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Orginal Article

Relationship of Humerus Retroversion Angle with Morphometric Parameters

Humerus Retroversiyon Açısının Kemik Parametreleri ile İlişkisi

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Highlights

-Anthropometric measurements are very important clinically.

-In addition, the importance of anthropometric and morphometric measurements to be made, especially in forensic medicine cases, in age and/or gender determination becomes apparent.

-At this point, it is important to carry out anatomical and clinical studies together.

Abstract

Background: This study aims to perform an analysis of the morphometric anatomical measurements of the humerus to make clinically successful evaluations. **Material and Method:** A total of 42 dry bone humerus were included in the study. Measurement parameters: Length of the humerus (LH), circumference of the surgical neck (CSN), width of the intertubercular sulcus (WIS), depth of the intertubercular sulcus (DIS), width of the epicondyle (WE), width of the trochlea humeri (WTH), length of the trochlea of humerus (LTH), width of the olecranon fossa (WOF), depth of the olecranon fossa (DOF), height of the olecranon fossa (HOF), transvers diameter of the head of humerus (TDH), vertical diameter of the head of humerus (VDH), minimum diameter of the shaft of humerus (Min-DS), maximum diameter of the shaft of humerus (Max-DS), width of the capitulum of humerus (WC), length of the capitulum of humerus (LC), the height of the coronoideal arch (HCA), the width of the coronoideal arch (WCA), the retroversion angle of the humerus (RAH) were determined. **Results:** According to the study results, mean and standard deviation values, LH; 300, CSN; 72±8.7, WIS; 8.2±1.6, DIS; 5.7±0.9, WE; 59, WTH; 15.6±4.4, WOF; 22.7±2.2, DOF; 13.4±2.1, TDH; 42.5±2.8, VDH; 44.8±3.5, Min-DS; 18.7±1.8, Max-DS ; 21.8±2.1, WS; 16.2±4.1, LC; 20.6±1.7, LTH; 20.7±4.4, HCA; 6.3, WCA; 11, HOF; 13.4±2.2, RAH; 28.2.
Conclusion: It is very important to calculate the average values of the anatomical structures in this bone to know the humerus bone's normal anatomical structure and to guide the surgical procedures in this region.
Keywords: Humerus, morphometry, retroversion angle.

Öz

Amaç: Bu çalışmanın amacı, klinik açıdan başarılı yönlendirmeler yapılabilmesi için humerus'un morfometrik anatomik ölçümlerinin analizinin yapılmasıdır. **Materyal ve Metod:** Çalışmaya yaşı, cinsiyeti ve kimliği bilinmeyen toplam 42 adet kuru kemik humerus dahil edilmiştir. Ölçüm parametreleri: Humerus uzunluğu (HU), cerrahi boyun çevresi (CBÇ), sulcus intertubercularis genişliği (SIG), sulcus intertubercularis derinliği (SID), epicondyler genişlik (EG), trochlea humeri genişliği (THG), fossa olecranii genişliği (FOG), fossa olecranii derinliği (FOD), humerus başının transvers çapı (HBTÇ), humerus başının vertikal çapı (HBVÇ), minimum corpus çapı (MinCÇ), maximum corpus çapı (MaxCÇ), capitulum humeri genişliği (CHG), capitulum humeri uzunluğu (CHU), trochlea humeri uzunluğu (THU), coronoideal ark yüksekliği (CAY), coronoideal ark genişliği (CAG), fossa olecranii yüksekliği (FOY), humerus retroversiyon açısı (HRA) olarak belirlenmiştir. **Bulgular:** Çalışma sonuçlarına göre ortalama ve standart sapma veya median değerleri, HU; 300, CBÇ; 72±8,7, SIG; 8,2±1,6, SID; 5,7±0,9, EG; 59, THG ; 15,6±4,4, FOG; 22,7±2,2, FOD; 13,4±2,1, HBTÇ; 42,5±2,8, HBVÇ; 44,8±3,5, MinCÇ; 18,7±1,8, MaxCÇ ; 21,8±2,1, CHG; 16,2±4,1, CHU; 20,6±1,7, THU; 20,7±4,4, CAY; 6,3, CAG; 11, FOY; 13,4±2,2, HRA; 28,2 olarak bulunmuştur. **Sonuç:** Humerus kemiğinin normal anatomik yapısını bilmek ve bu bölgedeki cerrahi prosedürleri yönlendirmek için bu kemikteki anatomik yapıların ortalama değerlerini hesaplamak çok önemlidir.
Anahtar kelimeler: Humerus, morfometri, retroversiyon açısı.

