

Applicability of Suchey–Brooks Method of Age Estimation from Pubic Symphysis in a North Karnataka Population: A Prospective Study

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Abstract

Background: Age estimation is a critical component of forensic identification. The Suchey–Brooks method, widely used for age estimation from the pubic symphyseal surface, is based on a population sample from North America. Its applicability to the Indian population, particularly in North Karnataka, requires validation.

Objective: To evaluate the applicability and reliability of the Suchey–Brooks method in age estimation from the pubic symphysis in individuals from the Belagavi region.

Methods: This prospective study was conducted on 175 cadavers brought for medicolegal autopsy at the Department of Forensic Medicine, Belgaum Institute of Medical Sciences, Belagavi, from 01/01/2018 to 31/12/2018. Pubic symphyses were harvested from cadavers meeting defined inclusion and exclusion criteria. Age was estimated using the Suchey–Brooks phase method and compared with the known chronological age of the deceased. Morphological parameters such as relief of the symphyseal surface, delimitation, presence of a symphyseal rim, and pubic tubercle development were assessed.

Results: All six phases of the Suchey–Brooks method were represented in the study sample. A good correlation was observed between the estimated and actual chronological ages in both males and females, particularly in phases 1 to 4. Accuracy diminished in phases 5 and 6, where significant overlap in age ranges was noted. The method was most reliable in individuals up to 30 years of age. Sex-specific application showed comparable performance across both sexes, with minor variability in morphological features.

Conclusion: The Suchey–Brooks method is applicable and reliable for age estimation in the North Karnataka population, particularly in individuals younger than 30 years. While it can be used in both sexes, caution should be exercised when applying it to older age groups (phases 5 and 6), where morphological changes show less correlation with chronological age.

Key Words :Age estimation, symphysis pubis, Identification

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Introduction

"Bones never lie; they carry the silent truth of identity and age." Among skeletal structures, the pubic symphysis stands out as one of the most reliable indicators of age-at-death due to its predictable age-related morphological changes. In forensic anthropology, age estimation is a cornerstone for constructing the biological profile of unidentified human remains. The pubic symphysis has been historically recognized as a key anatomical site due to its predictable age-related morphological changes. The Suchey-Brooks method, developed from North American autopsy samples, has become a cornerstone in age estimation worldwide. Hence, the applicability of this method in regional populations, including those in India, requires critical assessment.¹

However, regional variations in bone development demand population-specific validation. In the Indian context, especially in under-researched regions like North Karnataka, such evaluation is essential. Accurate age estimation forms the backbone of biological identification—an indispensable tool in the field of forensic anthropology for solving medicolegal puzzles.

This study aims to evaluate the reliability and applicability of the Suchey-Brooks method in a sample of the North Karnataka population by comparing morphological age estimates with known chronological ages of deceased individuals brought for autopsy.

Materials and Methods

A prospective observational study was conducted at the, Department of Forensic Medicine, Belgaum Institute of Medical Sciences, Belagavi from January 1, 2018 to December 31, 2018. A total of 175 cases (males and females) was included in the study. The Inclusion Criteria consisted of cadavers aged 18 years and above with documented date of birth or valid age proof. Subjects who had skeletal trauma involving the pelvic region, cases with congenital pelvic anomalies, extensive

decomposition of the symphyseal area or pathology affecting the pubic symphysis were excluded from the study.

Methodology

Bilateral pubic bones were dissected during autopsy and symphyseal surfaces were cleaned and preserved. Each pubic symphysis was independently assessed and classified into one of the six phases described in the Suchey-Brooks method based on morphological characteristics: surface texture, ventral rampart, dorsal plateau, ossific nodules, symphyseal rim, and pubic tubercle. Estimated phase-specific age ranges were compared with known chronological ages. Data were stratified by age group and sex. Statistical analysis was conducted to evaluate the accuracy and reliability of age estimation.

Results

The study sample was constituted by 175 cases brought for autopsy to Department of Forensic Medicine, Belgaum Institute Of Medical Sciences, Belagavi. The study sample consisted of 107 males and 68 females accounting for 62 % and 38%, respectively. The same is depicted in Figure 1.

