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The Importance of Morphometric Measurements of Adult Human Dry Hip Bone in Acetabular Reconstruction

Acetabulum Rekonstrüksiyonunda Erişkin İnsan Kuru Os coxae'sına ait Morfometrik Ölçümlerin Önemi

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Abstract

Objective: The aim of this study was to obtain morphometric measurements of adult human hip bones, examine the relationship among these measurement parameters, and develop regression equations to estimate the acetabular dimensions for acetabular reconstruction

Material and Method: Seventy-eight (39 right and 39 left) dry hip bones of unknown age and gender located in the laboratory of Çukurova University Faculty of Medicine, Department of Anatomy, were included in the study. Eleven hip bones with fractures, deterioration, deformities, and defects that would affect the measurements were excluded from the study. In our study, 14 morphometric measurements of hip bones were obtained. IBM SPSS program was used for statistical analysis.

Results: Single and multiple regression equations were developed from the hip bone morphometric measurements for the estimation of the morphometric measurements of the acetabulum. The standard error of estimate (SEE) values ranged from ±1.818 mm to ±3.546 mm in single regression equations, and between ±1.633 mm and ±2.107 mm in multiple regression equations. A lower SEE value was obtained in multiple regression equations than in single regression equations.

Conclusion: The regression equations developed in this study will allow us to obtain personalized measurements, which will aid clinicians in the correct and safe placement of the implant in hip replacement surgeries as well as in the prevention of complications with the use of appropriate prostheses.

Keywords: Acetabular reconstruction, regression analyses, acetabulum, hip bone

Öz

Amaç: Bu çalışmada, yetişkin insan Os coxae'sına ait morfometrik ölçümlerin elde edilmesi ve bu ölçüm parametreleri arasındaki ilişkinin incelenerek Acetabulum'un rekonstrüksiyonunda acetabulum boyutlarını tahmin etmek için regresyon denklemlerinin oluşturulması amaçlanmıştır.

Gereç ve Yöntem: Çalışmamıza Çukurova Üniversitesi Tıp Fakültesi Anatomi Anabilim dalı laboratuvarında yer alan yaş ve cinsiyetleri bilinmeyen 78 (39 sağ, 39 sol) kuru Os coxae dahil edilmiştir. Herhangi bir kırık, bozulma, deformite ve çalışmadaki ölçümleri etkileyecek kusur bulunan 11 Os coxae çalışmadan çıkarılmıştır. Çalışmamızda Os coxae'ya ait 14 morfometrik ölçüm elde edilmiştir. Ölçüm parametrelerinin istatistiksel analizinde IBM SPSS programı kullanılmıştır.

Bulgular: Acetabulum'un morfometrik ölçümlerinin tahmini için Os coxae'nın morfometrik ölçümlerinden tekli ve çoklu regresyon denklemleri oluşturulmuştur. Standart tahmini hata değerleri tekli regresyon denklemlerinde ±1,818 mm ile ±3,546 mm arasında iken, çoklu regresyon denklemlerinde ±1,633 mm ile ±2,107 mm arasında değişmektedir. Çoklu regresyon denklemlerinde, tekli regresyon denklemlerine kıyasla daha düşük standart tahmini hata değeri elde edilmiştir.

Sonuç: Oluşturduğumuz regresyon denklemleri kişiye özel ölçümler elde etmemizi sağlayacağı için kalça protezi ameliyatlarında implantın doğru ve güvenli bir şekilde yerleştirilmesi, uygun protez ile komplikasyonların önlenmesi konusunda klinisyenlere katkı sağlayacağı düşünülmektedir.

