ORIGINAL ARTICLE

Annals of Agricultural and Environmental Medicine
www.aaem.pl

Reliability of patellar volume in sex determination – a computed tomography study

Karol Jakubik[1,2,A-F], Mikołaj Jeżak[3,4,B-F], Mariola Janiszewska[5,C-F], Rafał Rutyna[4,D-F], Andrzej Górecki[6,D-F], Grzegorz Staśkiewicz[1,3,A-F]

[1] I Department of Medical Radiology, Medical University, Lublin, Poland
[2] Doctoral School, Medical University, Lublin, Poland
[3] Department of Correct, Clinical and Imaging Anatomy, Medical University, Lublin, Poland
[4] I Clinic of Anaesthesiology and Intensive Therapy, Medical University, Lublin, Poland
[5] Department of Medical Informatics and Statistics with E-Health Lab, Medical University, Lublin, Poland
[6] Department of Radiology, VoxeMedical Diagnostic Centre I, Łańcut, Poland
A – Research concept and design, B – Collection and/or assembly of data, C – Data analysis and interpretation, D – Writing the article, E – Critical revision of the article, F – Final approval of the article

Jakubik K, Jeżak M, Janiszewska M, Rutyna R, Górecki A, Staśkiewicz G. Reliability of patellar volume in sex determination – a computed tomography study. Ann Agric Environ Med. doi:10.26444/aaem/215852

Abstract

Introduction and Objective. Determination of the sex of skeletal remains is of great importance in forensic anthropology. Since skeletons can often be incomplete, sex assessment based on a single bone becomes useful. The aim of this study is to investigate the sexual dimorphism of the patella, and the accuracy of patellar measurements in determining the sex of an individual in a contemporary Polish population sample using computed tomography.

Materials and Methods. The study sample consisted of adult patients of Polish descent undergoing computed tomography angiography of lower extremities. A total of 130 individuals (69 males and 61 females) were included in the study. Five measurements were examined for left-hand side patellas: craniocaudal patella dimension (CCP), transverse patella dimension (TP), anteroposterior patella dimension (APP), patellar angle (PA) and patellar volume (PV).

Results. All studied measurements were significantly higher in males than in females. According to the receiver operating characteristics analysis, PV proved to be the most reliable parameter for distinguishing male from female patella, with an accuracy rate of 83.9%. The CCP and TP also showed high accuracy values of 82.3% and 81.5%, respectively. PA proved to be the least effective parameter for sex identification in the study (61.5% accuracy). The multivariate model, based on all measurements, achieved an accuracy of 82.3%. An analysis of variance showed that there was no statistically significant difference between the multivariate and the univariate model for patellar volume.

Conclusions. The results indicate that the patellar measurements, especially PV, may be useful in sex determination in the Polish population.

Key words

sexual dimorphism, sex prediction, patella, computed tomography, radiology, forensic anthropology

INTRODUCTION AND OBJECTIVE

Determination of the identity of a deceased person is a two-step procedure, involving the creation of a biological profile and assessment of the person's individual characteristics. Establishing a reliable biological profile is the most important part of the work of forensic anthropologists. The profile comprises sex, age, stature and ancestry. Individual traits of the deceased, such as moles, scars, tattoos, or any abnormalities and deformities visible on the decomposed body and/or skeleton, assist in the ante- and post-mortem comparison of traits. The whole procedure is designed to narrow the search and identify an individual from among a group [1]. Methods commonly used to determine sex can be classified as non-metric – morphological, or metric, which are very important in the identification process despite the existence and development of molecular techniques, such as DNA fingerprinting. Molecular methods are highly sophisticated, with a higher degree of reliability, although rather complex, invasive, expensive and time-consuming [1].