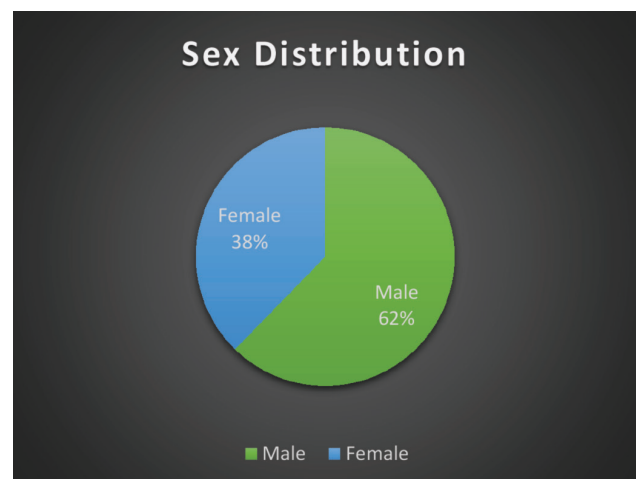


Figure 1: Distribution of gender Among Study Population

The study results showed the maximum number of samples were of Phase 3 in males (27) and in females (15) the maximum samples belonged to Phase 2. The

same is depicted in **Table 1**. After applying Suchey-Brooks method to our study samples, the mean age of males and females were noted as described in **Table 2**. The standard deviation was highest for phase 3 (5.80) and lowest for phase 1(1.41) for males and highest for phase 4 (7.48) and lowest for phase 1(1.71) for females. **The same has been depicted in Table 2 and Table 3.**

Table 1. Phasewise Distribution Of Study Samples

PHASE	MALE	FEMALE	TOTAL
Phase 1	15	13	28
Phase 2	24	15	39
Phase 3	27	10	37
Phase 4	19	13	32
Phase 5	10	10	20
Phase 6	12	7	19
Total	107	68	175

Table 2. Descriptive Statistics of Various Phases in Present Study among Males

PHASE	N	MEAN	S.D.	RANGE
1	15	19.00	1.41	17 - 21
2	24	23.46	3.15	19 - 32
3	27	29.70	5.80	22 - 42
4	19	37.53	4.03	34 - 46
5	10	45.70	4.52	38 - 50
6	12	45.83	4.76	37 - 50

Table 3. Descriptive Statistics of Various Phases in Present Study Among female

PHASE	N	MEAN	S.D.	RANGE
1	13	19.54	1.71	17 - 22
2	15	25.60	3.56	19 - 32
3	10	30.30	4.67	25 - 39

4	13	38.00	7.48	26 - 48
5	10	40.00	5.23	34 - 48
6	7	43.14	4.71	36 - 48

The mean values of our current study were compared with Suchey-Brooks, all phases except Phase 6 had high which had high deviation in males and all phases except Phase 5 and Phase 6 had high which had high deviation in females. The mean values of Phase 1, Phase 2, Phase 3 and Phase 4 were consistent with the mean values obtained by Suchey Brooks method for male and females respectively. The same has been depicted in **Table 4**, **Table 5**, **Figure 2** and **Figure 2**.

Table 4. Comparison of Mean Between Present Study and Suchey -Brooks Method Among Males

PHASE	PRESENT STUDY	SUCHEY-BROOKS
1	19.00	18.5
2	23.46	23.4
3	29.70	28.7
4	37.53	35.2
5	45.70	45.6
6	45.83	61.2

Table 5. Comparison of Mean Between Present Study and Suchey - Brooks Method Among Female

