Ain Shams Journal of Forensic Medicine and Clinical Toxicology
January 2024, 42:94-103

Assessment of the Reliability and Validity of Some Anthropometric Dimensions at the Distal Epiphyseal Ends of Radius and Ulna for Gender Identification Using Magnetic Resonance Imaging Among a Sample of the Egyptian Population - A Retrospective Study -

Rana Mohsen Saad[1], Asmaa Abdel Rahman Abdel Rahman[1], Rahma Farghaly Ali[2], Nesrine Abdel Rahman Mahmoud[1]

[1]Department of Forensic Medicine and Clinical Toxicology, Faculty of Medicine, Ain Shams University, Cairo, Egypt.
[2]Department of Diagnostic and Interventional Radiology, Faculty of Medicine, Ain Shams University, Cairo, Egypt.

Abstract

Introduction: Personal identification relies on sex identification. Anthropometric measurements are known to be reliable for sex identification in forensic cases. MRI has recently emerged as the preferred method for determining anthropometric measurements. The proximal ends and shafts of the radius and ulna are both sexually dimorphic. However, research on the utility of their distal ends for sex determination is limited.
Aim: To assess the reliability and validity of some anthropometric dimensions at the distal epiphyseal ends of radius and ulna for sex identification using Magnetic Resonance Imaging among a sample of the Egyptian population to adopt this method for sex identification in forensic practices.
Methodology: This cross-sectional retrospective study was conducted on 200 subjects (100 males and 100 females) using archived MRI films. Four dimensions were measured: the radial distal end width, radial height, ulnar distal end width, and ulnar styloid process length. The data was statistically analysed.
Results: The tested dimensions were found to be reliable and valid in sex discrimination with accuracy up to 87.5% for radial dimensions and up to 83.5% for ulnar dimensions.
Conclusion: The study demonstrated the high accuracy of the distal epiphyseal ends of the radius and ulna in identifying sex.

Received in original form: 6 January 2024
Accepted in a final form: 16 January 2024

Key words Gender Determination ; Radiology ; Forensic Anthropometry

Introduction

Sex is an important parameter in personal identification. Anthropometric analysis of bones has been shown to be accurate in determining sex in forensic cases, particularly in mass disasters (Sivakumar et al., 2020).

The skull, pelvis, and long bones are the most used identification bones. Several long bones have the potential to estimate sex. Long bone anthropometric dimensions are important in the forensic sex identification process. Long bones in anthropometry have the advantage of being easy to define measurements as well as being well preserved (Tetteh et al., 2021).

According to some studies, the dimensions of the upper limb have a higher ability for sex determination. Radius and Ulna both exhibit significant sexual dimorphism. As a result, anthropometric measurements of the radius and ulna have been successfully used for sex identification in a variety of populations, including Europeans, Asians, and North Americans (Jongmuenwai et al., 2021).

Most researches that studied the sex discrimination capability of radius and ulna used their proximal ends' dimensions as well as some dimensions along their shafts. However, there is lack of research dealing with the usefulness of distal ends of radius and ulna for sex determination (Monum et al., 2021).

The majority of anthropometric analyses are taken directly from bones, but recent advances in imaging technology allow radiological methods to be used to determine sex, age, and stature. Recently, MRI has become the method of choice for anthropometric determination because it is a quick, accurate, and non-invasive method that can examine all types of tissues, including soft tissue, with the least radiation effects (Daghighi et al., 2021).

Materials and Methods

Study type:

The cross-sectional retrospective method was used in this study because it is an observational study that involved the analysis of data collected from a population at a single point in time, allowing researchers to look at multiple parameters at once (Setia, 2016).

Sample size:

An estimated sample size of 200 participants - using the PASS 15 program - demonstrated that the sex could be determined with high confidence (Sensitivity =83%).

Materials:

Magnetic Resonance Imaging (MRI) films for wrist joints from 100 male and 100 female participants ranging in age from 18 to 68 years. The films were retrieved from the archives of the Diagnostic and Interventional Radiology Department at Ain Shams University Hospitals in Cairo, Egypt.

Ethical Approval:

This study was conducted after getting approval of the ethical committee of Faculty of Medicine, Ain Shams University, number (FMASU MS 868/2022/2023).

Approval was also obtained from the archive of Diagnostic and Interventional Radiology Department, Ain Shams University Hospitals (ASUH).

Methods:

The tested measures were obtained from the previously saved wrist MRI films taken on a 1.5 Tesla scanner (Ingenia, Philips Medical System) with the following settings: The field of view is 100 mm, the slice thickness is 2 mm, the matrix is 160 x 108 mm, and the voxel size is 0.5 x 0.68 x 2 mm. The data were collected using the coronal T1-weighted sequence. The tested dimensions at the lower ends of radius and ulna were measured by two of this study's researchers (the radiology consultant and one of the forensic researchers).

Tested dimensions:

1) Two distal radial dimensions: the radial distal end width (RDEW) which is the greatest distance between the most medial and lateral points on the distal epiphysis of the radius (Jongmuenwai et al., 2021). The radial height (RH) defined as the distance between the horizontal line at the level of the lunate fossa, which is perpendicular to the radius' axis, and the horizontal line at the level of the radial styloid process, which is also perpendicular to the radius' axis (Shrestha et al., 2022).
2) Two distal ulnar dimensions: the ulnar distal end width (UDEW) defined as the largest ulnar width at its distal end (Monum et al., 2021). The ulnar styloid process length (USPL) is the vertical distance between the styloid tip and the ulnar styloid process base (Toprak and Turkoglu, 2018).