Anahtar Kelimeler: Acetabular rekonstrüksiyon, regresyon analizi, Acetabulum, Os coxae

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INTRODUCTION

The os coxae has an irregular morphological structure. In the fields of urology, obstetrics and gynecology, and orthopedic surgery, as well as from a surgical viewpoint, knowing the size, location, and morphometric properties of the bone is critical. Considering various similar anatomical features is also important, especially when planning surgical procedures, such as hysterectomy, and total hip arthroplasty. Furthermore, Anatomical features such as location of the superior gluteal bundle, peripheral nerves and vessels include the morphology of the os coxae, which surrounds the structures that must be preserved during surgical procedures. In addition, acetabular bone morphometry should be considered for future reconstructions, especially in younger patients with an increased likelihood of revision surgery.[1]

Acetabular fractures are rare and complex injuries that are usually caused by high-energy traumas. The acetabulum's deep location, complex anatomy, and proximity to vital organs and structures make surgical treatment difficult.[2,3] The fact that acetabular fractures are less common than limb fractures and the difficulty of finding a specialist and experienced surgeon in this field makes treatment difficult.[4] The main purpose of acetabular fracture surgery is to achieve anatomical reduction and strong fixation while also ensuring the survival of the hip joint.[2,5]

In the literature, many measurement parameters of the coxae and its sections have been examined in various populations. These studies reported varying measurements among different populations. Furthermore, no study has been found in the literature that report all measurements of the ilium, ischium, pubis, and acetabulum, examine their relationships with one other, and establish a regression model for estimating acetabular sizes from these measurements.

Therefore, the aim of this study was to obtain morphometric measurements of adult human hip bones, examine the relationship among these measurement parameters, and develop regression equations to estimate the acetabular dimensions for acetabular reconstruction.

MATERIAL AND METHOD

Seventy-eight (39 right and 39 left) dry hip bones of unknown age and gender located in the laboratory of Çukurova University Faculty of Medicine, Department of Anatomy, were included in the study. Eleven hip bones with fractures, deterioration, deformities, and defects that would affect the measurements were excluded from the study. The length of the hip bone was measured in mm using a Lafayette anthropometer (Model 01290, Lafayette Instrument Company, Indiana). For other measurements, a 0.01-mm-accuracy digital vernier caliper (TTI Vernier caliper, 0–200 mm) and steel bar were used. A detailed description of each measurement is given in **Table 1**, and the measurements are shown in **Figure 1**.

Table 1. Definitions of morphometric measurements of hip bone.

Measurements	Definiton
Length of hip bone (LH) (7)	The distance from the most superior point on the iliac crest to a plane drawn along the inferior surface of the ischium
Width of hip bone (Ilium width) (WH) (7)	The distance between the anterior superior iliac spine and the posterior superior iliac spine
Minimum İliac Breadth (MIB) (8)	The distance between the points where the arch of the greater sciatic notch meets the posterosuperior margin of the acetabulum and the anterior border of the ilium meets the anterosuperior margin of the acetabulum
Iliac height (IH)(9)	The distance between the central point of the acetabulum and the outermost point on the iliac crest
Vertical diameter of acetabulum (VDA) (10)	The longest diameter of acetabulum measured along the axis of the body of the ischium
Anteroposterior diameter of acetabulum (ADA) (11l)	The longest distance on acetabular rim in anteroposterior axis
Maximum depth of acetabulum (MDA) (10)	For measuring it, a steel bar was placed across the horizontal diameter of the acetabulum. Then, the maximum depth of the acetabulum was noted as the perpendicular depth between the deepest point of the acetabulum and the steel bar
Linear length of acetabular notch (LLAN) (10)	The distance between the innermost edges of the articular surfaces of the acetabulum
Pubic body width (PBW) (12)	The shortest distance between the inferior-most point of the symphysis pubis and the obturator foramen, usually near the base of the face and on the dorsal surface
Length of pubic bone (LPB) (13)	The distance between the central point of the acetabulum and the upper end of the symphyseal surface of the pubic body
Length of pubic bone upto acetabulum (LPA) (13)	The distance between the upper medial end of the pubic bone and the nearest acetabular edge
Symphysis height (SH) (12)	The distance between the superior and inferior-most points of the pubic symphysis
Ischium length (IL)(14)	The distance between the central point of the acetabulum and the deepest point on the ischial tuberosity
Ischiopubic ramus thickness (IPR) (12)	The distance from the inferior-most point of the medial obturator foramen and the narrowest point inferior to the pubic symphysis

