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Original Article

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Determination of age, sex, and height using lower jaw measurements among Tiv ethnic group of Benue State

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Abstract

***Background & Aims*:** The identification of unknown human remains is a crucial aspect of forensic practice, especially in cases of putrefaction, skeletonization, or mutilation. Secondary methods such as anthropological profiling play a vital role in estimating sex, age, ancestry, and stature, contributing to the overall forensic investigation. This study aimed to investigate the use of lower jaw measurements for determining age, sex, and height among the Tiv ethnic group in Benue State.

***Materials & Methods*:** Four hundred participants (200 females and 200 males) aged 18–50 were included in the study. Biodata were collected using a questionnaire. Participants stood upright, facing forward, with the lower jaw exposed for measurements. Mandibular length was calculated as the sum of the tragus-to-angle and angle-to-symphysis distances, while mandibular width was measured as the distance between the mandibular angles. Symphysis height was determined by measuring the distance between the highest and lowest points of the chin. Height was recorded using a tape stadiometer, measuring from the vertex to the heel. Statistical analysis was performed using IBM SPSS version 23, employing descriptive statistics and Pearson correlation analysis, with significance set at $P < 0.05$.

***Results*:** The study revealed significant differences in various lower jaw measurements between males and females ($P \leq 0.01$), supporting their potential utility in sex determination. However, mandibular symphysis height was not reliable for sex determination within this group.

***Conclusion*:** This study highlights the importance of lower jaw measurements in forensic anthropology, particularly for sex determination within the Tiv ethnic group. The findings of this study have implications for forensic investigations in the Tiv ethnic group, where multiple parameters may be necessary for the accurate identification of unknown human remains.

***Keywords*:** Anthropology, Forensic, Human remains, Lower jaw, Mandible, Measurements

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Introduction

The determination of age, sex, and height (stature) is crucial for constructing a biological profile. The mandible is an accessible and durable bone that proves very useful in this regard (1). The mandible (lower jaw) is the hardest and strongest bone in the skull, making it reliable for forensic investigations in cases of putrefaction, skeletonization, and mutilation. The mandible is the largest bone in the human skull, forming the lower jawline and shaping the contour of the inferior third of the face (2). Its articulation with the skull base at the bilateral temporomandibular joints allows a range of movements facilitated by associated muscles, including dental occlusion with the maxilla. The use of lower jaw measurements for age, stature, and sex identification has a rich history dating back to the early 20th century. Pioneering anthropologists such as Franz Boas and Ales Hardwicke recognized the potential of mandibular morphology in determining biological characteristics (3,4).

This study was conducted among the Tiv ethnic group of Benue State, Nigeria. The Tiv people are of Bantu origin, with their ancestors migrating from their original homeland in Congo. During their migration, they passed through Swem, where they settled temporarily before eventually arriving at their current location in the Middle Belt region of Nigeria, specifically in Benue State (5). This research was conducted among the Tiv people due to the limited studies on mandibular measurements in African populations and the distinct cultural and environmental factors that may influence mandibular morphology. These factors include their preference for consuming coarse foods such as yams and grains and using teeth as tools for tasks like processing materials and fibers. This study investigates the potential of mandibular measurements for determining age, sex, and height among the Tiv ethnic group in Benue State, Nigeria.

Materials & Methods

Study Design

The subjects comprised both males and females of Tiv ethnicity. The sample size consisted of 400 subjects, divided into two groups: 200 males and 200 females, aged between 18 and 50 years, all of whom were normal subjects. These subjects were randomly selected through a simple random sampling method from the Tiv population in Benue State, Nigeria. This study employed a cross-sectional design, in which data were collected at a single point in time to assess mandibular morphology among the participants. The mandibular index was evaluated by measuring the length, width, and height of the lower jaw. All measurements were taken directly on the faces of the subjects by a single examiner to minimize inter-examiner errors.

Specific landmarks on the face were identified and marked using a ballpoint marker for accuracy. These landmarks included:

- **The tragus of the ear**, representing the mandibular condyle.
- **The soft tissue in the region of the angle of the mandible**, representing the angle of the mandible.
- **The soft tissue in the region of the chin**, representing the mandibular symphysis.