Eligibility Criteria:

- Inclusion criteria: include MRI films of Egyptian male and female patients ranging in age from 18 to 68 years.
- Exclusion criteria: include MRI films of male and female patients being under the age of 18 or being over the age of 68, having a history of bone fractures, known congenital or acquired skeletal diseases, bone malformations, or bone tumors.

Statistical analysis:

The collected data was statistically analyzed using the Number Cruncher Statistical Systems (NCSS) 2023 version 23.0.1 software.

- Reliability assessment: The reliability of the measurements of the RDEW, RH, UDEW, and USPL was assessed by comparing the mean values of the two researchers' readings at different times and in different situations using the paired (t) test, Pearson correlation coefficient, and scatter plot chart to outline the correlation between the two researchers' readings concerning the numerical values of the studied dimensions. The dimensions that were found to be reliable were then validated.
- Validity assessment: The mean and standard deviation of each dimension were calculated to ensure the validity of the studied dimensions for sex discrimination. The student's (t) test was then used to determine whether there was a statistical difference in mean values between males and females for each dimension. $P \leq 0.05$ was considered statistically significant. The reliable dimension that revealed a significant difference between male and female groups will then undergo additional validity tests, including sensitivity, specificity, and accuracy.

The ROC curve was outlined to determine the best cut-off value for calculating sensitivity, specificity, and accuracy. The area under the ROC curve was calculated to outline the parameter's overall capability for sex discrimination. AUC can range from 0.5 (no diagnostic ability) to 1.0 (perfect diagnostic ability). Because the data obtained from the sample are not fixed values but rather influenced by statistical errors, the AUC is frequently presented with a 95% confidence interval (CI).

Results

(I) Results of reliability assessment:

- Application of the paired (t) test: to the mean values of the RDEW, RH, UDEW, and USPL measures revealed no significant difference between the two researchers' readings (values are very close to zero). To confirm the statistical significance of the paired (t) test, P-value calculations were performed; results showed values >0.05, indicating no significant difference between the mean measures. The preceding findings support the null hypothesis' statistical significance and the reliability of the RDEW, RH, UDEW, and USPL measurements for sex differentiation (Table 1).
- Application of the Pearson correlation coefficient: to evaluate the degree of correlation between the two researchers' readings for the researched aspects of the RDEW, RH, UDEW, and USPL indicates a positive, perfectly linear high degree of correlation between the two researchers' measurements between (+0.5 and +1). Simultaneously, this table shows the confirmation of the Pearson correlation coefficient's statistical significance as a reliability test, through the computation of the p-value, which was determined to be ($p<0.001$) signifying a strong and significant correlation. The previous findings confirmed the reliability of the Pearson correlation as well as the

reliability of the RDEW, RH, UDEW, and USPL measurements as sex discriminators (Table 2).

- Outlining a Scatter Plot chart: showed that the points presenting the two researchers' readings concerning the numerical values of the chosen dimensions are rising, moving from left to right very close to each other in a perfect straight line, which asserts strong positive relationship between these numerical readings, as well as the reliability of the chosen dimensions as sex discriminators (charts 1 to 4).

(II) Results of validity assessment:

- The application of the student's (t) test on the mean values of all the studied dimensions (RDEW, RH, UDEW, and USPL) revealed significant difference between males and females at a (P-value < 0.05), confirming that the chosen dimensions have a sex discriminative power, and their validity parameters were assessed (Table 3).
- The evaluation of the validity parameters to confirm the sex discrimination capability of the tested dimensions was as shown in (Table 4).
  1) For each tested dimension, the estimated optimal cut-off value (the sex identification point) is a value, with variables falling below it were classified as female and variables falling above or equal to it were classified as male.
  2) Every optimal discriminative point corresponds to different levels of sensitivity, specificity, and accuracy as follows:
     ⇒ Regarding the radial dimensions, the RDEW optimal cut-off value was estimated to be [female<28.1≤ male]. Its sensitivity, specificity, and overall accuracy levels were 91%, 84%, and 87.5%, respectively. Meanwhile, the RH optimal cut-off value was determined to be [female<11≤ male] with levels of sensitivity (82%), specificity (66%) and overall accuracy (74%).
     ⇒ Regarding the ulnar dimensions, the UDEW sex identification point was calculated to be [female<17.5≤ male] that corresponds to a level of sensitivity of (83%), specificity of (84%) and an overall accuracy level of (83.5%). Ultimately, the USPL identification point was estimated to be [female<6.7≤ male], which showed a degree of sensitivity (61%), specificity (86%), and an overall accuracy (73.5%).
  3) Plotting the cut-off point of each individual dimension on the receiver operating characteristic (ROC) curve with its diagnostic sensitivity and specificity values resulted in curves of various shapes, but all with a common location in the upper-left hand corner and at different distances from the 45 ° diagonal line. According to the current study's findings, the RDEW, RH, UDEW, and USPL dimensions have a very good discriminative power for sex identification, with varying diagnostic sensitivity and specificity values on the ROC curve. The RDEW occupied the highest position, very close to the upper left corner, demonstrating the best sex discriminator accuracy of (87.5%), followed by the UDEW, which occupied a position below it, a few millimeters apart and demonstrating an accuracy level of (83.5%). (ROC curve 1).
  4) To validate the sex identification power for each individual dimension, the area under the ROC curve (AUC) was calculated with a 95% confidence interval (CI). According to the previous test results, RDEW showed the highest AUC (0.93), indicating its excellent sex discriminative power, followed by the UDEW and the RH with AUC of (0.89) and (0.80) respectively denoting their very good sex discriminative power. The lowest AUC (0.77) was observed with USPL dimension demonstrating its good sex discrimination ability.