The need for single-bone skeletal identification arises when the body is dismembered, significantly disfigured, or highly decomposed. In these scenarios, forensic anthropologists usually rely on the skull or pelvis to determine sex, both of which are considered the most reliable bones in determining the sex of skeletal remains, using metric or non-metric approaches [2]. However, the incompleteness of the skeleton or the destruction of highly sex dimorphic bones is often a significant problem. In such situations, methods of sex determination based on single bones become relevant [3–8]. The usefulness of the patella in determining sex has been studied previously, although to date not in the contemporary Polish population [9–14].

The present study was designed to investigate the sexual dimorphism of the patella and the accuracy of patellar measurements in determining the sex of an individual in a sample of the contemporary Polish population using computed tomography (CT).

Address for correspondence: Karol Jakubik, I Department of Medical Radiology, Medical University, Jaczewskiego 8, 20-090 Lublin, Poland
E-mail: karol_jakubik@outlook.com

Received: 08.11.2025; accepted: 19.12.2025; first published: 05.02.2026

MATERIALS AND METHOD

Data collection. The data utilised in the present study were obtained from a random selection of patients of Polish descent who underwent routine CT angiography (CTA) examinations of the lower limbs in the University Hospital No. 4 in Lublin, eastern Poland. The study sample consisted of 130 CTA examinations (69 males and 61 females) from an initial group of 200 CTA examinations (100 males and 100 females). Exclusion criteria included patients under 18 years of age, patellar fractures, knee replacement surgery, advanced osteoporosis and congenital abnormalities.

Ethical approval. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and was approved by the Bioethics Committee of the Medical University of Lublin (Approval No. KE-0254/238/11/2023). Informed consent was waived due to the retrospective nature of the study.

Imaging data. Computed tomography scans were performed using a 64-row scanner (GE Medical Systems) using a standard protocol with spiral acquisition and 1.2 mm slice thickness. CTA studies were used for the analysis due to high spatial resolution.

Measurements and 3D reconstruction. Measurements were obtained from CTA images using an AW4.7 workstation (GE Medical Systems). Using properly adjusted CTA scans, three linear measurements and one angular measurement were taken – craniocaudal patella dimension (CCP), transverse patella dimension (TP), anteroposterior patella dimension (APP) and patellar angle (PA) (Fig. 1A). Definitions of the linear and angular parameters of the patella are presented in Table 1. The 3D patella reconstruction was obtained by separating the investigated patella from the surrounding structures using multiple slice editing tools. Patellar volume (PV) was then calculated automatically after setting the proper threshold of ≥160 Hounsfield units (HU) (Fig. 1B).

Statistical analysis. Statistical analyses were performed using the statistical language R (version 4.3.1; R Core Team, 2023, on Windows 10 pro 64 bit); level of significance $\alpha = 0.05$. Descriptive statistics including mean, standard deviation, minimum and maximum values were calculated for measurements and age of subjects. The normality of the data distribution was tested using the Shapiro-Wilk test; Student's t-test was used to test the significance of inter-group differences. When the assumption of equality of variance was violated, the Welch's t-test was used. To estimate discrimination between sex groups, cut-off points were calculated for individual morphological parameters and patella dimensions. To maximise the number of correct classifications, the accuracy maximisation method was applied. The quality of the discrimination results was further assessed using key binary classification metrics. Specifically, measures of the area under the curve (AUC), sensitivity and specificity, were estimated. In addition, a multivariate model was used to estimate sex discrimination, which included all parameters tested. The logistic regression model implemented, using a probit linking function, allowed for the highest value of the coefficient of determination (Nagelkerke's R^2) compared to other competing functions, suggesting a better ability of the model to explain variation in the data. To compare the discriminatory ability of the univariate and multivariate models, an analysis of variance (ANOVA) test was applied. A likelihood ratio test was additionally applied.

Table 1. Definitions of linear and angular parameters of the patella

Parameter (abbreviation)	Definition
Craniocaudal patella dimension (CCP)	Distance between base and apex of patella
Transverse patella dimension (TP)	Distance between medial and lateral borders of patella
Anteroposterior patella dimension (APP)	Greatest distance between the anterior and posterior sides
Patellar angle (PA)	Angle between the lines parallel to the medial and lateral patellar facets

RESULTS

Descriptive statistics. The sample included 69 males and 61 females, with an average age of 59.84 and 60.25 years, respectively. The average age of all subjects was 60.03 (standard deviation – 16.30 years) and ranged from 18–93 years. Table 2 shows the descriptive statistics in the study sample.