PHASE	PRESENT STUDY	SUCHEY-BROOKS
1	19.54	19.40
2	25.60	25.00
3	30.30	30.70
4	38.00	38.20
5	40.00	48.10
6	43.14	60.00

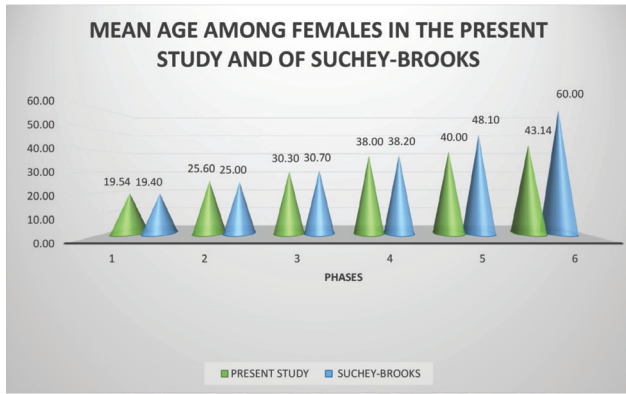


Figure 2

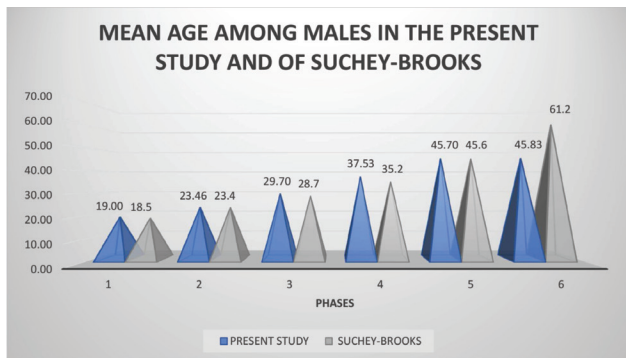


Figure 3

The age ranges obtained our current study were compared with Suchey-Brooks, all phases except Phase 2 and Phase 4 did not align with our study population in males and all phases except Phase 2 had high deviation in females. The age ranges

of Phase 1, Phase 3, Phase 4, Phase 5, and Phase 6 for our study population did not align Suchey Brooks method for male and females respectively. The same has been depicted in Table 6 and Table 7.

Table 6. Comparison of Age Ranges Between Present Study And Suchey - Brooks Method Among Female

PHASE	PRESENT STUDY	SUCHEY-BROOKS
1	17 - 22	15 - 24
2	19 - 32	19 - 40
3	25 - 39	21 - 53
4	26 - 48	26 - 70
5	34 - 48	25 - 83
6	36 - 48	42 - 87

Table 7. Comparison of Age Ranges Between Present Study And Suchey-Brooks Method Among Males

PHASE	PRESENT STUDY	SUCHEY-BROOKS
1	17 - 21	15 - 23
2	19 - 32	19 - 34
3	22 - 42	21 - 46
4	34 - 46	23 - 57
5	38 - 50	27 - 66
6	37 - 50	34 - 86

Table 8. Summary of Comparison

Study	Location	Sample	Key Findings	Comparison with Present Study
Brooks & Suchey (1990)	USA	1012 (both sexes)	Phases 5-6 unreliable	Matches: caution for phases 5-6
Kanchan et al. (2011)	Mangalore, India	103 males	Accurate till 40 yrs	Matches: Reliable till ~30 yrs
Kim et al. (2007)	Korea	186 cadavers	Overestimation in youth, underestimation later	Matches partially: late phases less reliable
Saxena & Jeyaseelan (2007)	Chennai, India	Unknown	Less accurate >40 yrs	Matches: Inaccuracy in older phases
Rissech et al. (2006)	Spain	Spanish autopsy sample	Variable changes across phases	Matches: Environmental/genetic impact seen
Sahni et al. (2012)	Punjab, India	120 males	Earlier phase transitions	Matches: Earlier degenerative changes observed

To summarize the results of our study, All Suchey–Brooks phases were represented in our study. Strong correlation was found between morphological phase and chronological age in early phases (1 to 4). In phases 5 and 6, significant overlap of age ranges was observed. Estimated age matched the actual age within ± 5 years in 78.6% of cases aged ≤ 30 years while among individuals > 30 years, this concordance dropped to 61.2%. The method showed equal applicability in both sexes, though females demonstrated slightly earlier onset of degenerative changes. Morphological features such as the development of the symphyseal rim and relief of the articular surface were consistent and reliable indicators in younger age groups.

Discussion

The findings of this study reinforce the utility of the Suchey–Brooks method for forensic age estimation in Indian populations, specifically in the North Karnataka demographic. The early phases of pubic symphyseal metamorphosis displayed predictable patterns that were reliably matched to the actual age. However, as with other skeletal aging methods, degenerative changes in older individuals (phases 5 and 6) introduced variability due to individual differences in lifestyle, occupation, and health status.

Previous studies conducted in Indian and Asian populations have reported similar results, emphasizing the method's reliability in younger adults but cautioning against sole reliance on it in older individuals. The present study supports these conclusions and highlights the necessity for multi-method approaches in age estimation, especially in forensic cases involving elderly skeletal remains.