     Despite the disparity of the estimated AUC values, all the calculated AUC values fall within the range of 0.5<AUC≤ 1, where (0.5) represents a test with statistically non-discriminative power and (1) represents a test with perfect discriminative power. Finally, the presence of a direct proportion relationship between the AUC values and the accuracy levels, where the highest AUC (0.93) corresponded to the highest detected sensitivity and accuracy levels of (91%) and (87.5%) respectively, and the lowest AUC (0.77) corresponded to the lowest detected sensitivity and accuracy level of (61%) and (73.5%) respectively, confirmed the sex discrimination validity of the tested dimensions.
- The application of the student's (t) test to the mean AUC values of the radial and ulnar dimensions revealed a non-significant statistical difference between their AUCs at (P-value = 0.7306). This demonstrates that the radial and ulnar distal epiphyseal ends have very good sex discrimination capabilities using coronal T1-weighted MRI scan and could be used independently to achieve nearly comparable sex discrimination power (Table 5).

Table (1): Paired (t) test compares the mean values of the two researchers' readings regarding the measurements of the radial distal end width (RDEW), radial height (RH), ulnar distal end width (UDEW) and ulnar styloid process length (USPL) using coronal T1-weighted MRI scan.

Tested Dimension	Mean ± SD (mm)		Paired (t) test	P-value
	First Researcher	Second Researcher		
RDEW	28.07 ± 2.81	28.07 ± 2.80	0.04	0.9649 (NS)
RH	11.03 ± 1.65	11.03 ± 1.64	0.04	0.9701 (NS)
UDEW	17.21 ± 2.06	17.21 ± 2.04	0.06	0.9491 (NS)
USPL	6.08 ± 1.28	6.08 ± 1.28	0.08	0.9396 (NS)

RDEW: radial distal end width, RH: radial height, UDEW: ulnar distal end width, USPL: ulnar styloid process length, SD: standard deviation, mm: millimeter, P-value: probability value, NS: not significant. P -value >0.05 is considered non-significant.

Table (2): Pearson correlation coefficient for the assessment of the degree of correlation between the two researchers' readings regarding the measurements of the radial distal end width (RDEW), radial height (RH), ulnar distal end width (UDEW) and ulnar styloid process length (USPL) using coronal T1- weighted MRI scan.

Tested Dimension	Pearson Correlation Coefficient(r)	P-value
RDEW	0.9975	<0.001 (S)
RH	0.9899	<0.001 (S)
UDEW	0.9911	<0.001 (S)
USPL	0.9838	<0.001 (S)

RDEW: radial distal end width, RH: radial height, UDEW: ulnar distal end width, USPL: ulnar styloid process length, P-value: probability value. P-value < 0.05 is considered significant correlation.

Table (3): Comparison between whole males and females' participants aging from 18 to 68 years as regard radial distal end width (RDEW), radial height (RH), ulnar distal end width (UDEW) and ulnar styloid process length (USPL), measured by coronal T1-weighted MRI scan using student's (t) test.

Measured Dimension	Mean ± SD		Student's (t) test	P-value
	Females (N=100)	Males (N=100)		
RDEW	26.37 ± 1.90	30.37 ± 1.94	14.73	<0.0001 (S)
RH	10.32 ± 1.31	11.96 ± 1.39	8.60	<0.0001 (S)
UDEW	15.97 ± 1.72	18.71 ± 1.49	12.03	<0.0001 (S)
USPL	5.54 ± 1.04	6.71 ± 1.29	7.07	<0.0001 (S)

RDEW: radial distal end width, RH: radial height, UDEW: ulnar distal end width, USPL: ulnar styloid process length, N: number, P: probability.

Table (4): Assessment of the validity parameters for the radial distal end width (RDEW), radial height (RH), ulnar distal end width (UDEW) and ulnar styloid process length (USPL) measured by coronal T1-weighted MRI scan as a tool for sex discrimination between male and female participants in all the tested age groups (N=200).

Whole Group	Cut-off Value (mm)	Sensitivity	Specificity	Accuracy	AUC (95% CI)
RDEW	F<28.1≤M	91%	84%	87.5%	0.93 (0.89-0.96)
RH	F<11≤M	82%	66%	74%	0.80 (0.74-0.86)
UDEW	F<17.5≤M	83%	84%	83.5%	0.89 (0.84-0.93)
USPL	F< 6.7≤M	61%	86%	73.5%	0.77 (0.69-0.82)

RDEW: radial distal end width, RH: radial height, UDEW: ulnar distal end width, USPL: ulnar styloid process length, AUC: area under the curve, CI: confidence interval, M: male, F: female, mm: millimeter.

Table (5): Student's (t) test compares the mean values of the area under the curve (AUC) obtained from the receiver operating characteristic (ROC) curves of radial and ulnar dimensions to compare their sex discrimination capabilities using coronal T1-weighted MRI scan:

	Radial Dimensions		Ulnar Dimensions	
	RDEW	RH	UDEW	USPL
AUC	0.93	0.80	0.89	0.77
Mean ± SD	0.87 ± 0.09		0.83 ± 0.08	
Student's (t) test	**0.40**			
P-value	**0.7306 (NS)**			

RDEW: radial distal end width, RH: radial height, UDEW: ulnar distal end width, USPL: ulnar styloid process length, AUC: area under the curve, SD: standard deviation, P: probability, NS: non-significant. P-value <0.05 is considered statistically significant.