Table 2. Descriptive statistics of patella measurements in the study sample with the result of the normality test

Parameter	M	SD	Min	Max	p Shapiro-Wilk
CCP, mm	42.01	4.48	33.50	55.00	0.199
TP, mm	45.70	4.22	35.60	57.40	0.632
APP, mm	22.20	1.88	17.00	26.00	0.216
PA, °	131.05	8.21	103.50	152.90	0.455
PV, cm^3	18.23	4.65	7.77	30.52	0.389

CCP – craniocaudal patella dimension; TP – transverse patella dimension; APP – anteroposterior patella dimension; PA – patellar angle; PV – patellar volume; M – mean value; SD – standard deviation; Min – minimum value; Max – maximum value; *p* – *p*-value of the statistical test

Assessment of the significance of the sex differences. Table 3 presents the distribution of age and tested patella parameters in relation to the sex factor of the participants with the results of the significance of sex differences. The age of the participants did not differ significantly between men and women ($p = 0.888$). With the exception of patella angle, all parameters studied had equal levels of variance in both the

Table 3. Distribution of age and tested patella parameters in relation to the sex factor of the participants with the results of the significance of differences

Parameter	Group (n = 130)		p	$\hat{g}_{Hedges}$
	Males (n1 = 69) M (SD)	Females (n2 = 61) M (SD)		
Age, years	59.84 (15.82)	60.25 (16.95)	0.888	0.03
CCP, mm	44.72 (3.62)	38.95 (3.22)	< 0.001	-1.67
TP, mm	48.23 (3.23)	42.84 (3.27)	< 0.001	-1.65
APP, mm	23.08 (1.67)	21.21 (1.59)	< 0.001	-1.14
PA, °	132.73 (9.39)	129.15 (6.17)	0.011	-0.45
PV, cm^3	21.91 (3.61)	14.88 (3.21)	< 0.001	-1.84

CCP – craniocaudal patella dimension; TP – transverse patella dimension; APP – anteroposterior patella dimension; PA – patellar angle; PV – patellar volume; n – group size; M – mean value value; SD – standard deviation; *p* – *p*-value of the statistical test; $\hat{g}_{Hedges}$ – Hedges' *g* effect size

