Cabezas *et al*. (2016) (East Asian population), and Sahu *et al*. (2020). CHI measurements were measured as an average of 50.02° in the present study, which is significantly different from the 133.8° value reported by Sahu *et al*. (2020). However, this difference is because of the different definition of the measurement direction and reference plane of the angle in both studies. While the external angle between the humeral head and the long axis of the humerus was measured in the Sahu *et al*. (2020) study, the internal angle between the same structures was evaluated in the present study. For this reason, it shows that the measurement difference is definitional. On the other hand, the mean curvature diameter of the caput humeri in the present study was found to be 47.73 mm, and 23.87 mm when calculated as radius, which is higher than that of Cabezas *et al*. (2016), falling between the mean values of 22.3 mm in the East Asian population and 24.6 mm in the North American population reported by. The results indicate that the Turkish population differs morphometrically from both populations and that region-specific reference values should be taken into account in prosthesis planning (Cabezas *et al*., 2016) **(**Table IV).

Glenoid dimensions and angular parameters (glenoid version and inclination) are directly related to shoulder joint biomechanics (Bodanki *et al*., 2021). Glenoid version (GV) represents the angle that the glenoid makes with the scapula and has a value range of approximately 0–10 degrees (van de Bunt *et al*., 2015). GV has been given to be associated with pathologies such as rotator cuff tears and glenohumeral instability (Tétreault *et al*., 2004). Also, it has been reported that excessive retroversion or inclination of the glenoid may lead to component placement failure in shoulder arthroplasty, increasing the risk of prosthesis instability, early loosening, and implant failure (Farron *et al*., 2006; Shapiro *et al*., 2007). For this reason, preoperative evaluation of GV is of great clinical importance (Bodanki *et al*., 2021). GV can be influenced by various individual variables, such as sex, age, handedness, and ethnicity (Matsumura *et al*., 2014; Piponov *et al*., 2016). Maintaining glenoid version within normal limits has been shown to reduce stress and wear on the glenoid component after arthroplasty (Strauss *et al*., 2009; Gates *et al*., 2020). In this context, careful evaluation of the GV is essential for both early diagnoses of pathologies and successful surgical planning. Studies by Mizuno *et al*. (2017) and Piponov *et al*. (2016), have demonstrated that glenoid version varies between sexes and different ethnic groups. The present study yielded similar results to other studies in the literature regarding CG width measurements. The GCI and CGV values obtained in the present study showed similar results to the study conducted by Mizuno *et al*. (2017). Of these measurements, the GCI was compared to the French population reported in the Mizuno *et al*. (2017) study, and the CGV was compared to the Japanese population reported in the same study. This result is highly consistent with the results of the present study. This suggests that these parameters may vary depending on geographical or ethnic factors (Table V). According to our results, the CGH and CSA parameters were found to be above the mean values reported in the literature in both male and female

Table IV. Comparison of caput humeri measurements with other studies in the literature.

Studies	Population	Caput Humeri Parameters					
		Caput Humeri Heigth, mm		Radius of the Caput Humeri, mm (Frontal/Sagittal)		Radius of Curvature of the Caput Humeri, mm (Axial/Frontal/Sagittal)	
		M	F	M	F	M	F
Suroto *et al*. (2022)	Indonesia	16.5 ±0.7	15.1±0.9	DF=44.3 ±2.3	DF=38.7 ±2.3	RF = 22.9 ± 1.2	RF = 20.6 ± 1.6
				DS=41.3 ±1.6	DS=36.7 ±2.4	RS = 21.7 ± 1.0	RS = 19.7 ± 1.3
Cabezas *et al*. (2016)	North America	19.7 ±1.7	17.3 ±1.4			RF = 24.6 ± 2.2	
						RA = 22.7 ± 2.3	
	East Asia	18.0 ±1.8	16.1 ±1.6			RF = 22.3 ± 1.9	
						RA = 20.9 ± 1.6	
Sahu *et al*. (2020)	India	17.4 ±1.4	16.0 ±1.5	DF=43.3±2.2	DF=38.7±2.3	23.6 ± 1.3	20.8 ± 0.9
				DS=41.2±1.9	DS=36.7±2.4		
Our Study	Turkey	17.91 ±1.53	15.85 ±1.5	CHD =47.83±2.14	CHD =41.22±2.35	CHR=47.73±2.83	CHR=42.11±2.97
						CHDSP=44.92±3.89	CHDSP=39.68±2.52
						CHDAP=44.75±2.10	CHDAP=39.06±2.22

Table V. Comparison of glenoid cavity measurements with other studies in the literature.