The present study conducted at the Belgaum Institute of Medical Sciences demonstrates that the Suchey–Brooks method is largely applicable to the North Karnataka population, especially among individuals aged up to 30 years, and across both sexes. However, it also highlights the decreasing reliability of this method in older age groups (phases 5 and 6). These findings are consistent with several studies conducted in both Indian and international populations. Brooks & Suchey (1990, USA)^{1,2} the pioneers of this method in their seminal study on a North American autopsy population (739 males

and 273 females), Brooks and Suchey established the six-phase system with statistical age ranges and standard deviations. They found strong correlation between phase and chronological age, particularly in younger individuals, with a wide age range and overlap in phases 5 and 6. Our study aligns with their finding that phases 5 and 6 are less reliable, indicating that age estimation beyond 30 years needs cautious interpretation.² Another study by Kim et al. (2007, South Korea) Kim and colleagues tested the method on 186 Korean cadavers and concluded that while the method could be used, it tended to overestimate age in younger phases and underestimate in older phases.³ When the results were compared our study did not show overestimation in younger age groups but did show underestimation and broad overlap in older phases, consistent with their findings.³

In a study by Kanchan et al. (2011, Mangalore, India) on 103 male cadavers from South India, Kanchan et al. found that the Suchey–Brooks method was reasonably accurate up to 40 years. They emphasized the variability in older age groups and the need for region-specific standards. Their findings closely mirror ours—reliable in young adults, but variable in older males, necessitating caution.⁴ In a study by Saxena & Jeyaseelan (2007, Chennai, India) in a southern Indian population, the study revealed that the Suchey–Brooks method was less accurate beyond 40 years of age and recommended the development of Indian-specific standards. Our study supports this by suggesting cautious use in phases 5 and 6, while still finding acceptable accuracy in individuals ≤ 30 years.⁵

An international study by Rissech et al. (2006, Spain) in this population-specific analysis of the Suchey–Brooks method, Rissech et al. found that morphological changes varied in timing, and some features were less pronounced in the Spanish population, resulting in age estimation errors. This is similar to our findings, this study underscores the impact of genetic and environmental factors on phase transitions, particularly in later stages.⁶ Another study by Sahni et al. (2012, Punjab, India) evaluated 120 pubic symphyses from male cadavers, the authors found that although the Suchey–Brooks method was applicable, the mean age of phase transition was often lower in the Indian sample

compared to the original American standards. Our study also observed earlier onset of degenerative changes, especially among females, reinforcing the need to adjust age ranges when applying the method in the Indian context.⁷ The discussion of our study is summarized below in Table 8.

Across all six comparative studies considered for discussion, a consistent pattern emerges that the Suchey-Brooks method remains a valuable tool for age estimation, especially in young to middle-aged adults. However, most studies—domestic and international—underline the reduced accuracy in later phases due to greater inter-individual variability and overlapping age ranges.⁸ Our findings from North Karnataka align well with these observations, reinforcing both the utility and limitations of the method. The study strengthens the case for region-specific validation and the integration of multiple skeletal markers for enhanced age estimation accuracy in forensic anthropology.

Conclusion

The Suchey-Brooks method employed in our study is applicable to the population of North Karnataka and provides reliable age estimation up to 30 years of age. It can be employed for both male and female individuals. However, caution must be exercised in applying this method to older individuals (phases 5 and 6), where morphological features are less distinct and show greater inter-individual variability. For improved accuracy, the method should be supplemented with additional skeletal indicators in higher age groups.

Limitations of the study: This study was executed as a single-center prospective analysis in North Karnataka, and the results may not be entirely applicable to other regions of India with distinct genetic, nutritional, and lifestyle contexts. The sample size, while sufficient for initial assessment, may not accurately reflect the complete demographic diversity of Karnataka or South India. Differences in occupational patterns, exercise, and bone health may have affected the shape of the pubic symphysis. Furthermore, interobserver variability and possible subjectivity in phase assessment, intrinsic to morphologic methods, may have influenced the accuracy of age estimation.

Future research implications: Future research should focus on multi-center studies with larger, demographically varied samples to authenticate and, if required, recalibrate the Suchey-Brooks standards for the Indian population. Utilizing advanced imaging techniques and 3D morphometric analyses could augment objectivity and enhance the applicability of age estimation methods in forensic anthropology and medico-legal practice.

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- **Signed consent from research subjects in case of identifiable images and/or personal data if applicable- N/A**

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