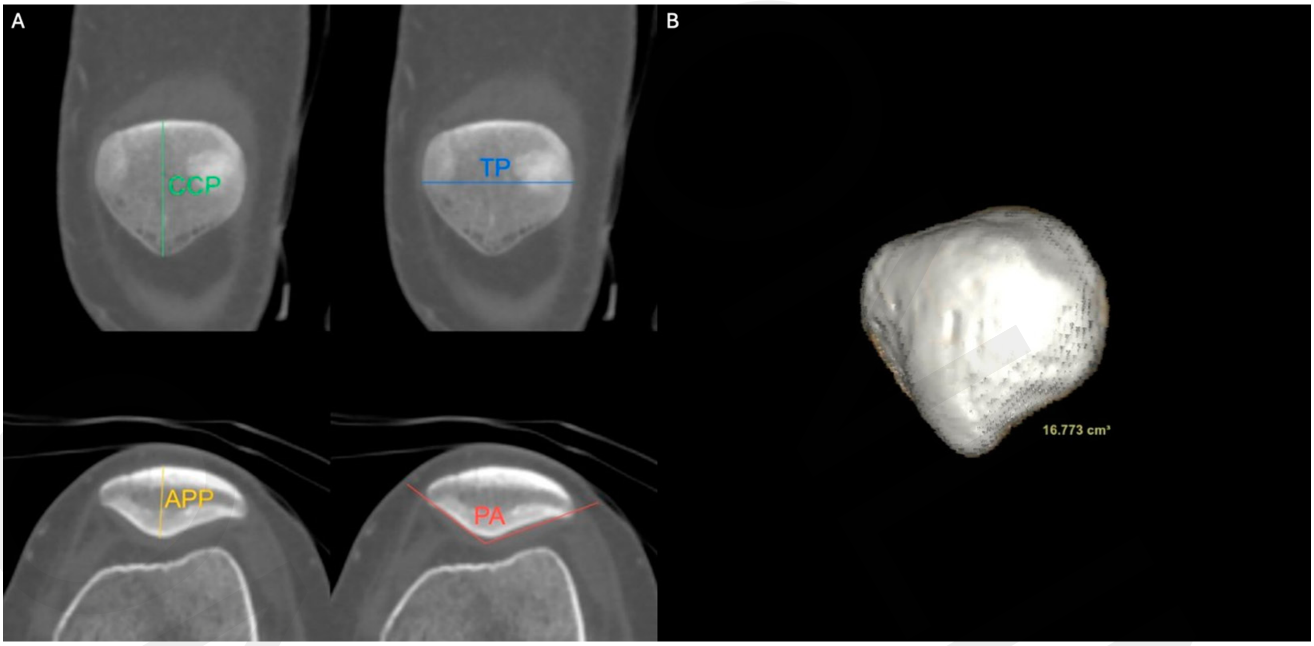

Figure 1. A. Measurements of the patella. B. 3D patella reconstruction with automatically calculated patellar volume.
CCP – craniocaudal patella dimension; TP – transverse patella dimension; APP – anteroposterior patella dimension; PA – patellar angle

Table 4. Estimated cut-off points of the tested patella parameters along with quality metrics of the diagnostic tests

Parameter	Optimal cut-off point	AUC	Sensi-tivity	Speci-ficity	Accuracy	Correctly classified	
						Males	Females
CCP, mm	≥ 42.00	0.886	78.3%	86.9%	82.3%	78.3%	86.9%
TP, mm	≥ 45.60	0.884	82.6%	82.0%	81.5%	82.6%	82.0%
APP, mm	≥ 21.70	0.798	85.5%	63.9%	75.4%	85.5%	63.9%
PA, °	≥ 133.10	0.635	37.7%	88.5%	61.5%	37.7%	88.5%
PV, cm³	≥ 17.49	0.905	84.1%	83.6%	83.9%	84.1%	83.6%

CCP – craniocaudal patella dimension; TP – transverse patella dimension; APP – anteroposterior patella dimension; PA – patellar angle; PV – patellar volume; AUC – area under the curve

male and female groups. CCP, TP, APP and PV values were significantly larger in males – $p < 0.001$. The effect size for these differences was also large, $\hat{g}_{Hedges}$ = [-1.14 to -1.84]. PA was also significantly different between males and females, with males having a greater mean angle (132.73°) compared to females (129.15°). However, the effect size was smaller ($\hat{g}_{Hedges}$ = [-0.45]).

Assessment of cut-off points. Table 4 reveals estimated cut-off points of the tested patella parameters along with quality metrics of the diagnostic tests. In the present study, the presence of a test trait was defined as the occurrence of male sex.

According to the metric of the AUC, PV proved to be the most reliable parameter for distinguishing male from female patella (AUC = 0.905). This was also confirmed by the high values of accuracy, sensitivity and specificity (83.9%, 84.1% and 83.6%, respectively). CCP and TP also showed high ability to discriminate sex, with AUCs of 0.886 and 0.884, respectively. The accuracy for CCP was 82.3%, and for TP was 81.5%, but it is worth noting that the sensitivity and specificity for these parameters were not as evenly distributed as for PV. APP showed moderate ability to discriminate between sexes (AUC = 0.798, 75.4% accuracy). Despite high sensitivity (85.5%), specificity for this parameter was significantly lower (63.9%). PA proved to be the least effective parameter for sex identification (AUC = 0.635). The accuracy, sensitivity and specificity for this parameter were relatively low (61.5%, 37.7% and 88.5%, respectively).