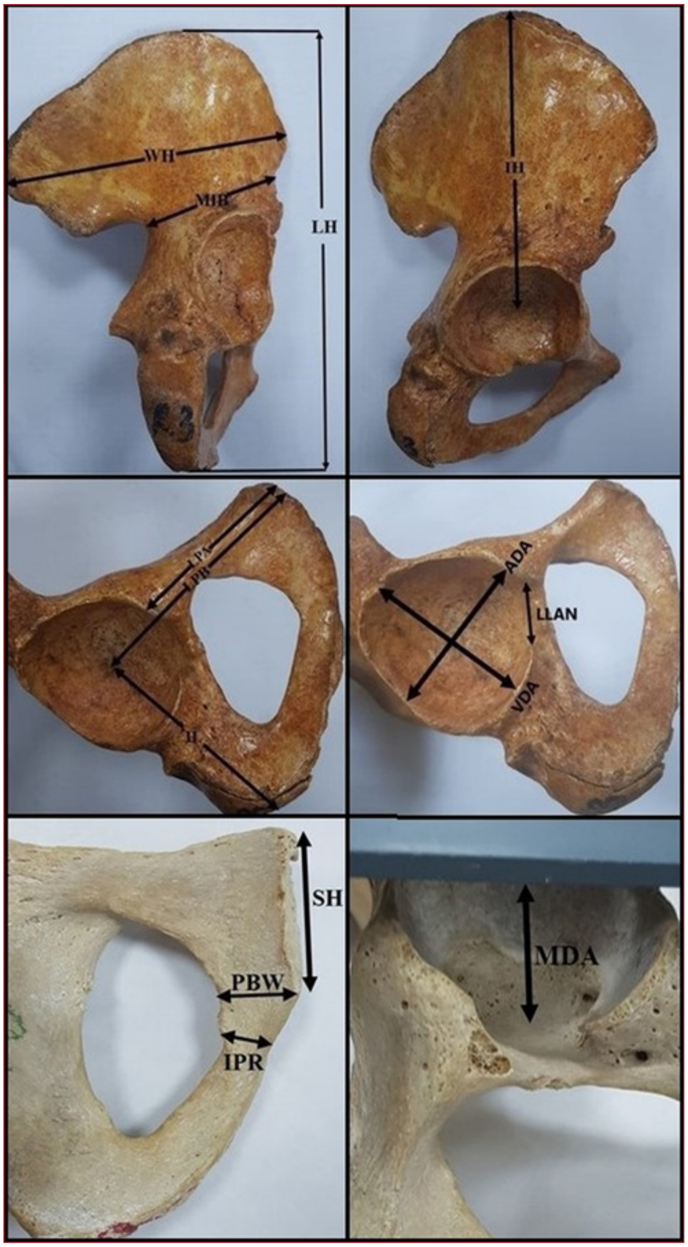

Figure 1. Morphometric measurements of the hip bone

LH: Length of hip bone, WH: Width of hip bone, MIB: Minimum İliac Breadth, IH: Iliac height, VDA: Vertical diameter of acetabulum, ADA: Anteroposterior diameter of acetabulum, MDA: Maximum depth of acetabulum, LLAN: Linear length of acetabular notch, PBW: Pubic body width, LPB: Length of pubic bone, LPA: Length of pubic bone upto acetabulum, SH: Symphysis height, IL: Ischium length, IPR: Ischiopubic ramus thickness

Only one author (A.K.A.) measured all the parameters twice. Intraclass correlation coefficients (ICCs with 95% confidence intervals) were used for reliability testing. When the intraobserver reliability was examined in all measurements, the ICC value was found to be 0.90–0.93. The intraobserver reliability of all measurements was excellent.[6]

Statistical Analysis

SPSS (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.) program was used for statistical analysis. Conformity of the variables to normal distribution was evaluated using Shapiro–Wilk test and histograms. Descriptive statistical analysis was performed to determine the mean, standard deviation, minimum, maximum, and standard error of mean (SEM) values. The relationship between quantitative variables was examined by Pearson correlation analysis. The dimensions of the hip bone were used for obtaining a single regression, and the determination coefficient of a regression estimation equation (adjusted R2) and standard error of estimate (SEE) were calculated. In addition, a multiple regression equation was acquired by a stepwise method by combining different variables. A p value <0.05 was accepted as statistically significant in all analyses.

