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Radiographic study on sex differences in hip joint morphology for Turkish adults

Türk erişkinlerindeki kalça eklem morfolojisinde cinsiyet farklılıkları üzerine radyografik çalışma

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Abstract

Aim: This study aims to determine the gender differences in hip joint functional anthropometric measurement values in Turkish adults.

Materials and Methods: Digital pelvis anterior-posterior radiographs of 300 randomly selected patients were analyzed. In these radiographs, reference lines were drawn and femoral neck-shaft angle (NSA), hip rotation center (HRC), abductor moment arm (AMA), body weight moment arm (BMA) were calculated. The relationship of the distribution of measurement results with gender and age was examined.

Results: It was determined that the mean NSA scores in men were significantly higher than in women (p<0.05). It was determined that AMA value was significantly higher in men and BMA value was significantly higher in women (p<0.05). BMA/AMA ratio was found to be statistically significantly higher in women (p<0.005).

Conclusion: Statistically significant differences were found between men and women in the mean of AMA, BMA and BMA/AMA in the Turkish population.

Keywords: Femur neck angle; Abductor moment arm; Hip rotation center.

Öz

Amaç: Türk toplumunda herhangi bir kalça patolojisi bulunmayan kişilerin radyografilerinde ölçülen kalça eklemi fonksiyonel antropometrik ölçüm değerlerinin dağılımı ve normal sınırlarının belirlenmesi amaçlandı.

Gereç ve Yöntem: Rastgele seçilen 300 hastanın dijital pelvis antero-posterior grafileri incelendi. Bu grafiler üzerinde referans çizgileri çizilerek, femur boyun açısı (FBA), kalça rotasyon merkezi (KRM), abdüktör moment kolu (AMK), vücut ağırlığı moment kolu (VMK) hesaplandı. Ölçüm sonuçlarının dağılımının cinsiyet ve yaş ile olan ilişkileri incelendi.

Bulgular: FBA ortalamalarının erkeklerde anlamlı olacak düzeyde kadınlardan yüksek olduğu saptandı (p<0,05). AMK değerinin erkeklerde, VMK değerinin ise kadınlarda anlamlı düzeyde daha yüksek olduğu saptandı (p<0,05). VMK/AMK oranının kadınlarda istatistiksel olarak anlamlı olacak şekilde daha yüksek olduğu görüldü (p<0,005).

Sonuç: Türk toplumuna ait AMK, VMK ve VMK/AMK ortalamalarında, kadınlar ile erkekler arasında istatistiksel olarak anlamlı farklılıklar bulunmuştur. Elde edilen verilerin protez cerrahisinde ameliyat öncesi planlamada ya da etnik özelliklere uygun protez üretiminde yol gösterici olabileceğini düşünmekteyiz.

Anahtar Kelimeler: Femur boyun açısı; Abdüktör moment kolu; Kalça rotasyon merkezi.

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Introduction

Clinical and experimental studies on implants used in hip arthroplasty have shown that the geometric harmony of the implant and the femur, as well as the balance of the forces acting on the hip joint, is necessary for permanent implant fixation.[1,2]

Prostheses placed in improper position result in aseptic loosening due to improper load distribution. Abnormal load distribution in the hip joint affects the long-term success of the surgery.[2,3] Because there is a strong relationship between the abductor moment arm (AMA) and the abductor load on the hip joint. Depending on the changes in the femoral offset and AMA, the activation angle of them. M.gluteus medius may change, as a result, hip joint function and the life of the hip prosthesis may be affected.[4] For the long-term success of the hip prosthesis, it is important to know the variations in the proximal femur anatomy and the differences that they may cause in the hip joint. In addition, most of the hip prostheses available on the market are designed taking into account the anthropological data of western societies.[5] This situation makes it necessary to reveal and evaluate morphological data to detect potential incompatibilities in other ethnic groups other than western countries.[6] On the other hand, studies on the anatomy of the hip joint have also shown anatomical differences based on gender, especially on the femoral side.[7,8] When we consider these differences, women tend to have a shorter femoral neck, a thinner femoral shaft, a lower femoral neck angle and a lower femoral offset.[7,8] It is beneficial to consider these differences in hip replacement applications.

This study aims to evaluate the hip joint geometry radiographically in the Turkish population and to analyze the data in terms of gender, to obtain reference values for the Turkish society.