Scatter Plot Charts:

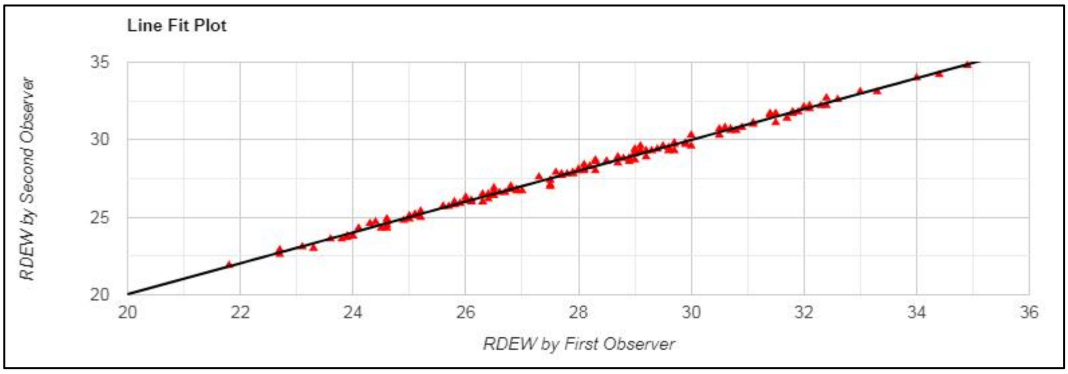


Chart (1): Scatter plot representing the correlation between the two researchers' readings regarding the radial distal end width measures using coronal T1-weighted MRI scan.

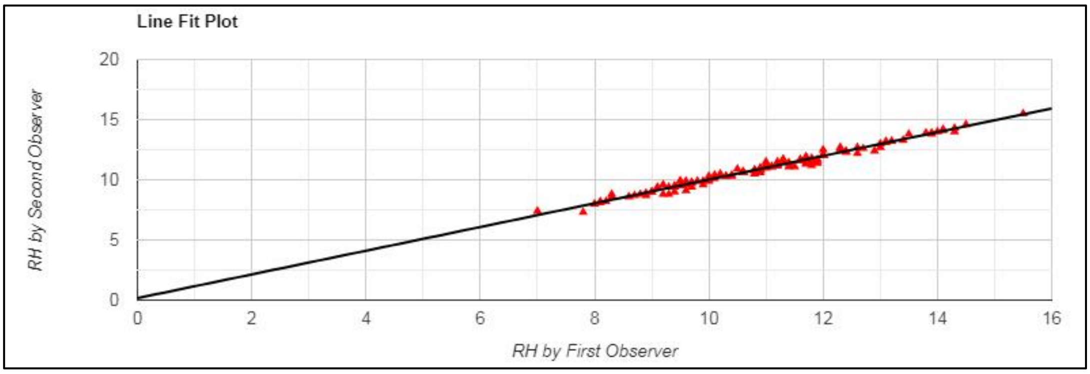


Chart (2): Scatter plot representing the correlation between the two researchers' readings regarding the radial height measures using coronal T1-weighted MRI scan.

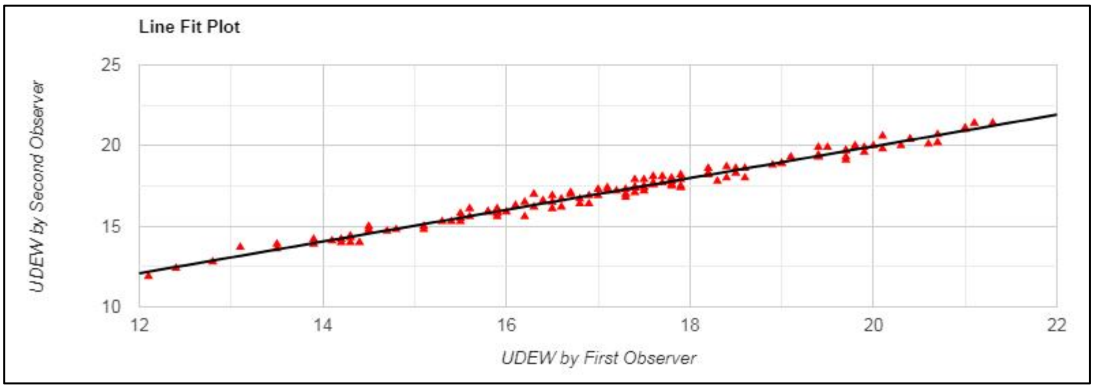


Chart (3): Scatter plot representing the correlation between the two researchers' readings regarding the ulnar distal end width measures using coronal T1-weighted MRI scan.