In the following analysis, a multivariate model was created based on all the measurements studied. The coefficients of the fitted logistic regression model examining the occurrence of male sex are shown in Table 5. Importantly, the model does not show collinearity of any explanatory variables. Finally, the model explained 64% of the variance in the dependent variable, i.e. it was a good fit to the data and had relatively high power in explaining patellar sexual dimorphism. A summary of the results in Table 5 suggested that PV was the only factor significantly affecting patellar sexual dimorphism. A logistic regression model, with a probit linking function, showed that each additional 1 cm³ of patella volume increased the relative risk of male sexual dimorphism by 22%.

Table 5. Coefficients of the fitted multivariate logistic regression model with probit link function, $R^2_{Nagelkerke}$ = 0.64

Explanatory variable	RR	CI 95%	p
Constant	0.00	0.00 – 0.00	0.001
CCP, mm	1.11	0.98 – 1.26	0.121
TP, mm	1.04	0.90 – 1.21	0.590
APP, mm	1.03	0.82 – 1.30	0.796
PA, °	1.02	0.98 – 1.06	0.277
PV, cm³	1.22	1.06 – 1.41	0.006

CCP – craniocaudal patella dimension; TP – transverse patella dimension; APP – anteroposterior patella dimension; PA – patellar angle; PV – patellar volume; RR – relative risk; CI 95% – 95% confidence interval; *p* – *p*-value of the statistical test; $R^2_{Nagelkerke}$ – Nagelkerke's pseudo-R-squared

Analysis of the results of the logistic regression models provided information on the predictive performance of sexual dimorphism based on the multivariate model. The multivariate model achieved an AUC of 0.915 (Fig. 2A), a value which is slightly higher (by about 0.01) compared to