Materials and Methods

The type of the study

This is a cross-sectional study of randomly selected Turkish adult population.

The samples of the research

Patients included in the study; those who have pelvis antero-posterior (AP) radiographs taken under outpatient or emergency room conditions in the hospital digital data system, who do not have any known history of hip pathology in the hospital archive, who do not have osteoarthrosis, fractures, tumoral or infectious lesions and who have completed skeletal maturity randomly selected from among. The study was conducted between January 2019 and March 2019 by examining digital pelvis AP radiographs of 150 male and 150 female 300 patients between the ages of 20 and 60, who comply with the criteria described.

Data collection tools

The right hip joint was evaluated in all patients included in the study. Pelvis AP radiographs were performed in the supine position with both lower extremities parallel to each other, 30° internal rotation from the hip joint, and the knee in full extension, standardized. The beam was centered on the symphysis pubis. By drawing reference lines on these graphs with the help of a software that measures the angle with 1/1000 precision, femoral neck-shaft angle (NSA), hip rotation center (HRC), abductor moment arm (AMA), bodyweight moment arm (BMA) and the distance between the highest point of the trochanter major and the hip rotation center (HRC-TM) were measured. The patients included in the study were divided into two groups according to their age, 20-40 and 21-60. The relationships of the measurements made with age groups and gender were examined. If it is necessary to define the measurements made;

1. The femoral neck-shaft angle (NSA) is the angle between the central axis of the femur and the axis of the femoral neck (Figure 1).[9]
2. The hip rotation center (HRC) was taken as the center of the drawn circle, drawing the circle that best fits the femoral head(Figure 2).[5]
3. The abductor moment arm (AMA) is the vertical distance from the center of the femoral head to a line drawn from the anterior superior iliac crest and tangent to the greater trochanter(Figure 2).[10]

4. Bodyweight moment arm (BMA) is the distance from the center of the femoral head to a vertical line across the symphysis pubis (Figure 2).[10]
5. The HRC-TM distance is the distance between the line drawn from the highest point of the trochanter major perpendicular to the anatomical axis of the femur to the center of hip rotation and the center of hip rotation (Figure 3).[11]

The relationships between the distribution of measurement results and gender and age were examined and related correlation analyzes were performed to determine the relationship between the evaluated parameters.

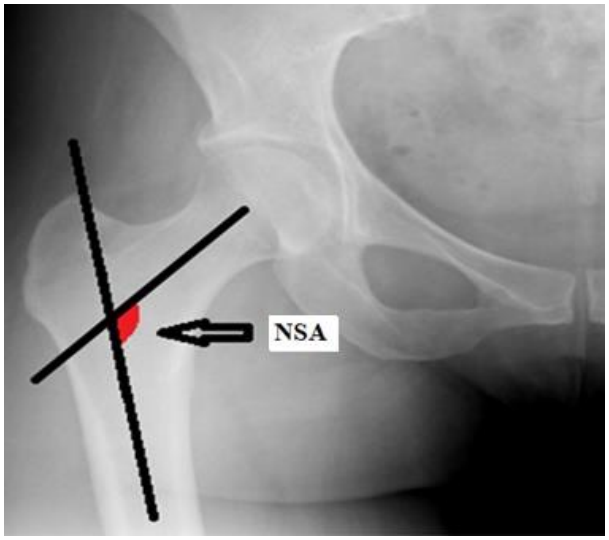

Figure 1. X-ray showing measurement neck-shaft angle (NSA).
*NSA: Femoral neck-shaft angle

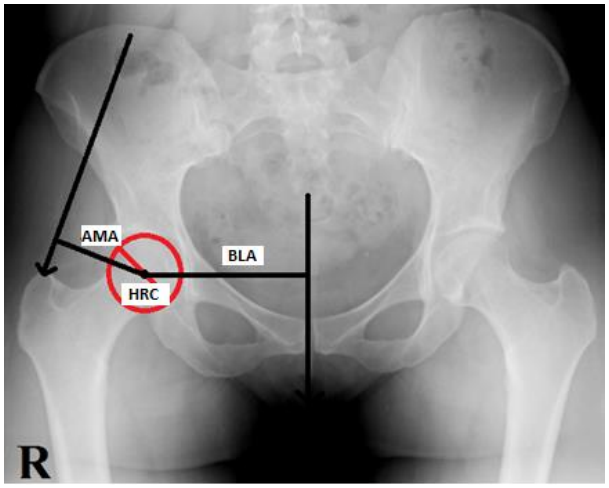

Figure 2. X-ray showing measurements of AMA, BMA and HRC.
*AMA: Abductor moment arm, BMA: Bodyweight moment arm, HRC: Hip rotation center