Studies	Population	Glenoid Cavity Parameters							
		Glenoid Cavity Height, mm		Glenoid Cavity Width, mm (Top/Middle/Bottom)		Glenoid Cavitas Inclination, degrees		Version of the glenoid cavity, degree	
		M	F	M	F	M	F	M	F
Suroto *et al*. (2022)	Indonesia	37.6±2.1	32.6±2.6	20.0±1.9	17.6±1.9	74.0±0.9	73.9±1.1	–12.3±1.1	–12.4±1.2
				27.2±2.0	23.2±2.2				
Cabezas *et al*. (2016)	North America	38.4±2.2	33.3±2.4	UW=24.5±2.8	UW=21.7±2.6				
				LW=30.5±2.2	LW=25.6±1.8				
	East Asia	34.3±2.6	31.9±2.5	UW=21.2±1.9	UW=20.3±2.1				
				LW= 25.7±2.1	LW=23.7±2.5				
Sahu *et al*. (2020)	India	31.8±2.1	29.9±1.9	24.5±1.9	22.5±1.5	77.8±4.2	81.5±5.9	–2.5±3.4	0.5±4.3
Mizuno *et al*. (2017)	Japan	35.3±1.8	31.4±1.8	27.4±2.4	23.5±1.6	10.4±6.9	12.8 ±5.1	-1.6±5.6	-3.0±4.4
	France	37.3±1.9	33.5±1.8	28.7±2.1	24.7±1.7	10.2±6.1	10.6 ±6.9	-6.2±4.5	-5.9±4.5
Our Study	Turkey	43.48±2.21	38.05±1.99	CGG_{MW} 24.83±1.73	CGG_{MW} 20.94±1.89	82.77±5.11	81.63±4.81	-2.64±4.12	-4.14±3.75
				CGG_{UW} 20.17±1.94	CGG_{UW} 17.11±1.62				
				CGG_{LW} 27.60±1.88	CGG_{LW} 23.48±1.61				

individuals. The CGH value was measured as 43.48±2.21 mm in males and 38.05±1.99 mm in females. The CSA value was measured as 39.98±4.94˚ in males and 39.63±4.3˚ in females. This suggests that there is a certain increasing trend in anatomical measurements regardless of sex and that there may be structural differences specific to the study sample (Tables V and VI). Although the CGH measurement is usually reported as radius in the literature, in this study, the same parameter was evaluated as diameter. This is only a methodological difference and does not change the basic structural feature of the measurement. For this reason, this difference was taken into account when comparing the results with the literature and does not affect the compatibility of the results with the general anatomical trend (Zumstein *et al*., 2014; Sahu *et al*., 2020; Zhang *et al*., 2023) (Table VII).

Table VI. Comparison of critical shoulder angle measurements with other studies in the literature.

Studies	Population	Critical Shoulder Angle, degrees	
		M	F
Cabezas *et al*. (2016)	North America	27.1±5.0	28.3±4.6
	East Asia	32.0±4.2	34.2±4.6
Sahu *et al*. (2020)	India	34.1±4.1	35.5±4.5
Our Study	Turkey	38.98±4.94	39.63±4.3

The long-term success of implants used in the shoulder joint depends on a correct understanding of the anatomical characteristics of the glenoid cavity and incorporating individual differences into surgical planning (Iannotti *et al*., 1992). For this reason, a detailed evaluation of glenoid morphometry in different populations is of great clinical importance. Bodanki *et al*. (2021), found the CGH value to be 32.9 ± 3.2 mm in their study on the Indian population, while in the present study, this value was 40.33 ± 3.40 mm. This difference is an indicator of morphological variation among ethnic groups and is particularly important for implant placement and prosthesis sizing. Glenoid width was found to be lower in the present study compared to the Bodanki *et al*. (2021) study. This suggests a narrower but longer glenoid cavity structure in Turkish individuals. In terms of version, a significant tendency toward retroversion (-3.27°) was detected in the present study, while neutral values (0.07°) were reached in the Bodanki *et al*. (2021) study. Retroversion of the glenoid is clinically important, particularly in terms of posterior instability, and should be carefully evaluated for implant positioning in surgical procedures such as total shoulder arthroplasty (Suroto *et al*.,

Table VII. Comparison of measurements of the radius of curvature of the glenoid cavity with other studies in the literature.

Studies	Population	Glenoid cavity curvature radius, mm	
Zumstein *et al. (*2014)	West	28.2±6.8	
Zhang *et al. (* 2023)	Chinese	23.49±2.48	
Sahu *et al.* (2020)	India	23.3±3.4	
Our Study	Turkey	M=45.7±5.07	F=41.67±4.79

