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Original Research Article

AGE ESTIMATION FROM PUBIC SYMPHYSIS CHANGES: PHASE ANALYSIS

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ABSTRACT

Background: In forensic anthropology and medical law, age estimation is an essential component. The pubic symphysis is a good anatomical landmark for adults to use when trying to estimate their age because of the way it changes in appearance as people get older. The purpose of this study is to use standardised phase analysis methods to examine the pubic symphysis and its phase-wise morphological alterations in relation to chronological age in people ranging from 18 to 49 years old.

Materials and Methods: A cross-sectional observational study was performed on 50 human pelvic bones (25 from males and 25 from females) with known ages between 18 and 49 years. This study was conducted at Government Medical College, Siddipet between March 2023 and February 2025. The bones were acquired via medicolegal autopsies and preserved skeletal collections. Age estimation was conducted via the Todd and Suchey-Brooks phase analysis methodologies. The morphological features of the pubic symphysis were analysed, encompassing surface granularity, margin delineation, ventral rampart development, and alterations in the dorsal plateau. Each bone received a phase score, and the relationship between phase and chronological age was statistically examined by linear regression and the Pearson correlation coefficient.

Results: Phase I accounted for 8% of the samples, Phase II for 12%, Phase III for 18%, Phase IV for 26%, Phase V for 22%, and Phase VI for 14%. The phase of pubic symphysis was positively correlated with chronological age ($r = 0.86$). Each phase's mean predicted age was very congruent with the known age. Across several stages, the estimation error varied from ±2.5 to ±5.7 years. The phase transitions in males occurred at a significantly earlier time than in females. Phases IV and V, which included participants aged 30–39, had the best accuracy rates, whereas the ages of early adults exhibited the most variation.

Conclusion: A dependable way to estimate age in people between the ages of 18 and 49 is through phase analysis of the morphology of the pubic symphysis. Forensic cases involving partially decomposed or skeletonised remains can benefit from the method's excellent correlation with actual age. Nevertheless, for better accuracy, it is important to consider both inter-individual and sex-based variances.

Keywords: Age estimation, Pubic symphysis, Forensic anthropology, Phase analysis, skeletal remains, Todd method, Suchey-Brooks method.

INTRODUCTION

Forensic anthropology and medico-legal investigations rely on age assessment as a key component, since it helps identify unidentified human remains. For the benefit of law enforcement and the legal system, an accurate determination of the deceased's age helps in the identification procedure. In childhood and adolescence, skeletal and dental markers can be used to estimate age. However, as the growth centres have fused and external signs of age become less noticeable, it becomes more difficult to

do so in adults, particularly in the 18–49 age range.[1-3]

Throughout maturity, there are noticeable and systematic changes to the appearance of the pubic symphysis, a joint that connects the pubic bones of the pelvis. Surface texture, form, and structural features all undergo predictable changes as we get older. Because of these changes, the pubic symphysis is a good place to look for signs of age in adults' bones. There have been a number of attempts throughout history to classify the pubic symphysis morphology according to age-related phases. The organised approach and reproducibility of the Suchey-Brooks and Todd methods have made them widely used. Features such as the formation of ventral ramparts or dorsal platens, surface granularity, and the presence and disappearance of ridges and furrows are used by these phase-based analyses to classify the symphyseal surface into discrete stages.[4-6]

The pubic symphysis goes through major morphological changes between the ages of 18 and 49, a time when conventional age indicators like tooth eruption or epiphyseal union do not apply. Improving our knowledge of symphyseal phase shifts can, therefore, substantially aid estimation in this age group.[7] Nevertheless, there are still obstacles to overcome because of the wide range of individual differences caused by things like sex, race, lifestyle, and job stress, even though pubic symphysis analysis is helpful. Localised studies are also necessary for calibrating phase-age correlations adequately due to population-specific variances. Forensic findings could be impacted by incorrect age estimations caused by misunderstandings.[8,9]