Introduction

Humerus is the longest and thickest bone of the upper extremity and it is the only bone that makes up the arm skeleton (1). Humerus has a total of eight ossification centres, one from the corpus, one from the caput, one from the capitulum, one from the trochlea, two from the tubercle and two from the epicondyle (2). Humerus is also of great importance since it is formed by the combination of more than one joints, it has the widest range of motion in the human body and it participates in the formation of shoulder complex which enables hand movements to be made in a functional way (3). The shoulder, which has the ability of approximately 170° elevation, 60° extension and 120-180° rotation, provides this range of motion from medial to lateral through sternoclavicular, acromioclavicular, glenohumeral and scapulothoracic joints and subacromial region, respectively (4). On the other hand, elbow joint is a hinge and synovial joint formed by the combination of humero-radial, humero-ulnar and proximal radio-ulnar joints and elbow joints allow one of the two bones to move independently, thanks to the articulation of the humerus with the radius and ulna (5). Proximal humerus fractures constitute 4-5% of all fractures and this rate increases with advancing age and takes its place in the most common fracture group after wrist and femur fractures (1). The most common clinical presentation in proximal humerus fractures is surgical neck fractures. Half of the fractures are treated surgically. Fractures of the distal region of the humerus constitute 5% of all fractures and 30% of elbow region fractures (6). In addition, radial nerve and profunda brachii artery may be damaged in shaft of humerus fractures, while ulnar nerve may be damaged in epiconylus medialis fractures. The angle between the axis passing through the proximal articular surface of the humerus and the axis passing through the distal articular surface is defined as the retroversion angle. This angle is approximately between 10-40° in adults. In new-borns, this angle is greater and decreases with age (6). This angle differs among societies and individuals (7). Existing literature data show the importance of examining the morphometry of the humerus in detail. Therefore, the aim of the present study is to perform morphometric analyses of the bone and to calculate the retroversion angle, based on the clinical importance of the humerus. It is thought that the analysis results of the parameters determined in the study will add clinical depth to pathological conditions such as glenohumeral arthrodesis, internal fixation, fracture stabilization, lateral and medial epicondylitis, cubital tunnel syndrome in more accurate analysis of shoulder and elbow anomalies and fractures.

Material and Method

The study was initiated with the 2022/56 decision numbered ethics committee approval of Clinical Research Ethics Committee. The study was carried out on 42 (23 left, 19 right) dry humerus bones of unknown age and sex from the bone collection Bolu Abant İzzet Baysal University Anatomy Department. The length of the humerus (LH), the circumference of the surgical neck (CSN), the width of the intertubercular sulcus (WIS), the depth of the intertubercular sulcus (DIS), the width of the epicondyle (WE), the width of the trochlea humeri (WTH), the length of the trochlea of humerus (LTH), the width of the olecranon fossa (WOF), the depth of the olecranon fossa (DOF), the height of the olecranon fossa (HOF), the transvers diameter of the head of humerus (TDH), the vertical diameter of the head of humerus (VDH), minimum diameter of the shaft of humerus (Min-DS), maximum diameter of the shaft of humerus (Max-DS), the width of the capitulum of humerus (WC), the length of the capitulum of humerus (LC), the height of the coronoideal arch (HCA), the width of the coronoideal arch (WCA) and the retroversion angle of the humerus (RAH) were measured by placing on an osteometric board by using a digital calliper. Retroversion angle measurement design: the bones were photographed from a distance of 100 cm under artificial light with the help of osteometric board. Photography system was set up by fixing the camera at a distance of 100 cm with an adjustable tripod. Shots were taken with digital SLR (Canon EOS 80D; ISO 100 f/4.5) camera. The photos taken were transferred to ImageJ (version 153e) program, reference points were determined and measurements were made.