RESULTS

Table 2 shows descriptive statistics (mean, standard deviation, minimum, and maximum values) for morphometric measurements of 78 dry hip bones.

Table 2. Descriptive statistics (mm) of morphometric measurements of dry hip bone.

Parameters	N	Mean (SD)	Min.	Max.	SEM
LH	78	209.85 (12.55)	184.00	239.00	1.421
WH	78	157.29 (9,84)	135.00	185.00	1.114
MIB	78	70.85 (6.73)	55.10	85.80	0.762
IH	78	128.54 (8.23)	112.41	148.40	0.932
VDA	78	52.22 (3.82)	41.20	59.72	0.432
ADA	78	51.49 (3.81)	40.10	59.22	0.432
MDA	78	26.04 (2.79)	19.30	33.10	0.316
LLAN	78	18.66 (2.47)	13.70	24.30	0.280
PBW	78	23.39 (2.55)	17.60	28.71	0.289
LPB	78	83.83 (4.97)	71.26	94.10	0.562
LPA	78	63.81 (5.47)	52.10	76.20	0.619
SH	78	37.39 (3.44)	31.10	45.60	0.389
IL	78	78.89 (5.76)	67.23	93.80	0.652
IPR	78	18.05 (2.03)	13.50	23.20	0.229

LH: Length of hip bone, WH: Width of hip bone, MIB: Minimum İliac Breadth, IH: Iliac height, VDA: Vertical diameter of acetabulum, ADA: Anteroposterior diameter of acetabulum, MDA: Maximum depth of acetabulum, LLAN: Linear length of acetabular notch, PBW: Pubic body width, LPB: Length of pubic bone, LPA: Length of pubic bone upto acetabulum, SH: Symphysis height, IL: Ischium length, IPR: Ischiopubic ramus thickness, N: Number, SD: Standard deviation, Min.: Minimum, Max.: Maximum, SEM: Standard error of mean.

The relationship among morphometric measurements of the ilium, ischium, pubis, and acetabulum of the hip bone is shown in **Table 3**. Statistically significant correlation coefficients among the measurements ranged from 0.233 to 0.881. LH measurement value has a statistically significant positive correlation with all other measurements except LLAN (p<0.05). In addition, no statistically significant correlation was found between the LLAN measurement and any of the other measurements (p>0.05). There was a statistically significant correlation between the ADA, VDA and MDA measurements of the acetabulum (p<0.05). In addition, a very strong positive statistically significant correlation was obtained between LH and IH (r: 0.853, p<0.001) and ADA and VDA (r: 0.881, p<0.001) measurements.

Table 3. Correlation between morphometric measurements of the hip bone

Parameters		IPR	IL	SH	LPA	LPB	PBW	LLAN	MDA	ADA	VDA	IH	MIB	WH	LH
LH	r	0.465**	0.719**	0.572**	0.457**	0.552**	0.317**	0.133	0.636**	0.685**	0.717**	0.853**	0.601**	0.658**	1
	p	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	0.247	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
WH	r	0.404**	0.483**	0.386**	0.443**	0.440**	0.329**	0.077	0.369**	0.539**	0.520**	0.670**	0.577**	1	
MIB	r	0.425**	0.678**	0.530**	0.440**	0.540**	0.242*	0.144	0.529**	0.731**	0.670**	0.644**	1		
	p	<0.001	<0.001	<0.001	<0.001	<0.001	0.033	0.208	<0.001	<0.001	<0.001	<0.001			
IH	r	0.445**	0.683**	0.446**	0.538**	0.564**	0.418**	0.119	0.622**	0.662**	0.678**	1			
	p	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.299	<0.001	<0.001	<0.001				
VDA	r	0.480**	0.752**	0.388**	0.246*	0.448**	0.190	0.177	0.559**	0.881**	1				
	p	<0.001	<0.001	<0.001	0.030	<0.001	0.096	0.122	<0.001	<0.001					
ADA	r	0.486**	0.768**	0.481**	0.215	0.497**	196	0.218	0.584**	1					
	p	<0.001	<0.001	<0.001	0.059	<0.001	0.085	0.055	<0.001						
MDA	r	0.347**	0.582**	0.308**	0.389**	0.475**	0.317**	-0.043	1						
	p	<0.001	<0.001	0.006	<0.001	<0.001	0.005	0.708							
LLAN	r	0.135	0.035	0.113	0.037	0.066	0.015	1							
	p	0.239	0.764	0.326	0.751	0.569	0.897								
PBW	r	0.603**	0.260*	0.233*	0.456**	0.401**	1								
	p	<0.001	0.01	0.040	<0.001	<0.001									
LPB	r	0.366**	0.573**	0.403**	0.772**	1									
	p	0.001	<0.001	<0.001	<0.001										
LPA	r	0.325**	0.407**	0.334**	1										
	p	0.004	<0.001	0.003											
SH	r	0.382**	0.528**	1											
	p	0.001	<0.001												
IL	r	0.442**	1												
	p	<0.001													
IPR	r	1													
	p														