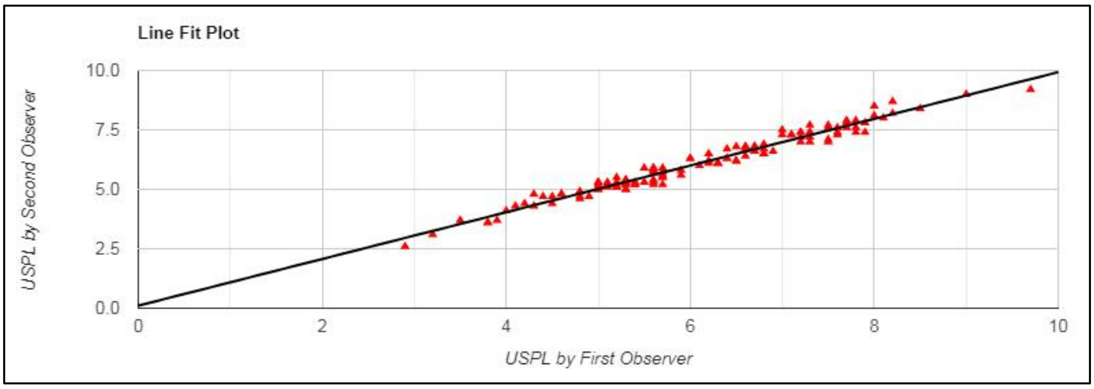
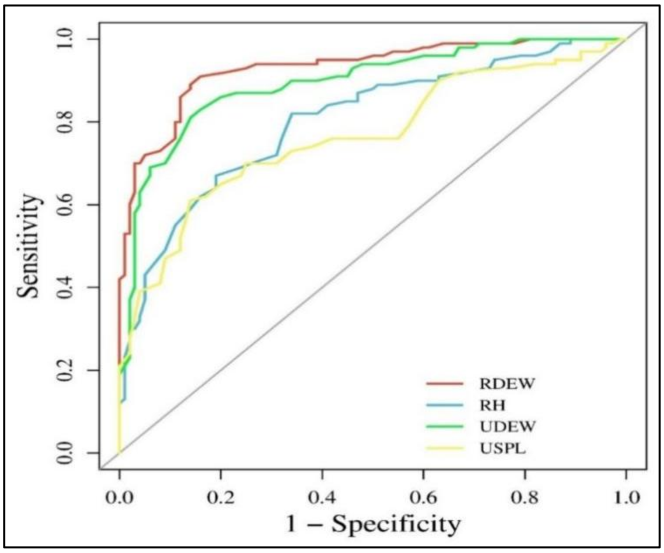


Chart (4): Scatter plot representing the correlation between the two researchers' readings regarding the ulnar styloid process length measures using coronal T1-weighted MRI scan.

Receiver operating characteristic (ROC) curves showing sensitivity and specificity values for the valid dimensions (RDEW,RH, UDEW and USPL).



Curve (1): Shows the ROC Curve for the four valid dimensions: RDEW, RH, UDEW and USPL of the whole studied population.

Images of Coronal T1-weighted MRI Scan films demonstrating some examples for the radial and ulnar tested dimensions in males and females of various ages

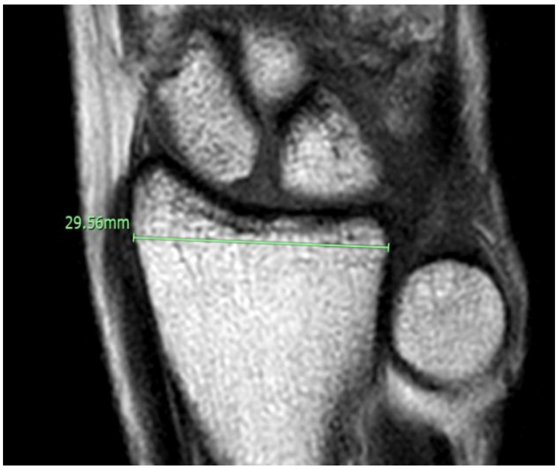


Figure (1): Coronal T1-weighted MRI image showing the RDEW in a 43 years old male

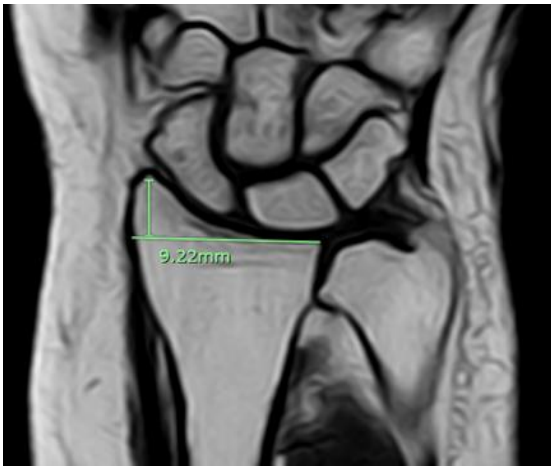


Figure (2): Coronal T1-weighted MRI image showing the RH in a 67 years old male

Figure (3): Coronal T1-weighted MRI image showing the UDEW in a 52 years old female

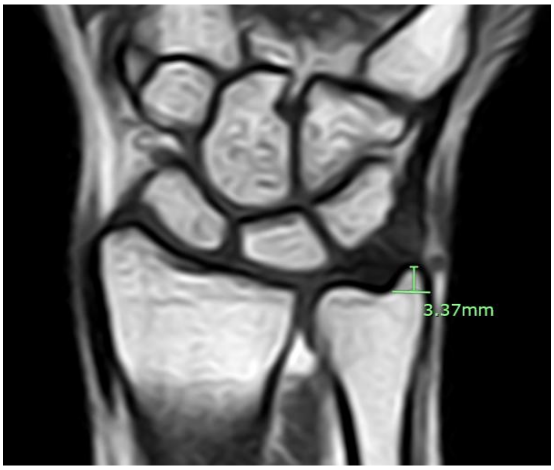


Figure (4): Coronal T1-weighted MRI image showing the USPL in a 40 years old female.

Discussion

Sex is an important personal identification parameter. Anthropometric measurements are known to be reliable in forensic cases, particularly in mass disasters (Sivakumar et al., 2020). Long bone anthropometric dimensions are crucial for forensic sex identification due to their feasibility in measuring dimensions and good preservation (Tetteh et al., 2021). The radius and ulna, long bones with high sexual dimorphism, have been successfully used for sex identification in various populations (Jongmuenwai et al., 2021).

However, the majority of the studies required the presence of the entire radius and ulna, which is not always possible in forensic practices. Although the distal ends of the radius and ulna are well known and play an important role in age determination, there a lack of researches demonstrating their usefulness in sex determination. As a result, this study was conducted to evaluate the reliability and validity of some anthropometric dimensions at the distal epiphyseal ends of the radius and ulna for sex identification using Magnetic Resonance Imaging in an Egyptian population sample.