Determined parameters:

1- The length of the humerus (LH): The distance between the most proximal end of the humerus and the most distal end of the trochlea humeri.
2- The circumference of the surgical neck (CSN): Surgical neck circumference was measured as in Figure 1.
3- The width of the intertubercular sulcus (WIS): The transverse length between tuberculum majus and tuberculum minus.
4- The depth of the intertubercular sulcus (DIS): Depth of groove between tuberculum majus and tuberculum minus.
5- The width of the epicondyle (WE): The distance between the most medial end of the epicondylus medialis and the most lateral end of the epicondylus lateralis.

6- The width of the trochlea humeri (WTH): The distance between the most lateral and most medial of the trochlea humeri.
7- The length of the trochlea of humerus (LTH): The distance between the most proximal and most distal of the trochlea humeri.
8- The width of the olecranon fossa (WOF): The widest distance of olecranon fossa parallel to the epicondylar line.
9- The depth of the olecranon fossa (DOF): The distance from the deepest part of the olecranon fossa to the epicondylar line.
10- The height of the olecranon fossa (HOF): The longest distance between the most proximal and the most distal of the olecranon fossa.
11- The transvers diameter of the head of humerus (TDH): The distance between the most lateral and the most medial articular surfaces of the caput humeri.
12- The vertical diameter of the head of humerus (VDH): The distance between the most proximal and the most distal articular surfaces of the caput humeri.
13- Minimum diameter of the shaft of humerus (Min-DS): The shortest distance of the corpus humeri.
14- Maximum diameter of the shaft of humerus (Max-DS): The longest distance of the corpus humeri.
15- The width of the capitulum of humerus (WC): The distance between the most lateral and most medial of the capitulum humeri.
16- The length of the capitulum of humerus (LC): The distance between the most proximal and the most distal of the capitulum humeri.
17- The height of the coronoideal arch (HCA): The distance between the most proximal and the most distal of the coronoideal arch.
18- The width of the coronoideal arch (WCA): The distance between the most lateral and most medial of the coronoideal arch.
19- The retroversion angle of the humerus (RAH): The angle between the axis passing through the articular surface located proximal to the humerus and the axis passing through the articular surface located distal to the humerus.

Statistical Analyses

After the parameters were measured, statistical analyses were made with Minitab® 21.2 (64-bit) program. Whether the parameters measured showed a normal distribution was determined with Anderson Darling test. Minimum, maximum and median values were included for parameters which were not normally distributed, while mean and standard deviation values were included for parameters which were normally distributed. Two simple t-test was applied to parameters with normal distribution, while Mann Whitney U test was applied to parameters which did not show normal distribution. The correlation between parameters was found with Pearson correlation test.

Results

Table 1 and Table 2 show the descriptive statistics in the study. WIS, DIS and WC parameters were found to be statistically significant as a result of the analysis conducted. Table 2 shows the correlation coefficients between the parameters. As a result of Pearson correlation test, positive strong correlation was found between WTH-CSN, VDH-CSN, LTH-CSN, HOF-WTH, HOF-LTH, WTH-LH. Negative correlation was found between RAH and LH, DIS, WE, TDH, VDH, LH, HCA, WCA, HOF; while positive weak correlation was found between CSN, WIS, WTH, WOF, DOF, Min-DS, Max-DS, WC, LC.

Table 1. Minimum, maximum, median, mean, standard deviation and p values of the parameters (*).

	Mean±Std / Median		**Minimum**		**Maximum**		**P**
	R	L	R	L	R	L	R
LH	300	300	250	255	340	350	0.667
CSN	72±8.8	72.1±8.8	-	-	-	-	0.950
WIS	7.5±0.2	8.8±0.3	-	-	-	-	0.004
DIS	6.0±0.1	5.4±0.2	-	-	-	-	0.027