An in-depth phase examination of the morphology of the pubic symphysis in individuals ranging in age from 18 to 49 years is the subject of this study. The purpose of this study is to determine whether there is a strong relationship between chronological age and phase-based morphological changes by analysing 50 samples with known ages and sexes. While taking sex differences into consideration and offering a reference for age estimation in the examined population into consideration, the objective is to confirm and maybe improve upon current phase analysis methods for better forensic application.[10-12]

MATERIALS AND METHODS

This cross-sectional observational study involved 50 human pelvic bones (25 from males and 25 from females) with a known chronological age ranging from 18 to 49 years. This study was conducted at Government Medical College, Siddipet between March 2023 and February 2025. The specimens were obtained from medicolegal autopsies and curated bone collections with authenticated demographic information. Ethical approval was secured from the institutional review board before the study commenced. Age estimation was conducted by classifying the alterations in the pubic symphysis into phases according to the recognised Todd and Suchey-Brooks classification systems. Each pubic symphysis was categorised into a phase from I to VI according to distinct morphological parameters.

Inclusion Criteria:

- Pelvic bones of individuals with confirmed age between 18 and 49 years.
- Specimens with well-preserved pubic symphyseal surfaces suitable for morphological examination.
- Both male and female specimens included to assess sex-based variations.
- Specimens sourced from medicolegal autopsies or skeletal collections with verified identification records.

Exclusion Criteria:

- Bones with pathological alterations affecting the pubic symphysis (e.g., arthritis, trauma, or congenital deformities).
- Specimens with significant postmortem damage or decomposition obscuring morphological features.
- Specimens from individuals with metabolic bone diseases or systemic conditions influencing bone morphology.
- Cases lacking accurate or verified chronological age data.

Statistical Analysis: A statistical analysis was conducted to ascertain the association between the designated phase and the actual chronological age. Linear regression analysis and Pearson's correlation coefficient were employed to evaluate the strength of the link. Sex-based differences were assessed utilising suitable statistical analyses.

RESULTS

Analysis was performed on 50 pelvic specimens, 25 of which were male and 25 of which were female, ranging in age from 18 to 49 years. Based on variations in the pubic symphysis morphology, the specimens were classified into six phases according to the Suchey-Brooks system. Here is a summary of the data: specimen distribution, phase connection with chronological age, sex-wise differences, and regression analysis results.

Table 1: Distribution of Samples across Pubic Symphysis Phases

Phase	Morphological Description	Number of Samples	Percentage (%)
I	Young adult: ridges and furrows clearly defined	4	8.0
II	Smoother surface, loss of furrows, early rim development	6	12.0
III	Ventral rampart formation, granular surface begins	9	18.0
IV	Rim well formed, dorsal plateau starts appearing	13	26.0
V	Rim erosion, dorsal plateau well developed	11	22.0
VI	Rim irregular, dorsal plateau eroded, porous surface	7	14.0

The majority of the participants seen in Phase IV were in the 30-39 age range. There were the fewest specimens in the youngest phase (I), which corresponds to ages close to 18 years.

Table 2: Mean Chronological Age in Each Pubic Symphysis Phase

Phase	Mean Age (years)	Standard Deviation (SD)	Age Range (years)
I	19.2	1.1	18 – 20
II	24.5	2.3	21 – 27
III	29.7	3.0	26 – 33
IV	34.8	3.5	31 – 39
V	41.2	2.9	38 – 44
VI	46.5	2.1	44 – 49

As the pubic symphysis phase progressed, the average age rose steadily. The fact that the oldest individuals within the study range were in Phase VI confirms that the morphological alterations were gradual.

Table 3: Correlation between Pubic Symphysis Phase and Chronological Age

Statistical Parameter	Value
Pearson Correlation Coefficient (r)	0.86
Coefficient of Determination (R^2)	0.74
p-value	<0.001

The relationship between chronological age and the pubic symphysis phase was found to be strongly positive (r = 0.86) and statistically significant (p < 0.001). Phase shifts accounted for almost 74% of the age variability.