Mandibular Measurements

The following measurements were recorded:

- **Mandibular Length:** Calculated as the sum of two distances: from the tragus of the ear to the angle of the mandible and from the angle of the mandible to the mandibular symphysis.
- **Mandibular Width:** The distance between the two angles of the mandible.
- **Mandibular Symphysis Height:** The distance between the highest and lowest points of the chin.
- **Height of the Subject:** Measured in an upright standing position, from the vertex of the head to the heel.

Materials Used

Tape stadiometer, plastic flexible tapes, cellophane tape, hand gloves, lab coat, questionnaires, and consent forms.

Calibration of Measuring Instruments

To ensure accuracy and consistency in data collection, a flexible plastic measuring tape was used for

lower jaw measurements. Before measuring, the tape was checked for elasticity, wear, and possible distortions to prevent inaccuracies. Standardization was maintained by ensuring that all measurements were taken by the same researcher using a uniform technique. Additionally, repeated measurements were conducted on a sample subset to assess intra-observer reliability.

Informed Consent

Written informed consent was obtained from the participants by attaching the consent form to the questionnaire and giving it to the subjects for approval before the commencement of the research.

Data Collection Methods

The subjects were asked to stand in an upright position while facing forward and to remove any accessory covering the lower jaw. The flexible tape was used to measure the mandible, and the tape stadiometer was used to measure their height. The mandibular index was assessed by measuring the length, width, and height of the mandible. The measurements were taken directly on the face of the subjects by the same person to avoid inter-examiner errors as described by Akinbami (2016) (6).

Statistical Analysis

The Statistical Package for Social Sciences (IBM SPSS, Version 23, Armonk, New York, USA) was used for data analysis. Results were computed using descriptive statistics and Pearson correlation analysis (r or two-tailed correlation coefficient) to evaluate the strength and direction of the relationship between jaw measurements and the variables of interest—age, sex, and height. A high positive or negative correlation would indicate that lower jaw dimensions can serve as a reliable predictor of these characteristics.

The paired t-test was applied to compare numerical data, specifically:

- The measured vs. estimated age and height, assessing the accuracy of predictions derived from jaw measurements.
- Differences in jaw measurements between males and females, determining if the variations were statistically significant.

A *P-value* of less than 0.05 was considered statistically significant. These statistical methods provided a rigorous framework for assessing the predictive potential of mandibular dimensions in forensic and anthropological applications.

Results

The results presented are lower jaw measurements in relation to age, sex, and height among the Tiv people in Benue State.

Table 1. The mean and standard deviation (SD) and test of mean difference in the lower jaw measurements of males and females among the Tiv people

Variables	Male			Female			T-Test		
	Mean ± S.D	Min	Max	Mean ± SD	Min	Max	T-test value	*P-value*	Inf.
Tragus to mandibular angle (cm)	7.80 ± 0.83	5.50	10.00	7.12 ± 0.71	6.00	9.00	8.794	< 0.001	S
Mandibular angle to chin (cm)	10.94 ± 0.80	7.50	12.50	10.24 ± 0.61	8.50	12.00	9.976	< 0.001	S
Total length of mandible (cm)	18.75 ± 0.95	15.50	21.50	17.37 ± 0.78	14.50	19.30	15.947	< 0.001	S
Mandibular width (cm)	24.21 ± 0.75	22.00	26.00	23.16 ± 0.87	21.00	25.50	12.899	< 0.001	S
Mandibular	4.61 ± 0.51	3.50	6.00	4.63 ± 0.46	4.00	7.00	-0.370	0.711	NS

Variables	Male			Female			T-Test		
	Mean ± S.D	Min	Max	Mean ± SD	Min	Max	T-test value	*P-value*	Inf.
symphysis height (cm)									
Height/stature (cm)	161.47 ± 4.37	152.00	180.00	157.11 ± 5.43	140.50	171.00	8.828	< 0.001	S

Note: *S.D = Standard deviation, Inf = inference, NS = Not significant, S = Significant*

Table 1 presents the mean and standard deviation (SD) for various lower jaw measurements in males and females of the Tiv ethnic group, along with the results of the t-test to compare the means between males and females. The mean differences in tragus to mandibular angle, mandibular angle to chin, total length of mandible, mandibular width, and height were all significantly positive, with $p < 0.001$. interestingly, the mandibular symphysis height (cm) had a *P-value* of 0.711, which is not significant.