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

Single regression equations were obtained from the hip bone morphometric measurements for the estimation of the morphometric measurements of the acetabulum; the SEE, adjusted R2, and p values are shown in **Table 4**. In the regression analysis, we found that the regression equations developed for the estimation of VDA, ADA and MDA measurements of the acetabulum were statistically significant (P<0.05). The SEE values in single regression equations ranged from ±1.818 mm to ±3.546 mm. The highest correlation coefficient values and the lowest SEE values were obtained from the single regression equations developed for the estimation of ADA (R2:0.776, SEE: ±1.818) and VDA (R2:0.776, SEE: ±1.822) measurements.

Multiple regression equations were obtained for the estimation of the morphometric measurements of the acetabulum; the SEE, adjusted R2, and p values are shown in **Table 5.** The SEE values in multiple regression equations ranged from ±1.633 mm to ±2.107 mm. The highest correlation coefficient values and the lowest SEE values were obtained from the multiple regression equations developed for the estimation of ADA (R2:0.822, SEE: ±1.633) measurements. As a result of the regression analysis, when we compared the single and multiple regression equations, it was seen that the SEE was lower in the multiple regression equations.

Table 4. Single regression equations for acetabular dimensions (mm) prediction from the measurements of the hip bone

Regression equations	±SEE	Adjusted R2	p value
VDA = 2.682 + (0.218 × LH)	2.682	0.514	< 0.001
VDA = 20.489 + (0.202 × WH)	3.288	0.270	< 0.001
VDA = 26.343 + (0.365 × MIB)	2.944	0.414	< 0.001
VDA = 11.779 + (0.315 × IH)	2.830	0.454	< 0.001
VDA = 6.794+(0.882) × ADA)	1.822	0.776	< 0.001
VDA = 32.313 + (0.765 × MDA)	3.191	0.312	< 0.001
VDA = 23.323 + (0.345 × LPB)	3.439	0.201	< 0.001
VDA = 36.120 + (0.431 × SH)	3.546	0.150	< 0.001
VDA = 12.870 + (0.499 × IL)	2.535	0.566	< 0.001
VDA = 35.934 + (0.903 × IPR)	3.376	0.230	< 0.001
ADA = 7.773 + (0.208 × LH)	2.797	0.470	< 0.001
ADA = 18.606 + (0.209 × WH)	3.234	0.291	< 0.001
ADA = 22.164 + (0.414 × MIB)	2.622	0.534	< 0.001
ADA = 12.015 + (0.307 × IH)	2.878	0.439	< 0.001
ADA = 5.572+(0.879×VDA)	1.818	0.776	< 0.001
ADA = 30.714 + (0.798 × MDA)	3.118	0.341	< 0.001
ADA = 19.526 + (0.381 × LPB)	3.333	0.247	< 0.001
ADA = 31.551 + (0.533 × SH)	3.367	0.231	< 0.001
ADA = 11.371 + (0.509 × IL)	2.459	0.590	< 0.001
ADA = 34.999 + (0.914 × IPR)	3.356	0.237	< 0.001
MDA = -3.652 + (0.142 × LH)	2.171	0.404	< 0.001
MDA = 9.565 + (0.105 × WH)	2.613	0.136	0.001
MDA = 10.481 + (0.220 × MIB)	2.385	0.280	< 0.001
MDA = -1.093 + (0.211 × IH)	2.202	0.387	< 0.001
MDA = 4.706 + (0.409 × VDA)	2.332	0.312	< 0.001
MDA = 4.015 + (0.428 × ADA)	2.282	0.341	< 0.001
MDA = 17.926 + (0.347 × PBW)	2.666	0.102	0.005
MDA = 3.666 + (0.267 × LPB)	2.474	0.226	< 0.001
MDA = 13.364 + (0.199 × LPA)	2.590	0.152	< 0.001
MDA = 16.697 + (0.250 × SH)	2.675	0.095	0.006
MDA = 3.769 + (0.282 × IL)	2.286	0.339	< 0.001
MDA = 17.429 + (0.477 × IPR)	2.637	0.120	0.002