Table 4: Sex-wise Distribution of Pubic Symphysis Phases

Phase	Males (n=25)	Females (n=25)
I	3 (12%)	1 (4%)
II	4 (16%)	2 (8%)
III	6 (24%)	3 (12%)
IV	5 (20%)	8 (32%)
V	4 (16%)	7 (28%)
VI	3 (12%)	4 (16%)

The pubic symphysis phases were often reached earlier by males than by females. Phases IV and V were more common in females, suggesting a little postponement of morphological development.

Table 5: Age Estimation Error across Phases

Phase	Mean Error (Years)	Standard Deviation (Years)
I	±2.5	1.1
II	±3.2	1.5
III	±4.1	2.0
IV	±2.7	1.3
V	±3.8	1.6
VI	±5.7	2.2

It appears that the dependability was highest for the early and mid-adult age groups, since the lowest age estimation errors were seen in phases I and IV. Possible as a result of inter-individual heterogeneity, error margins grew in subsequent stages.

DISCUSSION

Forensic anthropologists rely on pubic symphysis morphological changes as a primary indicator of age, particularly for adults when other skeletal markers are less accurate. Using well-established phase classification methods, this study set out to examine the pubic symphysis morphological changes in men and women from the ages of 18 to 49 and determine whether or not these changes correlate with chronological age. Stewart, 1979, and Işcan, 2013, reported the most participants grouped together in phases III–V, which correspond to the 26–44 age range, according to the study's sample distribution throughout phases. This shows that pubic symphyseal morphology is changing across this age range, which is in line with the normal demographic distribution of adults.[13,14]

Jantz, 2005 reported the adults in the examined age range can still rely on phase analysis as a trustworthy approach for estimating their age, as evidenced by the substantial positive correlation (r = 0.86) between pubic symphysis phase and actual age. This confirms the reliability of changes in the pubic symphysis as a marker of biological ageing, in line with earlier studies that found correlation coefficients usually between 0.70 and 0.90.[15] It is interesting to note that this study found gender disparities, with males showing slightly earlier transitions to advanced phases than females. Krogman, 1962 and White,

2005 reported the data points to the possibility that biology and, more specifically, lifestyle variables impact the pubic symphysis ageing rate. Similar patterns have been found in other investigations, which raises the possibility that hormones, jobs, or biomechanics impact the rate of bone remodelling. When using phase analysis for forensics, it is crucial to take sex-specific criteria into account, as these results show.[16,17]

Mukhopadhyay, 2014 and Sutikno, 2016 reported the acceptable precision for forensic contexts is indicated by the accuracy of age estimation, which is shown by the mean error ranging from ±2.5 to ±5.7 years. Phases I and IV, which occur in the early to mid-adult years, have the fewest errors, but phase VI, which occurs in the late years of life, may have more errors because of the increasing morphological heterogeneity that comes with ageing and because people's skeletal degeneration is different. Variability in bone remodelling can be accelerated or delayed by factors like physical activity, nutrition, and underlying health issues.[18,19]

Schmitt, 2005 and Kanchan, 2010 reported in there study has many positive aspects, it does have some drawbacks, such as a limited sample size and the possibility of unaccounted-for population-specific differences. Also, we can't see how people's pubic symphysis evolves over time because the study was cross-sectional.[20,21] Ubelaker, 2015 and Hanihara, 2007 reported the accuracy and define phase standards, future studies should use longitudinal data and larger, more diverse populations. Finally, the results of this study show that pubic symphysis phase analysis is a good way to estimate an adult's age in forensic situations involving people in their twenties and thirties. Improving the accuracy of this strategy still requires taking into account sex-specific adjustments and comprehending population disparities.[22,23]

CONCLUSION

Phase analysis of pubic symphysis morphology offers a practical and dependable way to estimate age in adults aged 18–49 years, according to the present study. The use of pubic symphyseal alterations in forensic investigations is supported by a good association between chronological age and these changes. Incorporating these changes can boost accuracy, even though there were sex-related disparities in phase progression. In medicolegal contexts, the approach proved to be a useful tool for age assessment due to its acceptable precision, especially in the early to mid-adult age ranges. The development and validation of phase-specific age norms necessitate additional study with bigger and more varied populations.

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