WE	59.0	59.0	45.9	46.2	63.9	73.1	0.723
WTH	14.7±0.9	16.4±0.9	-	-	-	-	0.216
LTH	20.1±4.1	21.2±4.7	-	-	-	-	0.411
WOF	22.7 ± 2.1	22.7 ± 2.4	-	-	-	-	0.928
DOF	12.9 ± 1.9	13.9±2.3	-	-	-	-	0.155
HOF	13.8 ± 2.2	13.0±2.3					0.228
TDH	42.1±2.3	43.0 ± 3.2	-	-	-	-	0.303
VDH	44.5 ± 2.9	45.1 ± 3.9	-	-	-	-	0.538
Min-DS	19.0 ± 1.8	18.5 ± 1.7	-	-	-	-	0.449
Max-DS	22.3 ± 1.9	21.3 ± 2.2	-	-	-	-	0.142
WC	15.7 ± 1.3	16.6 ± 1.4	-	-	-	-	0.033
LC	20.3 ± 1.0	20.8 ± 2.2	-	-	-	-	0.376
HCA	6.8	5.9	4.2	4.1	10.8	11.7	0.312
WCA	11.3	11.0	7.6	6.8	15.3	17.9	0.079
RAH	28.2	28.2	20.6	23.2	34.8	35.2	0.448

Abbreviations:(*)The length of the humerus (LH), the circumference of the surgical neck (CSN), the width of the intertubercular sulcus (WIS), the depth of the intertubercular sulcus (DIS), the width of the epicondyle (WE), the width of the trochlea humeri (WTH), the length of the trochlea of humerus (LTH), the width of the olecranon fossa (WOF), the depth of the olecranon fossa (DOF), the height of the olecranon fossa (HOF), the transvers diameter of the head of humerus (TDH), the vertical diameter of the head of humerus (VDH), minimum diameter of the shaft of humerus (Min-DS), maximum diameter of the shaft of humerus (Max-DS), the width of the capitulum of humerus (WC), the length of the capitulum of humerus (LC), the height of the coronoideal arch (HCA), the width of the coronoideal arch (WCA), the retroversion angle of the humerus (RAH), right (R), left (L) .

Table 2. Pearson correlation test results (*)

	LH	CSN	WIS	DIS	WE	WTH	WOF	DOF	TDH	VDH
CSN	0.143									
WIS	0.139	0.278								
DIS	0.191	0.357	0.067							
WE	0.413	0.166	0.215	0.027						
WTH	0.042	0.699	0.348	0.233	0.042					
WOF	0.351	0.012	0.283	-0.003	0.526	-0.028				
DOF	0.282	0.391	0.514	-0.040	0.156	0.299	0.362			
TDH	0.571	0.493	0.300	0.093	0.534	0.310	0.397	0.417		
VDH	0.590	0.678	0.421	0.335	0.355	0.504	0.286	0.518	0.713	
Min-DS	0.432	0.246	0.239	0.158	0.542	0.082	0.450	0.320	0.390	0.312
Max-DS	0.427	0.128	0.124	0.181	0.529	-0.081	0.426	0.266	0.346	0.224
WC	0.454	0.398	0.350	0.017	0.510	0.401	0.240	0.471	0.576	0.541
LC	0.197	0.066	0.295	-0.028	0.039	0.173	0.027	0.258	0.064	0.178
LTH	0.137	0.671	0.284	0.292	0.033	0.813	-0.061	0.321	0.404	0.566
HCA	0.139	-0.453	-0.178	-0.076	0.222	-0.696	0.375	-0.072	-0.067	-0.260
WCA	0.406	-0.270	-0.036	-0.024	0.544	-0.274	0.392	-0.078	0.069	0.083
HOF	0.339	-0.434	-0.125	-0.228	0.285	-0.617	0.453	0.093	0.083	-0.124
RAH	-0.159	0.192	0.288	-0.058	-0.067	0.049	0.098	0.254	-0.006	-0.093

	Min-DS	Max-DS	WC	LC	LTH	HCA	WCA	HOF
CSN								
WGI								
DGI								
WE								
WTH								
WOF								
DOF								
TDH								
VDH								
Min-DS								
Max-DS	0.836							
WC	0.336	0.272						
LC	0.027	0.084	0.352					
LTH	-0.025	-0.175	0.403	0.163				
HCA	0.232	0.371	-0.159	-0.195	-0.765			
WCA	0.399	0.460	-0.027	0.052	-0.424	0.393		
HOF	0.378	0.472	0.025	0.030	-0.668	0.743	0.523	
RAH	0.155	0.095	0.109	0.069	-0.035	-0.038	-0.324	-0.053