Table 2. Lower jaw measurement and test of relationship with Age (both genders combined)

Variables	Age		
	R	*P-value*	Inf.
Tragus to mandibular angle(cm)	-0.66	0.186	NS
Mandibular angle to chin (cm)	0.143	0.004	S
Total length of mandible (cm)	0.052	0.301	NS
Mandibular width(cm)	0.032	0.518	NS
Mandibular symphysis height(cm)	0.010	0.843	NS

Note: *R = Pearson's correlation value, Inf.= Inference, NS= Not significant, S=Significant*

Table 2. shows Pearson's correlation values (R), *P-values*, and inferences for various lower jaw measurements in relation to age, with both genders combined. The only statistically significant relationship observed between these measurements and age is for the mandibular angle to chin ($p < 0.05$). The other measurements do not show a significant correlation with age in the studied population.

Table 3. Examining the relationship between mandibular- chin and age using regression analysis

Variables	AGE prediction		
	R_E	R^2(%)	*P-value*
Mandibular angle- chin center	6.097 + (2.267 × Ma-Cc)	2.1%	0.004

Note: R^2 = coefficient of determination

R_E = regression equation

Ma-Cc = Mandibular angle to Chin center

Age = 6.097 + (2.267 × Ma-Cc)

Table 3 presents the results of regression analyses examining the relationship between mandibular angle to chin centre and age. The Coefficient of Determination (R^2) value is 2.1%. While there is a statistically significant relationship between Ma-Cc and age, the low R^2 suggests that Ma-Cc may not be a very robust predictor of age on its own.

Table 4 presents the results of the correlation analysis between lower jaw measurements and height for both genders combined among the Tiv ethnic group in Benue State.

Table 4. Lower jaw measurement and test of relationship with height (both genders combined)

Variables	Height		
	R	*P-value*	Inf.
Tragus to mandibular angle (cm)	0.162	0.001	S
Mandibular angle to chin (cm)	0.198	< 0.001	S
Total length of mandible (cm)	0.264	< 0.001	S
Mandibular width (cm)	0.285	< 0.001	S
Mandibular symphysis height (cm)	0.021	0.679	NS

Note: *R = Pearson's correlation value, Inf.= Inference, NS = Not significant, S = Significant*

It can be observed that there is a positive correlation/relationship between tragus-mandibular angle, mandibular angle-chin, total length of mandible, mandibular width, and height ($p < 0.001$). however, there is no positive correlation between mandibular symphysis height and height ($p = 0.679$).

Table 5. Examining the relationship between mandibular- chin and height using regression analysis

Variables	Height prediction (CM)		
	R_E	R^2 (%)	*P-value*
Tragus – mandibular angles	151.539 + (1.039 × Ta-Ma)	2.6%	0.001
Mandibular angle- chin center	145.019 + (1.348 × Ma-Cc)	3.9%	< 0.001
Total length of mandible	136.165 + (1.281 × TM)	7.0%	< 0.001
Mandibular width	121.762 + (1.585 × MW)	8.1%	< 0.001

Note: R^2 = coefficient of determination
R_E = regression equation
Ta-Ma = Tragus – Mandibular angles
Ma-Cc = Mandibular angle to Chin center
TM = Total length of mandible
MW = Mandibular width

Table 5 presents the results of a regression analysis examining the relationship between various lower jaw measurements and height.

The results of the current study suggest that each of the examined variables (tragus–mandibular angle, mandibular angle–chin center, total length of mandible,

and mandibular width) has a statistically significant relationship with height. However, the coefficients of determination (R^2) are relatively low (2.6%, 3.9%, 7.0%, and 8.1%), indicating that the models explain a small percentage of the variability in height.

Discussion

The determination of age, sex, and height is a critical component in forensic anthropological investigation (7). In forensic cases where skeletal remains are recovered, the preservation of individual elements is highly variable, thus not all bones are suitable for analysis. It is well known that the probability of a particular skeletal element surviving damaging taphonomic processes is strongly correlated with its structural density (g/cm^3) (8). As the mandible has a particularly dense layer of compact bone, it is frequently recovered largely intact, and is thus a more suitable element for forensic analysis (9).