SEE: Standard Error of Estimate

Table 5. Multiple regression equations (Stepwise) for the prediction of acetabular dimensions (mm) from the measurements of the hip bone

Regression equations	±SEE	Adjusted R2	p value
ADA = 3.732 + (0.700 × VDA) + (0.158 × MIB)	1.633	0.822	< 0.001
VDA = 0.692 + (0.736 × ADA) + (0.065 × LH)	1.732	0.800	< 0.001
VDA = 1.185 + (0.758 × ADA) + (0.084 × LH) - (0.148 × SH)	1.692	0.812	< 0.001
MDA = (-5.246) + (0.099 × LH) + (0.205 × ADA)	2.107	0.446	< 0.001

SEE: Standard Error of Estimate

DISCUSSION

Studies on the morphometry of the hip bone are conducted not only in the field of anatomy but also in other fields, such as anthropology, forensic medicine, radiology, obstetrics, orthopedics, and traumatology. Knowledge of morphometric measurements of the hip bone is critical as it helps in various areas, such as specimen identification, gender determination from skeletal remains, treatment of pelvic fractures, and acetabular reconstruction. Our study is based on the active use of regression equations for the prediction of morphometric measurements specific to individuals, especially in acetabular reconstruction procedures.

Many studies have been published in the literature that evaluate the morphometry or radiological images of dry hip bones obtained from various populations. There is no study in the deep literature review that estimates the morphometric properties of the acetabulum with regression analyzes. Several studies investigated the morphometry of the hip bone in various societies. A large number of these studies have been conducted in India owing to the country's diverse geographic regions, which are home to a large number of societies and ethnicities with varying population characteristics. These studies reported highly variable measurements of the acetabulum. The comparison of our study with previous studies in the literature examining the VDA, ADA, MDA and LLAN measurements of the acetabulum is shown in **Table 6**.

The mean ranges of VDA, ADA, MDA, and LLAN measurements of the acetabulum were found to be 48.06–52.83 mm, 46.53–50.31 mm, 23.56–29.99 mm, and 20.55–23.58 mm, respectively.[10,11,15-18] Upon the examination of radiological images of Chinese adults, Zeng et al. found the mean MDA value to be 19.3 mm on the right and 19.4 mm on the left in male and 17.3 mm on the right and 17.4 mm on the left in female.[19] In a study conducted by Indurjeeth et al. on the dry hip bones of the Black African population of South Africa, mean VDA, MDA, and LLAN values were found to be 54.84 mm, 31.30 mm, and 21.72 mm, respectively.[20] Ukoha et al. examined the dry hip bones of Nigerians, another African community, and found VDA and MDA measurements of 55.80 mm and 29.70 mm on the right

Table 6. Measurements of the acetabulum (mm) reported by previous studies.