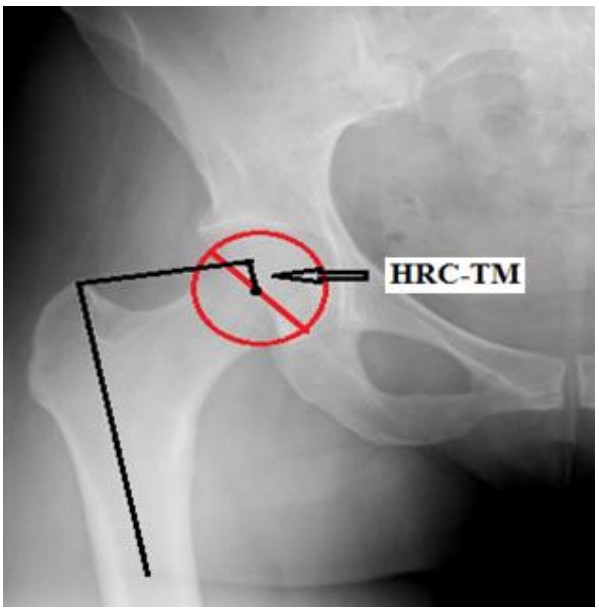

Figure 3. X-ray showing measurement HRC - TM distance.
*HRC-TM: Distance between the highest point of the trochanter major and the hip rotation center

Measurements were made by a four-year orthopedic and traumatology resident and an orthopedic and traumatology specialist. After observers were trained in the measurement method, they carried out their measurements independently and unaware of each other. To evaluate the intra-observer reliability, measurements were repeated twice by a four-year orthopedic and traumatology resident. The second measurement was reperformed three weeks after the first measurement, by randomly selecting 30% of the patients (90 patients), regardless of gender. The measurement of all patients was repeated by the orthopedic and traumatology specialist to evaluate the interobserver reliability. Intra-observer and inter-observer reliability of the measurements were determined at a 95% confidence interval by calculating the intraclass correlation coefficient (ICC). According to Landis and Koch's ICC interpretation, a value of 0.00-0.20 was considered as slight reliability, 0.21-0.40 fair reliability, 0.41-0.60 moderate reliability, 0.61-0.80 substantial reliability and values above 0.80 as excellent reliability.[12] The results of the analysis were made to determine the intra-observer (ICC_1) and inter-observer (ICC_2) reliability of the data obtained as a result of the measurements are given in Table 1.

Table 1. Intra-observer and inter-observer reliability analysis results.

	ICC_1	ICC_2
NSA	0.995	0.863
HRC-TM	0.998	0.857
AMA	0.992	0.859
BMA	0.988	0.889

*NSA: Femoral neck-shaft angle, AMA: Abductor moment arm, BMA: Bodyweight moment arm, HRC-TM: Distance between the highest point of the trochanter major and the hip rotation center ICC: intraclass correlation coefficient

Statistical analysis

Statistical data analysis of the study was performed with IBM SPSS version 23. The averages of the variables were found and the nonparametric Mann-Whitney test was used to understand the mean rank differences of two independent groups with non-normal dependent variables. The collected data were analyzed statistically using the t-test for significance and the Pearson correlation analysis method for correlation. The correlation between the parameters examined was evaluated according to the Pearson correlation coefficient. To reject statistical tests, the significance level was taken as 0.05.

The ethical aspect of research

This study was conducted with the necessary approval from the Health Sciences University Haydarpaşa Numune Training and Research Hospital Non-Interventional Research Ethics Committee (Ethics committee approval number: HNEAH-KAEK 2021/161 and date: 25/05/2021).

Results

300 patients including 150 men and 150 women were included in the study. The age range is between 20 and 60 years, with a mean age of 39.23±0.69 (Table 2). The patients included in the study were divided into two different age groups: 20-40, 41-60 (Table 3).