Several methods were used to validate the reliability; first, MRI was chosen as the measuring method, with measurements obtained through MRI images, which guarantee high reliability and low subjectivity of the measurements taken, as opposed to direct measurement from bones, which has a high risk of subjectivity (Yasar Teke et al., 2018). Second, two researchers obtained measurements of the tested dimensions at different times and in different situations. To avoid potential variations, the dimensions were taken based on specific, well-defined anthropometric points that determine the landmarks at which the measurement was taken (Monum et al., 2021). Finally, the results of both researchers were then compared using three statistical tests; the paired (t) test, Pearson correlation coefficient and scatter plot charts to assess their degree of similarity and to ensure the reliability of the RDEW, RH, UDEW, and USPL measures.

The verification of reliability was consistent with Thom et al. (2020) who used computed tomographic scanning to investigate the reliability of radial dimensions in sex differentiation in a sample of 40 males and 34 females' cadaveric forearms. The study used dimensions from the entire radius, including the distal end width and the radial height. The study demonstrated that distal radial dimensions can reliably distinguish between males and females. Furthermore, Jongmuenwai et al. (2021) conducted a study on donated cadavers from a sample of northern Thai population (100 males and 100 females) using several dimensions from the entire radius, including the radial distal end width (RDEW) to evaluate its usefulness in sex differentiation. According to the study, the distal end of the radius can reliably determine sex distinction. Monum et al. (2021) studied the ulna of donated cadavers from the northern region of Thailand, 100 males and 100 females. To assess inter-researcher reliability, two researchers used a digital vernier caliper to measure ulnar dimensions. According to the study, the dimensions of the ulnar bone, including its distal epiphyseal end, are reliable for use in sex discrimination.

The observed anthropometric disparity between men and women, as well as the radius and ulnar sexual dimorphism, could be attributed to a variety of factors including hormones, genetics, lifestyle, and environmental factors. Male bones are typically larger than female bones. This is due to differences in the type and rate of production of sex steroids, which contribute to sexual dimorphism. Furthermore, testosterone promotes bone growth, resulting in larger skeletons with larger long bone sizes, including arm bones (Burr and Allen, 2019). Furthermore, gene expression on sex chromosomes differs between males and females. Differences in gene expression can affect bone cell function (osteoblasts, osteocytes, and osteoclasts), which control skeletal growth, bone mass maintenance, and bone quality (Mun et al., 2021).

The sex discrimination capability of RDEW and RH was assessed by many researchers; Karimi Jeshni et al. (2018) investigated the sex differentiation capability of the maximum width of radius in radiographic images of 90 Iranian adults (45 males and 45 females). According to the study, males have a significantly higher mean value of maximum radius width than females. Thom et al. (2020) investigated the capability of radial dimensions in sex differentiation on cadaveric forearms from 40 males and 34 females using computed tomographic scanning and reported that males have a significantly larger distal width of radius than females. Jongmuenwai et al. (2021) confirmed the validity of RDEW as a sex discriminator for the Thai population with an accuracy of (89.5%). The effectiveness of RH for sex differentiation was assessed by Shrestha et al. (2022) and Nalbant et al. (2022) who studied 125 patients' wrist radiographs, they discovered that males had significantly higher RH mean values than females.

On the other hand, several research investigations looked into the sexual dimorphism of some lower ulnar dimensions, as shown. Toprak and Turkoglu (2018) evaluated the sexual dimorphism of USPL in a study using MRI scans on a sample of 100 people, 64 of whom were women and 36 were men. The study discovered that the mean value of the USPL in males is significantly higher than in females with a cut-off value of ($F<6.4$ mm$\leq$ M) and has the capability to identify sex with (55%) sensitivity, (74%) specificity, and (67%) accuracy. Monum et al. (2021) in their aforementioned study reported that males had a wider mean ulnar distal end width than females, and this difference in means was statistically significant, they also confirmed that the UDEW had an accuracy of up to (83.5%) in discriminating between males and females which is similar to the results of the current study.

The current study's assessment of the validity parameters for the lower radial and ulnar epiphyseal dimensions was consistent with other studies that found the accuracy rate of the tested dimensions in sex differentiation to be high and promising. This could be explained by the fact that they are epiphyseal dimensions, and according to several studies, the epiphysis is the most sexually dimorphic part of any long bone. This phenomenon affects the radius and ulna as well. Several studies have shown that the epiphyseal radial dimensions have the highest accuracy in sex identification when compared to other non-epiphyseal radial dimensions (Jongmuenwai et al., 2021). The well-known physiological theory proving that mechanical compression and tension increase the rate of bone growth elucidated the aforementioned phenomenon. Loads applied to long bones cause the stress exerted on the epiphyses to be greater than the stress exerted on other parts of bone, causing the epiphysis to increase in size significantly than other bone parts (Liu et al., 2022). Moreover, although bones do not vary much in length after puberty, they still have the ability to grow appositionally (in thickness) in response to tension produced by weight and muscle exertion. Consequently, males who exert more physical effort have larger mean epiphyseal dimensions, making distal radial and ulnar dimensions an excellent sex discriminative tool capable of differentiating between males and females with high accuracy up to 92.5% (Hucke et al., 2023).

As previously demonstrated, the measured ulnar and radial epiphyseal dimensions are consistent with some literature studies but differ from others, particularly those conducted on different populations with different lifestyles, physical activities, dietary patterns, and races. Several factors contribute to this disparity and variation.