Author (year)	N	Population	VDA	ADA	MDA	LLAN
Sacheva et al. (10) (2019)	100	Indian	males: 52.83 females: 48.83	males: 50.31 females: 46.53	males: 29.99 females: 23.56	males: 21.51 females: 20.55
Singh et al. (11) (2020)	92	Indian	48.21	47.81	27.45	23.58
Arunkumar et al. (15) (2021)	104	Indian	48.98	-	24.12	-
Vyas et al. (16) (2013)	152	Indian	-	right: 47.90 left: 48.30	right: 27.10 left: 26.50	-
Parmara et al. (17) (2013)	100	Indian	Curved: 49.07 Irregular: 49.18 Straight: 49.79	-	Curved: 26 Irregular: 26.25 Straight: 26.56	-
Sreedevi & Sangam (18) (2017)	80	Indian	right: 49.40 left: 48.06	-	right: 24.09 left: 25.16	right: 22.25 left: 22.52
Zeng et al. (19) (2012)	100	Chinese	-	-	males right: 19.30 left: 19.40 females right: 17.30 left: 17.40	-
Indurjeeth et al. (20) (2019)	100	South Africa	54.84	-	31.30	21.72
Ukoha et al. (21) (2014)	100	Nigerian	right: 55.80 left: 54.60	-	right: 29.70 left: 30.20	-
Baharuddin et al. (22) (2011)	120	Malay	-	-	males: 16.17 females: 14.81	-
Aksu et al. (23) (2006)	154	Turkish	-	54.29	29.49	-
Demir et al. (24) (2018)	72	Turkish	-	-	-	22.50
Bağcı Uzun et al. (25) (2020)	96	Turkish	right: 53.04 left: 54.67	right: 52.38 left: 45.63	right: 24.87 left: 22.85	right: 18.08 left: 20.25
Present study	78	Turkish	52.22	51.49	26.04	18.66

and 54.60 mm and 30.20 mm on the left, respectively.[21] Baharuddin et al. examined the acetabulum on CT images in the Malay population and obtained the mean MDA value of 14.81 mm in female and 16.17 mm in male.[22] Aksu et al. examined 154 hip bones of the Turkish population, and the mean values of ADA and MDA measurements were found to be 54.29 mm and 29.49 mm, respectively.[23] Demir et al. examined adult hip bones of the Turkish population obtained from several university collections and obtained the mean LLAN value of 22.5 mm.[24] In the study conducted by Bağcı Uzun et al., the mean values of VDA, ADA, MDA, and LLAN measurements were found to be 53.04–54.67 mm, 52.38–45.63 mm, 24.87–22.85 mm, and 18.08–20.25 mm on the right and left, respectively.[25] In the present study, the mean values of VDA, ADA, MDA, and LLAN measurements were 52.22 mm, 51.49 mm, 26.04 mm, and 18.66 mm, respectively. When we examined our measurements of the acetabulum, all the measurement values we obtained were lower than those of Africans. Moreover, when we compared VDA, ADA and MDA measurements with other studies, the values we obtained from our study were found to be close to Indians, but higher than Chinese. In addition, when we evaluated in terms of LLAN measurement, it was observed that the data we obtained were lower than both Africans and Indians. The reasons for the similarities and differences of our results with the measurement results in studies conducted on different populations; There may be many factors such as genetics, sample size, gender, ignoring bilateral measurements, measurement technique. The most important thing that we mainly focus on in this study was that it was possible to predict individual or society-specific measurements that were deemed surgically important and necessary with the regression equations developed for society by developing a large data pool according to its own and using this data.

The study's limitation is the lack of age and gender data on the hip bones. Further multicenter studies using these data and larger samples can be planned to investigate the Turkish population in more detail.

CONCLUSION

The SEE values obtained in the present study were quite small, with a maximum SEE value of 3.5 mm and 2.1 mm in single and multiple regression equations, respectively. The regression equations developed in this study will allow us to obtain personalized measurements, which will aid clinicians in the correct and safe placement of the implant in hip replacement surgeries as well as in the prevention of complications with the use of appropriate prostheses. Furthermore, the regression equations will help clinicians measure difficult regions in acetabular fractures. Finally, the findings will guide future studies and researchers on this subject, potentially leading to different perspectives and new ideas

ETHICAL DECLARATIONS

Ethics Committee Approval: Ethics committee approval is not required as the material of our research is the human skeleton collection.

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