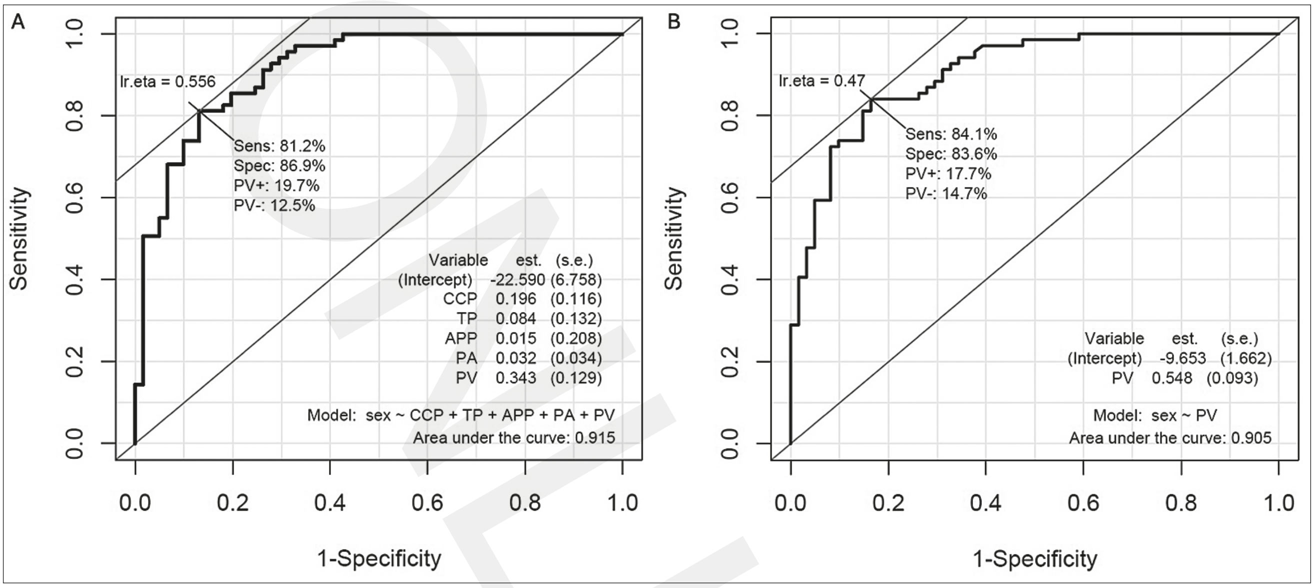

Figure 2. A. Receiver operating characteristics (ROC) curve for multivariate model consisting of all studied parameters. B. ROC curve for patellar volume (PV). CCP – craniocaudal patella dimension; TP – transverse patella dimension; APP – anteroposterior patella dimension; PA – patellar angle; PV – patellar volume

the univariate model, which was based only on PV (Fig. 2B). Furthermore, the multivariate model had a lower level of sensitivity (81.2% vs. 84.1% for the univariate model), but a slightly higher level of specificity (86.9% vs. 83.6% for the univariate model) and lower level of accuracy (82.3% vs. 83.9% for the univariate model). However, despite these differences, the ANOVA test showed that there was no statistically significant difference between the multivariate and univariate models ($p = 0.189$).

DISCUSSION

The present study aimed to assess the utility of patella measurements in sex determination using CT in a contemporary Polish population. Studies which focus on sex determination utilising radiological methods, such as CT or magnetic resonance imaging (MRI), have a vital role in modern forensics. These methods provide novel approaches in the field, allowing a non-invasive, accurate and repeatable examination of a large amount of contemporary skeletal data. Moreover, radiological methods enable the study of both ante-mortem and post-mortem subjects. Many researchers have used post-mortem CT examinations in their studies, as the assessment of bone morphology using CT does not differ significantly from calliper measurements [15–18]. According to Lo Re et al., the use of post-mortem imaging is vital as a complementary technique, and it becomes crucial in certain selected cases and situations, such as putrefied, carbonized, or highly damaged bodies. It is also used as a preliminary evaluation in mass disasters [15]. According to INTERPOL's Disaster Victim Identification (DVI) Guide, CT imaging is an important element in identifying victims of mass casualties disasters and can be used to determine the sex of human remains [19]. For instance, DVI protocol was used to identify a corpse that had been buried in an Italian cemetery that had collapsed into the sea [20]. Initially, the sex was inferred based on the appearance of the well-preserved body.

In the past, numerous studies have focused on using the patella in sex determination [9–14]. In the current study, CCP, TP, APP and PV values were significantly larger in males than in females, and previous studies performed on different populations have also reported that the mean values of patellar measurements for males were usually greater than in females. In the present study, the univariate analysis of linear and angular parameters of patella yielded a sex accuracy rate of 61.5% – 82.3%. A comparison with previous research that was also based on radiological methods can be found in Table 6. It may be argued that studies on the accuracy of patella measurements in sex determination reach conclusions.

The most reliable and accurate parameter for distinguishing male from female patella in the present study was PV. Given the amount of research on sexual dimorphism of the patella and its use for sex determination, only a few researchers have investigated the utility of patellar volume. In the research by Singla et al., a water displacement method was used for measuring PV [21], whereas Michiue et al. and Zhan et al. have utilised CT scans and automatic measurement methods

Table 6. Comparison of sex determination using patellar dimensions with previous studies

Study	Population sample	Material	Statistical method	Accuracy		
				Univariate	Multivariate	PV
Yasar Teke et al. [10]	Turkish	MRI scans of clinical patients	DFA	79.0% – 86.5%	89.0%	–
Michiue et al. [9]	Japanese	Postmortem CT scans	ROC	70.9% – 87.7%	85.7% – 93.3%	85.5% – 87.7%
Zhan et al. [11]	Chinese	CT scans of clinical patients	ROC	73.1% – 85.7%	81.9% – 91.6%	85.7%
The present study	Polish	CT scans of clinical patients	ROC	61.5% – 83.9%	82.3%	83.9%