At first, Gelu et al. (2018) suggested that disparities in the socio-economic class between the studied populations in different researches, affect the results of these studies, as poverty-stricken areas are typically characterized by overcrowding, malnourishment, and decreased food quality in addition to a lack of hygienic conditions and medical facilities. The combination of the preceding factors has a negative impact on the individuals' growth and development, lowering their degree of sexual dimorphism. Moreover, Maass and Friedling (2018) added that males are more influenced by environmental stresses, putting them at risk for gracile morphologies and, as a result, a decline in overall sexual dimorphism. Mechanical stress and population's physical activity patterns influence the amount and duration of growth, hormonal levels, and muscle mass. So, they have a significant impact on sexual dimorphism. According to López-Lázaro et al. (2020), each geographic zone has its own pattern of physical activity, nutritional attainment, and access to health care, which all influence the degree of sexual dimorphism in its inhabitants. Anthropometric studies, while looking at the same bones and dimensions, were conducted at different times and on different generations, and thus may have been influenced by secular trends. Secular trends influence the evolution of sexual dimorphism levels over time. As a result, studies conducted in different decades are unlikely to reveal the same pattern of sexual dimorphism (Grine et al., 2020). In terms of the racial factor, the degree of sexual dimorphism varies greatly because each population has a distinct environment, socioeconomic status, nutrition, and feeding habits (Monum et al., 2021). Nutrition is an essential aspect that could never be ignored. Males are more sensitive to protein deficits, especially when they occur over an extended period, therefore a diet lacking in essential protein will stunt their growth more than that of females. Over time, this lessens the disparity in bone size between men and women, which affects the degree of sexual dimorphism (Maranho et al., 2022). The degree of sexual dimorphism is also influenced by genes; the regional dominance of specific genes and their expression vary by population. It was observed that the heritability of bone size variation in the wrist bones exceeds 50% (Ngidi et al., 2023).

Finally, the differences observed between the current study and the other studies may be due to differences in the measurement and technique methods used, which can eventually lead to some variation in results, but only to a certain extent. To begin with, the type of samples and the measuring methods, as some studies employed direct caliper measurement from cadaver samples (Jongmuenwai et al., 2021). While the current study obtained measurements from archived MRI films which reduces the degree of subjectivity between individuals. Also MRI is known for its high accuracy in anthropometric studies (Utomo et al., 2020). This could explain why the current findings were more accurate than those of previous studies. Aside from the previously mentioned factors, the sample size, age of the study population, statistical analyses used in each study, and the choice of the cut-off value for each dimension all differ. All these factors, as well as many others, could result in and explain minor differences between study findings.

Conclusion and Recommendations

The reliability of the tested dimensions at the distal ends of the radius and ulna [radial distal end width (RDEW), radial height (RH), ulnar distal end width (UDEW), and ulnar styloid process length (USPL)] as sex discriminators was established in this study. Furthermore, the current study confirmed that among the radial and ulnar dimensions, the RDEW and UDEW dimensions have the highest sex discrimination accuracy, and thus each could be used solely as a sex identifier. For the preceding consideration, it was recommended that the already investigated radial and ulnar dimensions be assessed in conjunction with other radial and ulnar dimensions on a larger scale of the Egyptian population with a larger sample size of different age groups. Further research should be conducted to develop a sex identification equation based on radial and ulnar dimensions for the Egyptian population. In addition, an anthropometric dimensions database for the Egyptian population will be created to be used in times of need, such as natural disasters.

References

Burr DB and Allen MR (2019): Basic and applied bone biology (Second). Academic Press an imprint of Elsevier. Retrieved January 3 2024. https://www.sciencedirect.com/science/book/9780128132593.

Daghighi MH, Pourisa M, Javanpour-Heravi H et al., (2021): Application of knee MRI in forensic age estimation: A retrospective cohort. Radiography. 27(1): 108–114.

Gelu A, Edris M, Derso T et al., (2018): Undernutrition and associated factors among children aged 6-59 months living in slum areas of Gondar city, northwest Ethiopia: a cross-sectional study. Pediatric Health, Medicine and Therapeutics. 9: 81–88.

Grine FE, Lee C, Mongle CS et al., (2020): Secular trends in cranial size and shape among black South Africans over the late 19th and 20th centuries. Annals of Human Biology. 47(5): 446–456.

Hucke L, Holder J, van Drongelen S et al., (2023): Influence of tension-band plates on the mechanical loading of the femoral growth plate during guided growth due to coronal plane deformities. Frontiers in Bioengineering and Biotechnology.11: 1165963.

Jongmuenwai W, Boonpim M, Monum T et al., (2021): Sex estimation using radius in a Thai population. Anatomy and Cell Biology. 54(3): 321–331.

Karimi Jeshni S, Akhlaghi M and Varzandeh M (2018): The diagnostic value of radius bone in forensic identification using radiographic images in Iranian population. International Journal of Medical Toxicology and Forensic Medicine. 8(1): 29–36.

Liu P, Tu J, Wang W et al., (2022): Effects of mechanical stress stimulation on function and expression mechanism of osteoblasts. Frontiers in Bioengineering and Biotechnology.10: 830722.

López-Lázaro S, Pérez-Fernández A, Alemán I et al., (2020): Sex estimation of the humerus: A geometric morphometric analysis in an adult sample. Legal Medicine. 47: 101773.

Maass P and Friedling LJ (2018): Morphometric analysis of the humerus in an adult South African cadaveric sample. Forensic Science International. 289: 451-e1.

Maranho R, Ferreira MT and Curate F (2022): Sexual dimorphism of the human scapula: a geometric morphometrics study in two Portuguese reference skeletal samples. Forensic Sciences. 2(4): 780–794.