Lower Jaw Measurements among Tiv Males and Females

In this study, tragus to mandibular angle, mandibular angle to chin center, total length of mandible and mandibular width measurements showed a significant difference between males and females. This significant difference suggests that these measurements can be employed for sex determination among the Tiv ethnic group, aligning with findings in the study of Pereira et al. (2020) which concluded that it is possible to estimate sex using mandibular measurements (10). This is different from the findings of Shimaa et al. (2020) which concluded that the mandibular ramus is less valuable in sex determination (1).

Combined Lower Jaw Measurements in Relationship to Age in both Genders

For tragus to mandibular angle (cm), the lack of statistical significance suggests that there is no substantial relationship between tragus to mandibular angle and age in this population, agreeing with the findings of Ulusoy and Ozkara (2022), which concluded that mandibular measurements cannot be used for age estimation in sub-adults (11).

In contrast, the mandibular angle to chin (cm) exhibits a statistically significant *P-value*. This finding suggests that the mandibular angle to chin may serve as a significant indicator for age determination within the Tiv ethnic group, correlating with the findings of Abu-Taleb and El Beshlawy (2015), which concluded that mandibular ramus length is beneficial in age determination among selected Egyptian populations (12).

The total length of mandible (cm), mandibular width (cm), and mandibular symphysis height (cm) show very weak positive correlations with age, but none of these correlations are statistically significant. Thus, there is no substantial evidence to support a significant relationship between these measurements and age in the studied population. This is different from the findings of Shimaa et al. (2020) which concluded that mandibular ramus length is valuable in age estimation (1).

The results highlight the complexity of associating lower jaw measurements with age in the Tiv ethnic group. While the mandibular angle to chin shows a statistically significant relationship, the limited explanatory power (low R^2) emphasizes the importance of considering multiple factors for accurate age prediction.

Lower Jaw Measurement and Test of Relationship with Height (Both Genders Combined)

The examination of the correlation between lower jaw measurements and height for both genders combined among the Tiv ethnic group in Benue State reveals intriguing insights. The positive correlation coefficients (R values) indicate a positive linear relationship between lower jaw measurements and height in this population.

In this study, tragus to mandibular angle, mandibular angle to chin, total length of mandible, and mandibular width exhibit statistically significant correlations with height. This implies that there is a meaningful relationship between these lower jaw measurements and height among the Tiv ethnic group. This is different from the findings of Pelin et al. (2010), which concluded that cephalofacial anthropometric variables were not good variables for predicting height (13).

Conversely, mandibular symphysis height does not show a statistically significant correlation with height. This is different from the findings of Shrestha et al. (2015), who found statistically significant correlation coefficients between all the anthropometric mandibular variables and height for their entire sample (14).

The regression equations reveal that tragus – mandibular angles, mandibular angle- chin center, total length of mandible, and mandibular width all contribute significantly to predicting height among the Tiv ethnic group. However, the R^2 values are relatively low.

It is crucial to consider the practical significance of these findings. While the relationships are statistically significant, the low R^2 values suggest that factors beyond these lower jaw measurements play a substantial role in determining height within the Tiv ethnic group agreeing with Jośe et al. (2019), which concluded that height may be estimated less accurately in cases where only cephalofacial dimensions are available for legal medical examination (4). The study emphasizes the complexity of height determination and the need for a comprehensive understanding of various influencing factors.

Conclusion

In conclusion, this study investigated the utility of lower jaw measurements for determining age, sex, and height among the Tiv ethnic group of Benue State. The findings revealed significant differences in various lower jaw measurements between males and females, supporting their potential use in sex determination. However, the study identified limitations in the reliability of mandibular symphysis height for sex determination within this population.

The relationship between lower jaw measurements and age displayed a gender-specific pattern, with significant correlations found in females but not in males. While tragus to mandibular angle and mandibular angle to chin showed statistically significant relationships with age in females, the low coefficient of determination emphasized the need for caution in relying solely on these measurements for accurate age predictions.

The investigation into the correlation between lower jaw measurements and height demonstrated varying degrees of association. While some measurements exhibited statistically significant correlations with height, the low R^2 values indicated limited explanatory power. The study emphasized the complex nature of height determination, suggesting the influence of factors beyond lower jaw measurements.

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None declared.

Ethical statement

Ethical approval was obtained from the University of Ilorin Ethical Review Committee, with the approval number UERC/ASN/2024/2761

Data availability

The raw data supporting the conclusions of this article are available from the authors upon reasonable request.

Conflict of interest

The authors have no conflict of interest in this study.

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Author contributions

None declared.

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