2022). Iannotti *et al*. (1992) conducted a study to measure the dimensions of the humeral head and glenoid articular surfaces in the shoulder joint and to define the basic glenohumeral relationships. They emphasized the biomechanical importance of selecting a glenoid radius ~2–3 mm larger than the humerus and the need for a wider range of size options in prosthesis design and sizing. In their study evaluating the anatomy of the glenoid cavity and the suitability of implants in this region for their population, Slocum *et al*. (2021), stated that preoperative shoulder CT scans can provide a general idea of glenoid morphology for surgical planning, and that various precautions can be taken during surgery by optimizing glenoid implant fixation. In the present study, by presenting detailed glenoid and humeri measurements specific to the Turkish population, the results draw attention to morphological variability related to both age and sex, and are consistent with the literature emphasizing that individual anatomy should be taken into account in implant planning. Tellioglu & Karakas (2013) conducted a study in Turkey using morphometric methods on the humerus to demonstrate sex differences and determine the best discriminatory variables, and found that these morphometric measurements allowed for sex differentiation with high accuracy. Frutos (2005) also aimed to determine sex using a series of morphometric measurements (e.g., maximum head diameter, midshaft circumference/ diameters, epicondylar width, humerus length) taken from adult humeri in a group of individuals of Guatemalan origin and demonstrated that population-specific humerus metrics have very high discriminatory power in sex determination. In this context, the measurements of the humeri cap and glenoid cavity obtained in the present study also indicated sex-based morphological differences, with significantly higher values observed in males for all parameters except CHI, CSA, and CGV. These results are consistent with the literature supporting the discriminatory power of bone metrics in sex discrimination.

The present study had several limitations. Firstly, because of its retrospective design, demographic data were not available. Secondly, because only healthy individuals were included, comparisons with individuals with pathological conditions were not possible. Also, the age range of 20-60 years precluded the assessment of anatomical variations in younger or older individuals. All these limitations necessitate caution in interpreting the results.

In conclusion, the present study evaluated the humeral head and neck lengths, humeral head diameter and radius measurements, and glenoid version angles in healthy individuals in detail, and the resulting data were analyzed considering demographic variables such as age and sex. The results contribute to the normative measurements of these anatomical structures and can be used as reference data in clinical practice, particularly in shoulder surgery and prosthesis planning. In preoperative planning for shoulder surgery, the scapula, its relative angles, and glenoid version values are crucial for the accuracy of the surgical approach and the success of implant placement. These angles not only ensure accurate assessment of anatomical alignment but also allow the surgeon to be prepared for potential complications that may be encountered during the operation. For this reason, careful analysis of parameters such as scapular inclination and scapulothoracic angle, particularly when assessing the spatial orientation of the glenoid, appears to be critical for improving surgical outcomes.

ÖZCAN, B.; POLAT, S.; BÖLGEN, C.; ÖKSÜZLER, M. & GÖKER, P. Evaluación anatómica y radiológica-morfométrica de la cabeza del humera y cavidad glenoidea en individuos sanos. *Int. J. Morphol., 44(2)*:720-729, 2026.

RESUMEN: El estudio tuvo como objetivo evaluar anatómica y radiológicamente, desde una perspectiva morfométrica, los húmeros y la cavidad glenoidea en individuos turcos sanos, y determinar valores de referencia específicos para la población turca mediante el análisis de las posibles relaciones entre estas estructuras y los efectos de las variables demográficas. Se examinó a un total de 190 individuos sanos (80 hombres y 110 mujeres) de entre 20 y 60 años de edad con imágenes de tomografía computarizada disponibles. Se evaluaron las posibles relaciones entre la morfometría de la cabeza del húmero y la cavidad glenoidea en individuos turcos sanos, y las mediciones morfométricas de estas estructuras también se correlacionaron con variables demográficas. Se midieron el diámetro frontal del húmero, la longitud del húmero, la inclinación del húmero, el radio del húmero, el diámetro sagital del húmero, el diámetro axial del húmero, la altura glenoidea, el ancho medio glenoideo, el ancho superior glenoideo, el ancho inferior glenoideo, el radio de curvatura glenoidea, el ángulo crítico del hombro, la inclinación glenoidea y la versión glenoidea. Las mediciones morfométricas de la cavidad glenoidea y la cabeza del húmero demostraron correlaciones significativas con las variables demográficas. Cuando se evaluaron la escápula y las estructuras relacionadas en diferentes grupos de edad, se observaron cambios significativos relacionados con la edad en los siguientes parámetros: inclinación del húmero, diámetro del húmero en el plano axial, inclinación glenoidea, radio de curvatura de la cavidad glenoidea y ángulo crítico del hombro ($p<0,05$). Se observaron diferencias significativas relacionadas con el sexo en las mediciones de la cabeza humeral y caviad glenoidea, excepto en la inclinación de la cabeza del húmero, el ángulo crítico del hombro y la versión de la cavidad glenoidea, con valores más altos en hombres. Los parámetros de configuración axial no mostraron diferencias significativas entre sexos ($p>0,05$). Los resultados del estudio contribuyen a las mediciones normativas de estas estructuras anatómicas y pueden utilizarse como datos de referencia en la práctica clínica, particularmente en cirugía de hombro y planificación protésica. Se ha demostrado que un análisis cuidadoso de parámetros como la inclinación escapular y el ángulo escapulotorácico, al evaluar la orientación espacial de la cavidad glenoidea, es fundamental para mejorar los resultados quirúrgicos.

PALABRAS CLAVE: Escápula; Cavidad glenoidea de la escápula; Ángulo crítico del hombro.

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