Abbreviations: (*)The length of the humerus (LH), the circumference of the surgical neck (CSN), the width of the intertubercular sulcus (WIS), the depth of the intertubercular sulcus (DIS), the width of the epicondyle (WE), the width of the trochlea humeri (WTH), the length of the trochlea of humerus (LTH), the width of the olecranon fossa (WOF), the depth of the olecranon fossa (DOF), the height of the olecranon fossa (HOF), the transvers diameter of the head of humerus (TDH), the vertical diameter of the head of humerus (VDH), minimum diameter of the shaft of humerus (Min-DS), maximum diameter of the shaft of humerus (Max-DS), the width of the capitulum of humerus (WC), the length of the capitulum of humerus (LC), the height of the coronoideal arch (HCA), the width of the coronoideal arch (WCA), the retroversion angle of the humerus (RAH).

Table 3. Comparison of literature data. HRA is measured in degrees, other values in millimeters. Right and left side values are written respectively (*)

	Akman et al, TR (17)	Desai et al., IND (13)	Niraj et al. SA (18)	Patil et al., IND (19)	Sinha et al. IND (12)	Andrin et al., F (15)	Goldberg et al, US(16)	Yılmaz, TR (1)	Kastamoni, TR (6)	Tellioğlu et al. TR (2)	This study, TR
N	120	90	200	250	49	70	1104	80	54	104	42
LH	307.1±20.8 307.8±18.9	292.3±22.9 289.4±21.8	308.5±19.1 307.2±16.1	311±3 303±5	290.17±18.67 283.36±22.80	-	-	298.5±3.08 311.6±2.44	320.04±30.44 307.13±28.15	292 (F) 313 (M)	300 300
TDH	-	-	-	-	-	-	-	-	-	37.0 (F) 41.9(M)	42.1±2.3 43.0±3.2
VDH	-	-	-	-	-	-	-	-	-	40.5±2.6 (F) 45.8±2.0 (M)	44.5±2.9 45.1±3.9
RAH	-	-	23.16 26.6	-	-	37	35±7	-	36.44±4.97 31.34±5.51	-	28.2 28.2
DIS	-	-	-	-	-	-	-	3.79±0.64 3.96±1.09	3.08±0.95 3.51±0.85	4.3±0.7 (F) 4.7±0.6 (M)	6.0±0.1 5.4±0.2
WIS	-	6.9±1.2 7.1±1.1	-	-	-	-	-	6.72±0.64 6.52±1	7.79±0.77 7.34±0.65	10.01±0.5 (F) 10.6±0.9 (M)	7.5±0.2 8.8±0.3
WE	-	-	-	-	57.64±5.33 56.11±5.41	-	-	58.21±5.24 57.07±4.78	57.44±4.87 56.18±4.86	54.7±3.5 (F) 61.3±3.4 (M)	59.0 59.0
Min-DS	-	-	-	-	-	-	-	-	-	15.8(F) 19.2 (M)	19.0±1.8 18.5±1.7
Max - DS	-	-	-	-	-	-	-	-	-	19.3(F) 21.8 (M)	22.3±1.9 21.3±2.2
WC	-	-	-	-	-	-	-	-	-	16.1(F) 18.3 (M)	15.7±1.3 16.6±1.4

LC	-	-	-	-	-	-	-	-	-	20.0(F) 22.2 (M)	20.3±1.0 20.8±2.2
WTH	-	-	-	-	-	-	-	-	35.91±5.24 35.31±5.42	22.7±1.5 (F) 22.9±1.3 (M)	14.7±0.9 16.4±0.9
LTH	-	-	-	-	-	-	-	-	-	23.4 (F) 25.5 (M)	20.1±4.1 21.2±4.7
WOF	-	21.2±1.8 20.7±2.1	-	-	-	-	-	-	22.32±2.34 22.34±2.95	-	22.7±2.1 22.7±2.4
DOF	-	-	-	-	-	-	-	5.34±0.97 5.35±1.05	6.86±1.4 6.65±1.3	-	12.9±1.9 13.9±2.3
CSN	-	-	-	-	-	-	-	-	75.3±9.5 75.5±8.6	91 (F) 92(M)	72±8.8 72±8.8