Table 2. Average age of women, men and the total population.

	n	Average Age±SD	Distribution
Women	150	38.72±10.4	20-58
Men	150	39.74±13.46	20-60
Total	300	39.23±0.69	20-60

* SD: Standart Deviation

The comparison results of the mean values of NSA, HRC-TM, AMA, BMA and BMA/AMA by age are shown in Table 4. In the evaluation made according to age groups, the average of the NSA values for the patients in the 20-40 age group is statistically significantly higher than the patients in the 41-60 age group (p=0.001). On the contrary, the mean of HRC-TM values for patients in the 41-60 age group was statistically significantly higher than that of patients in the 20-40 age group (p=0.001). There was no statistically significant difference between the two age groups in the mean values of BMA, AMA, and BMA/AMA

Table 3. Distribution between gender and age groups

Age (year)	Sex		Total
	Women	Men	
20 - 40	76 (25.3%)	82 (27.4%)	158 (52.6%)
41 - 60	74 (24.6%)	68 (22.7%)	142 (47.4%)
Total	**150**	**150**	**300**

Tablo 4. Comparison of variables according to age

	Age Range (year)		p
	20-40 age	41-60 age	
NSA (°)	133.76	131.27	0.001
HRC-TM (mm)	6.36	7.95	0.001
AMA (mm)	101.02	101	0.951
BMA (mm)	50.7	51.08	0.421
BMA / AMA	2.02	2.12	0.383

*NSA: Femoral neck-shaft angle, AMA: Abductor moment arm, BMA: Bodyweight moment arm, HRC-TM: Distance between the highest point of the trochanter major and the hip rotation center
* Independent Sample t-Test: p<0,05

The comparison results of the mean values of NSA, HRC-TM, AMA, BMA and BMA/AMA by gender are shown in Table 5. It was found that the average NSA was higher in males at a statistically significant level (p=0.046). There was no statistically significant difference in HRC-TM values between both sexes (p>0.05). In the statistical analysis of BMA averages by gender, it was observed that the mean of females was significantly higher than the males' averages (p=0.009), while the opposite result was obtained in the AMA values (p=0.034). As a result, it was found that the mean BMA/AMA values were statistically significantly higher in females (p=0.005) (Table 5).

The relationship between the NSA, HRC-TM, AMA, BMA, and BMA/AMA parameters were tested with Pearson correlation analysis. While there was a moderately negative statistically significant correlation between

these parameters, NSA and HRC-TM values (r=-0.474, p<0.01), no statistically significant results were obtained in the correlation analysis between other parameters.

Table 5. Comparison of variables according to gender.

	Women Mean+SD (Min.-Max.)	**Men Mean+SD (Min.-Max.)**	**Total Mean+SD (Min.-Max.)**	***p***
NSA (°)	129.01±5.98 (118.6-139.5)	131.15±6.12 (119.4-148.5)	130.08±6.07 (118.6-148.5)	0.046
HRC-TM (mm)	6.56±4.24 (0-19.2)	7.67±5.36 (2-29.7)	7.17±4.81 (0-29.7)	0.117
BMA (mm)	101,16±7,6 (72.2-127.1)	100,06±7,68 (68.3-116.9)	101,01±7,63 (68.3-127.1)	0.009
AMA (mm)	49.78±6.89 (4.5-65.7)	51.99±7.53 (27.3-67.1)	50.88±7.29 (4.5-67.1)	0.034
BMA/AMA	2.16±0.51	1.98±0.34	2.07±0.41	0.005

*NSA: Femoral neck-shaft angle, AMA: Abductor moment arm, BMA: Bodyweight moment arm, HRC-TM: Distance between the highest point of the trochanter major and the hip rotation center, SD: Standart Deviation
* Independent Sample t-Test: p<0,05

Discussion

This study, it was aimed to reveal the distribution of hip joint functional anthropometric measurement values measured in the radiographs of individuals who do not have any hip pathology in the Turkish population, the possible differences in terms of gender, and the change over time. The results of the retrospective cross-sectional analysis of 150 men and 150 women showed that there were significant differences between men and women in the distributions of NSA, BMA, AMA, and BMA/AMA. Especially the significant differences between the sexes in the AMA and BMA values support that gender is an important factor in hip replacement placement.