MRI – magnetic resonance imaging; CT – computed tomography; PV – patellar volume; DFA – discriminant function analysis;, ROC – receiver operating characteristics analysis in order to obtain bone volume [9, 11]. The accuracy of sex determination for PV in the first study was 85.5% for the right patella and 87.7% for the left patella [9]. Zhan et al. have reported a 85.7% accuracy for PV [11]. In both studies, the accuracy rate for PV was slightly higher than that obtained in the current study (82.3%). The volume of the patella in the studies mentioned, including the present study, was the most accurate parameter for sex determination based on the patella. Analysis showed that in the present study there was no statistically significant difference between the multivariate model and the PV-based univariate model, suggesting that the simpler univariate model was as effective as the more complex model. Therefore, the univariate model seemed to be preferential.

In the current study, the most reliable linear parameters were CCP and TP, with 82.3% and 81.5% accuracy, respectively. The parameter with the highest accuracy rate in the study by Yasar Teke et al. was found to be the TP (86.5%) [10]. In the study by Michiue et al. the best performing linear parameter was found to be the maximum height, with an accuracy of 82.3% and 80.9% for the right and left patella, respectively [9]. In the Zhan et al. study, the most accurate linear parameters were maximum height and maximum breadth, with 82.3% accuracy each [11].

The worst performing linear parameter in the studies by Yasar Teke et al., Michiue et al. and Zhan et al. was found to be the APP (in the mentioned studies, accuracy in sex determination for this parameter was respectively 79.0%, 70.9–74.1% and 75.0%) [9–11]. In the present study, the accuracy for APP of the patella was 75.4%; however, the parameter that demonstrated the poorest performance was PA. This parameter had a relatively low accuracy, sensitivity and specificity (61.5%, 37.7% and 88.5%, respectively), suggesting that it was not optimal for the purposes of sex determination.

Differences in the accuracy of patellar measurements in sex determination between studies can be explained by population and geographical differences, measurement differences included in previous studies, and differences in the methodology adopted to perform the measurements.

Limitation of the study. A limitation of the study is the small sample size and higher average age of participants, compared to similar studies. However, it should be noted that the data obtained were collected exclusively from cases that had been referred to a single centre. Furthermore, given that the data in question pertains to radiological images, PV was measurable. It is important to acknowledge that the PV parameter requires further research to ascertain its applicability in dry bones.

CONCLUSIONS

Based on the data reported in the present study, it can be concluded that there was significant sexual dimorphism in all studied parameters and dimensions of the patella. The study indicates that the patella is valid as a bone for sex determination, and may be used as an alternative in forensic casework when additional sex dimorphic bones are unavailable. Further research is needed in other populations on the accuracy of sex estimation using patellar measurements, especially patellar volumetry.