Abbreviations: (*)The length of the humerus (LH), the circumference of the surgical neck (CSN), the width of the intertubercular sulcus (WIS), the depth of the intertubercular sulcus (DIS), the width of the epicondyle (WE), the width of the trochlea humeri (WTH), the length of the trochlea of humerus (LTH), the width of the olecranon fossa (WOF), the depth of the olecranon fossa (DOF), the height of the olecranon fossa (HOF), the transvers diameter of the head of humerus (TDH), the vertical diameter of the head of humerus (VDH), minimum diameter of the shaft of humerus (Min-DS), maximum diameter of the shaft of humerus (Max-DS), the width of the capitulum of humerus (WC), the length of the capitulum of humerus (LC), the height of the coronoideal arch (HCA), the width of the coronoideal arch (WCA), the retroversion angle of the humerus (RAH), female (F), male (M), United State (US), France (F), Turkey (TR), India (IND), South Asia (SA).

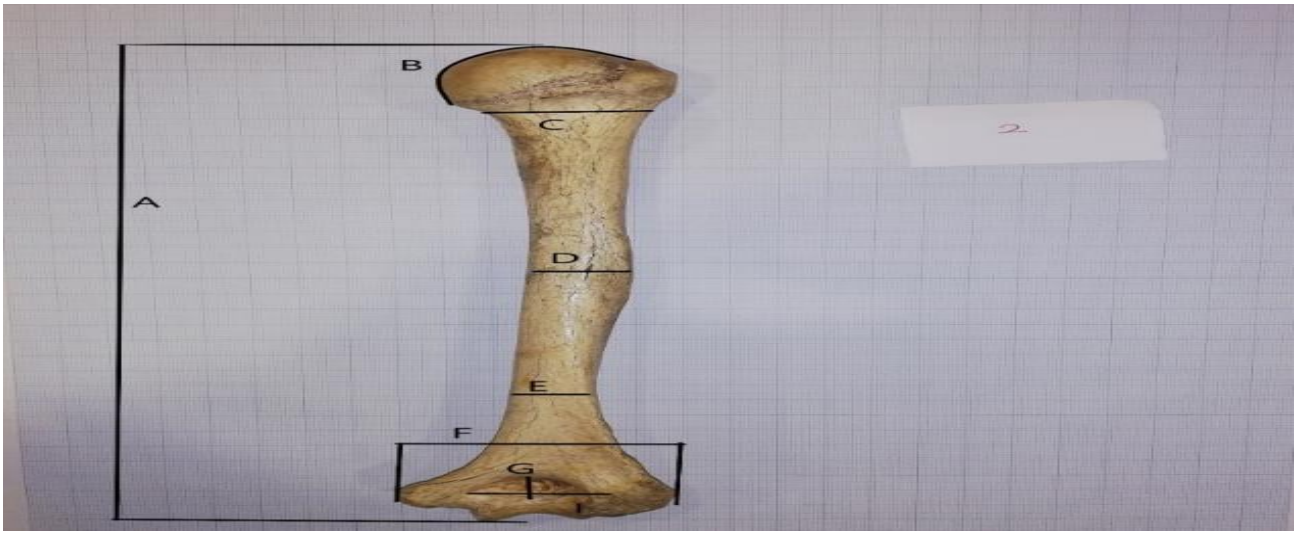

Figure 1. A: The humeral length, **B:** The vertical diameter of the head of humerus, **C:** The circumference of the surgical neck, **D:** The maximum diameter of the shaft of humerus, **E:** The minimum diameter of the shaft of humerus, **F:** The width of the epicondyle, **G:** The height of the olecranon fossa, **I:** The width of the olecranon fossa.

Figure 2. A: The height of the coronoideal arch, **B:** The width of the coronoideal arch, **C:** The length of the capitulum of humerus, **D:** The width of the capitulum of humerus, **E:** The length of the trochlea of humerus, **F**: The depth of the olecranon fossa, **G:** The depth of the intertubercular sulcus.