Numerous studies in the literature have analyzed proximal femur morphology using different measurement methods.[13,14] The hip joint is an anatomical formation with high variability between individuals and societies.[6] NSA is at the forefront of these high variability formations. In the literature, while the average of NSA in the Turkish population is 129.71°, it has been shown that it is 124.42° in India, 122.9° in Switzerland, and 129.2° in the French.[14-17] In this study, the Turkish society was analyzed cross-sectionally and the mean NSA was found to be 130.08°. The results were close to the data related to the Turkish population in the literature, and we think that the reason for the existing small difference is due to the fact that the selected patients are the patient population living in a single region.

The most important parameter related to the morphological differences in the hip joint anatomically is gender.[18] In the literature, there are many studies comparing the NSA values between sex in different ethnic groups.[11,19,20] In a study conducted on the Turkish population, the mean NSA values in men and women were found to be 130.31° and 129.11°, respectively.[17] In this study, NSA was found to be statistically significantly higher in males (p<0.05). In addition, while the AMA value was high in the male population, BMA was found to be high in the female population (p<0.05). Considering the fertility characteristics of women, this is an expected situation. Therefore, the offset to be chosen while placing the prosthesis in hip joint surgeries, taking this matter into consideration, will allow for a more anatomical placement.

The balance in the hip joint depends on the mechanics of the relationship between body weight and hip abductors.[21] The length of the moment arm formed by the hip abductors is smaller than the length of the moment arm formed by the body weight. Therefore, the abductor muscle group must generate a force greater than bodyweight to maintain pelvic stability.[11] The hip joint reaction force is proportional to the force exerted by the hip abductor muscle group on the proximal femur. Therefore, the key factor affecting the magnitude of the joint reaction force on the femoral head is the ratio of the bodyweight moment arm to the abductor moment arm.[22] According to the information available in the literature, this ratio is between 2-2.5.[23]

Anything that increases the moment arm ratio also increases the abductor muscle strength required for walking and thus the strength of the femoral head. In our study, this ratio was found to be 2.07±0.41, and a result consistent with the literature was obtained. However, there is a statistically significant difference between male and female patients. The ratio of AMA to BMA in women was found to be significantly higher than the value found in men. We think that the main reason for this is the gender-related variability in the structure of the pelvis in men and women. It will be useful to consider this situation in both the preparation of the acetabulum and the femoral offset adjustments, especially in total hip replacement applications. Because changes in femoral offset can lead to increased joint reaction force and premature wear of polyethylene.

In studies in the literature where the distance between the upper end of the trochanter major and the hip rotation center was measured, this value was found to be between 7 and 9.5 mm.[6,8,24] In this study, this distance was found to be 6.56±4.24 for females and 7.67±5.36 for males. These values, which vary from society to society, should be taken into account so that a prosthesis placement to be made by taking the reference point of the trochanter major does not cause leg length inequality, and more importantly, an increase in joint reaction force. Otherwise, a prosthesis placed at a high level may cause protrusion of the femoral head by causing increased joint reaction force, especially in fracture cases where the partial prosthesis is applied.

Limitation of the study

The weaknesses of our study can be expressed as retrospective planning, the fact that the patient population included in the study was recruited from the same region of Turkey.

Conclusion

The geometric structure and functional anthropometric measurements of the hip joint in Turkish society may differ from the values of both Western and Asian societies. In addition, the results we obtained in our study showed that gender also caused these differences. For example, in the Turkish society, significant differences were found between women and men in the results of AMA, BMA and their ratios. Considering this difference when placing the prosthesis in hip replacement surgeries, a better function and longer survival can be expected in the prosthesis as a result of the procedures to be performed.

Ethics Committee Approval

Approval was taken from the Ethical Board of the Health Sciences University Haydarpaşa Numune Training and Research Hospital Non-Interventional Research Ethics Committee (Ethics committee approval number: HNEAH-KAEK 2021/161 and date: 25/05/2021) and written permission was taken from University. The study was conducted in accordance with the Helsinki declaration principles.

Author Contributions

Idea, design, collection of resources, analysis and interpretation of results and literature, written and critical: BK, MB, HB, MK.

Conflict of Interest

There is no conflict of interest to declare

Financial Disclosure

There is no person/organization supporting this study financially.

Peer-review

Externally peer-reviewed.

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