REFERENCES

1. Krishan K, Chatterjee PM, Kanchan T, et al. A review of sex estimation techniques during examination of skeletal remains in forensic anthropology casework. Forensic Sci Int. 2016;261:165.e1–165.e8. doi:10.1016/j.forsciint.2016.02.007
2. Ogawa Y, Imaizumi K, Miyasaka S, Yoshino M. Discriminant functions for sex estimation of modern Japanese skulls. J Forensic Leg Med. 2013;20(4):234–238. doi:10.1016/j.jflm.2012.09.023
3. Chatterjee PM, Krishan K, Singh RK, Kanchan T. Sex estimation from the femur using discriminant function analysis in a Central Indian population. Med Sci Law. 2020;60(2):112–121. doi:10.1177/0025802419900576
4. Tallman SD, Blanton AI. Distal Humerus Morphological Variation and Sex Estimation in Modern Thai Individuals. J Forensic Sci. 2020;65(2):361–371. doi:10.1111/1556-4029.14218
5. Zhang K, Yang M, Cui JH, et al. Stature estimation from the combination of clavicle, scapula, and sternum from 3D-VRT images in Chinese population. Anthropol Anz Ber Uber Biol-Anthropol Lit. 2019;76(1):69–78. doi:10.1127/anthranz/2019/0887
6. Bedalov A, Bašić Ž, Marelja I, et al. Sex estimation of the sternum by automatic image processing of multi-slice computed tomography images in a Croatian population sample: a retrospective study. Croat Med J. 2019;60(3):237–245. doi:10.3325/cmj.2019.60.237
7. Peleg S, Pelleg Kallevag R, et al. New methods for sex estimation using sternum and rib morphology. Int J Legal Med. 2020;134(4):1519–1530. doi:10.1007/s00414-020-02266-4
8. Karaca AM, Senol E, Eraslan C. Evaluation of the usage of the cervical 7th vertebra in sex estimation with measurements on computerized tomography images. Leg Med Tokyo Jpn. 2023;62:102220. doi:10.1016/j.legalmed.2023.102220
9. Michiue T, Hishmat AM, Oritani S, et al. Virtual computed tomography morphometry of the patella for estimation of sex using postmortem Japanese adult data in forensic identification. Forensic Sci Int. 2018;285:206.e1–206.e6. doi:10.1016/j.forsciint.2017.11.029
10. Yasar Teke H, Ünlütürk Ö, Günaydin E, et al. Determining gender by taking measurements from magnetic resonance images of the patella. J Forensic Leg Med. 2018;58:87–92. doi:10.1016/j.jflm.2018.05.002
11. Zhan M jun, Li C lin, Fan F, et al. Estimation of sex based on patella measurements in a contemporary Chinese population using multidetector computed tomography: An automatic measurement method. Leg Med. 2020;47:101778. doi:10.1016/j.legalmed.2020.101778
12. Rahmani E, Mohammadi S, Babahajian A, et al. Anthropometric characteristics of patella for sex estimation using magnetic resonance images. Forensic Imaging. 2020;23:200412. doi:10.1016/j.fri.2020.200412
13. Indra L, Vach W, Desideri J, et al. Testing the validity of population-specific sex estimation equations: An evaluation based on talus and patella measurements. Sci Justice. 2021;61(5):555–563. doi:10.1016/j.scijus.2021.06.011
14. Srinak N, Sukvitchai P. Sex estimation from patella using discriminant analysis in Central Thai population. Can Soc Forensic Sci J. 2023;56(4):231–247. doi:10.1080/00085030.2023.2175956
15. Lo Re G, Salerno S, Terranova MC, et al. Virtopsy and Living Individuals Evaluation Using Computed Tomography in Forensic Diagnostic Imaging. Semin Ultrasound CT MR. 2019;40(1):67–78. doi:10.1053/j.sult.2018.10.013
16. Brough AL, Bennett J, Morgan B, et al. Anthropological measurement of the juvenile clavicle using multi-detector computed tomography--affirming reliability. J Forensic Sci. 2013;58(4):946–951. doi:10.1111/1556–4029.12126
17. Stull KE, Tise ML, Ali Z, Fowler DR. Accuracy and reliability of measurements obtained from computed tomography 3D volume rendered images. Forensic Sci Int. 2014;238:133–140. doi:10.1016/j.forsciint.2014.03.005
18. Wu GT, Audlin JR, Grewal JS, Tatum SA. Comparing Caliper versus Computed Tomography Measurements of Cranial Dimensions in Children. The Laryngoscope. 2021;131(4):773–775. doi:10.1002/lary.29086
19. Disaster Victim Identification (DVI). Accessed July 2, 2025. https://www.interpol.int/en/How-we-work/Forensics/Disaster-Victim-Identification-DVI
20. Tettamanti C, Frigiolini F, Franceschetti L, et al. A Forensic Approach to Complex Identification Cases: The Collapse of an Italian Cemetery into the Sea. Genes. 2025;16(3):277. doi:10.3390/genes16030277
21. Singla K, Singi Y, Sinha R, Dhattarwal K. Estimation of Sexual Dimorphism by Osteometric Analysis of Patella. J Punjab Acad Forensic Med Toxicol. 2021;21:58–67. doi:10.5958/0974–083X.2021.00010.8