Discussion

Mobility and stability of shoulder depend on the amount of humeral retroversion (8–10). Retroversion movement also affects glenohumeral joint mechanism. Pain and pathologies in this region are among the most common symptoms in musculoskeletal system (11). Therefore, evaluation of the parameters of the humerus and especially retroversion angle is of great importance. When the literature is reviewed, the highest and the lowest HL values were measured in Turkish and Indian populations, respectively (6,12). While the data were 320.04±30.44 and 307.13±28.15 on the right and left, respectively in a study conducted on 54 dry bones in Turkey, they were 290.17±18.67 and 283.36±22.80 in a study conducted on 49 dry bones in India (6,12). In the present study, which was designed to make a detailed morphometric evaluation, a total of 19 different measurements were made, two on the humeral shaft, seven on the proximal end and ten on the distal end. LH value in the study was found as 300 on the right and on the left **(Table 1).** The study result is within the limits of literature data. The number of studies examining TDH and VDH is limited in literature **(Table 3).** In a study examining gender differences through humerus in Turkish population, TDH values were found as 37.0, 41.9 and VDH values were found as 40.5±2.6, 45.8±2.0 in women and men, respectively (2). The data obtained in this study were examined as right and left and they were found to be higher when compared with the literature. Since not knowing the gender of bones in the collection which were used as material in the study makes the validation of the data impossible, it seems to be a disadvantage. When DIS and WIS parameters were examined, the lowest DIS values were in a study conducted in 2021 as 3.08±0.95 and 3.51±0.85, respectively on the right and left (6). Similarly, in a study conducted in 2020, the lowest DIS values were found as 6.72±0.64 and 6.52±1, respectively on the right and left (1). The highest WIS values were found as 10.01±0.5 and 10.6±0.9, respectively for women and men in a study examining the differences between genders (2). When the literature is reviewed, as stated in Table 3, the highest DIS value is the data obtained in the present study (**Table 3).** WIS, WOF and LC values of the study are in parallel with the literature (2,6,13). In addition, although the results in literature for WE, Min-DS, Max-DS, DOF values were found to be close, the highest numerical values seem to be data obtained in the present study (1,2,6,12). On the other hand, when the literature was reviewed for CSN, WTH and LTH, the lowest numerical values were found to be in the present study (2,6). In a study conducted, it was stated that the changes in retroversion angle in the functional treatment of humeral fractures could easily be tolerated by patients as long as retroversion angle was within appropriate limits (14). When the results of this study were compared with HRA values in literature, although they were close to the results in a study conducted in South Asian population, they were found to be numerically lower than the studies conducted in France and America **(Table 3).** When the WTH-CSN, VDH-CSN, LTH-CSN, HOF-WTH, HOF-LTH, WTH-LH parameters, which have a strong positive correlation, are evaluated **(Table 2)**, the increase in the variables will provide valuable data in clinical prosthesis designs or in cases where identification is required in the field of forensic medicine (16, 20). It was also stated in a study conducted in 2022 that not only morphometric differences should be known, but also the differences between populations should be taken into account in prosthesis designs (20). Therefore, the differences between populations were examined. In studies on musculoskeletal system, occupations of individuals, working conditions required by these occupations and at the same time ergonomic conditions in work are important factors in the emergence of musculoskeletal system. It is thought that the reason why some parameters in the study are different from the results on Turkish population shown in **Table 3.** As a result, the results of the present study were in parallel with the data obtained from studies in literature. In addition, the difference between right and left bones for WIS, DIS and WC parameters were found to be significant. When the correlation of RAH with other parameters was examined, a negative weak correlation was found between LH, DIS, WE, Min-DS, Max-DS, LTH, HCA, WCA and HOF while a positive weak correlation was found between CSN, WIS, WTH, WOF, DOF, Min-DS, Max-DS, WC and LC.

Conclusion

The present study is a cross-sectional study and although it does not reflect the whole Turkey population, it gives a general information about Bolu sample. Morphometric data obtained from the humerus with various methods can be a reference in anthropology, radiology and physiotherapy-rehabilitation areas and in studies planned for problems in the clinic. They can also be a guiding source in understanding radiological anatomy of the humerus better, in humerus fractures and conditions that affect the shoulder and the arm, various surgeries such as shoulder joint prosthetic replacement arthroplasty and surgical interventions such as grafting. The data obtained in the field of forensic medicine provide data about the mean size of the humerus.

Study Limitation

The fact that no data were known about the age, gender of the bones used in the study and the life conditions of the individuals the bones belonged to were important parameters that limited the study. In addition, the presence of diseases that can affect the bone tissue and joints such as osteoporosis, rheumatoid arthritis and osteoarthritis are not known.

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