Monum T, Jongmuenwai W, Thunyacharoen S et al., (2021): Sex estimation using ulna in a Thai population. International Journal of Morphology. 39(6): 1535–1542.

Mun SH, Jastrzebski S, Kalinowski J et al., (2021): Sexual dimorphism in differentiating osteoclast precursors demonstrates enhanced inflammatory pathway activation in female cells. Journal of Bone and Mineral Research. 36(6): 1104–1116.

Nalbant A, Ismailoglu E, Turhan E et al., (2022): Radiographic morphometry of the distal end radius in Anatolian population. Int. J. Morphol. 41(1):297-302.

Ngidi NL, Olojede SO, Lawal SK et al., (2023): Morphometric study of the radius bone in a KwaZulu-Natal population: Laterality and sexual dimorphism. Forensic Science International: Reports.7: 100316.

Setia MS (2016): Methodology series module 3: Cross-sectional studies. Indian Journal of Dermatology. 61(3): 261.

Shrestha S, Mansur DI, Shrestha R et al., (2022): Radiographic study of distal radius parameters in patients visiting tertiary care hospital. Kathmandu University Medical Journal (KUMJ). 20(78): 136–140.

Sivakumar N, Bansal D, Narwal A et al., (2020): Gender determination analysis using anthropometrical dimensions of 2D:4D, foot index and mandibular canine index. Journal of Oral and Maxillofacial Pathology: JOMFP. 24(3): 510–516.

Tetteh J, Appiah AK, Abaidoo CS et al., (2021): The forensic use of percutaneous femur length in height and sex estimation among Ghanaians. Forensic Science International: Reports. 4(12): 100234.

Thom ML, Willmore K, Surugiu A et al., (2020): Females are not proportionally smaller males: relationships between radius anthropometrics and their sex differences. HAND. 15(6): 850–857.

Toprak U and Turkoglu S (2018): Anthropometric and clinical analysis of the distal ulna and extensor carpi ulnaris tendon using MRI. Surgical and Radiologic Anatomy. 40(9): 989–994.

Utomo DN, RanuhIGNDM, ChilmiMZ et al., (2020): Anthropometric studies of distal femur and proximal tibia using magnetic resonance imaging methods in public hospitals. EurAsian Journal of BioSciences. 14(2): 3309-3313.

Yasar Teke H, Ünlütürk Ö, Günaydin E et al., (2018): Determining gender by taking measurements from magnetic resonance images of the patella. Journal of Forensic and Legal Medicine. 58: 87–92.

تقييم موثُوقية وصلاحية بعض القياسات البشرية للأطراف المشاشية السفلى لعظمى الزند و الكعبرة لتحديد الجنس باستخدام التصوير بالرنين المغناطيسي في عينة من المصريين
ـ دراسة استرجاعية-

رنا محسن سعد[1] و أسماء عبد الرحمن عبد الرحمن[1] و رحمة فرغلي علي[2], نسرين عبد الرحمن محمود[1]

الملخص العربي

المقدمة: الجنس هو مَعلم أساسى لتحديد الهوية الشخصية، فمن المعروف أن القياسات البشرية يمكن الاعتماد عليها لتحديد الجنس في قضايا الطب الشرعي وخاصة في الكوارث الجماعية. و لقد أصبح التصوير بالرنين المغناطيسي الطريقة المفضلة لتحديد القياسات البشرية. فبرغم ما أُظهرته كل من عظمتى الكعبرة و الزند من اختلاف كبير بين الجنسين في شكل الأطراف القريبة وكذا أعمدتهما مع ذلك هناك نقص في الأبحاث التي تتناول فائدة الأطراف السفلية للكعبرة والزند في تحديد الجنس.

تهدف هذه الدراسة: إلى تقييم موثوقية وصلاحية بعض القياسات البشرية للأطراف المشاشية السفلى لعظم الزند و الكعبرة لتحديد الجنس بإستخدام التصوير بالرنين المغناطيسي في عينة من المصريين من فئات عمرية مختلفة لإعتماد هذه الطريقة لتحديد الجنس في الممارسات الطبية الشرعية.

طريقة البحث: تم إجراء هذه الدراسة المستعرضة بأثر رجعي على أفلام التصوير بالرنين المغناطيسي المؤرشفة لـ 200 شخص (100 ذكر و100 أنثى) تتراوح أعمارهم (بين 18 و68 عامًا)، مأخوذة من أرشيف قسم الآشعة التشخيصية والتداخلية بمستشفيات جامعة عين شمس بالقاهرة، مصر.

تم قياس أربعة أبعاد: عرض النهاية البعيدة للكعبرة ،(RDEW) ارتفاع الكعبرة ،(RH) عرض النهاية البعيدة للزند (UDEW) وطول الزائدة الإبرية للزند .(USPL) تم تحليل النتائج احصائيا.

النتائج: قد تبين أن الأبعاد التي تم اختبارها موثوقة وصالحة في التمييز بين الجنسين و بدقة تصل إلى 87.5% لأبعاد الكعبرة و تصل إلى 83.5% لأبعاد الزند.

الإستنتاج: أثبتت الدراسة الحالية الموثوقية و الصلاحية و الدقة العالية للنهايات المشاشية السفلى للكعبرة و الزند في تحديد الجنس.

1. قسم الطب الشرعي والسموم الإكلينيكية، كلية الطب- جامعة عين شمس - القاهرة- مصر
2. قسم الأشعة التشخيصية والتداخلية، كلية الطب- جامعة عين شمس - القاهرة- مصر