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POPULATION-SPECIFIC AURICULAR MORPHOMETRY: A REVIEW OF AGE- AND SEX-RELATED DIMORPHISM AND ITS APPLICATIONS IN FORENSIC ANTHROPOLOGY AND RECONSTRUCTIVE SURGERY

S.K. Aremu[1,2]

1. Department of Otorhinolaryngology, Afe-Babalola University, Ado-Ekiti, Ekiti State, Nigeria
2. Department of Otorhinolaryngology, Federal Teaching Hospital, Ido-Ekiti, Ekiti State, Nigeria

Correspondence:
Prof. S.K. Aremu
Department of Ear Nose and Throat,
College of Medicine and Health Sciences,
Afe-Babalola University,
Ado-Ekiti, Ekiti State,
Nigeria
Email: aremusk@abuad.edu.ng

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ABSTRACT

Background: **The human auricle is structurally complex and morphologically distinctive, with dimensions that vary systematically by age, sex, and ethnicity. This variation is important for forensic identification, reconstructive surgery, and aural device design. Despite substantial global literature on auricular anthropometry, population-specific data for sub-Saharan African populations—particularly Nigerians—remain limited, making uncritical application of foreign standards clinically inappropriate.**

Objective: **To critically synthesise existing evidence on auricular anthropometry, focusing on age- and sex-related variation in pinna dimensions, ethnic differences, and forensic/clinical applications, with emphasis on the Nigerian context.**

Methods: **A narrative systematic review drew on peer-reviewed studies from PubMed, Google Scholar, and Springer, spanning foundational and recent publications through 2025. Parameters reviewed included total ear length, total ear width, total lobular length, and total lobular width, measured via contact and non-contact methods.**

Results: **Evidence consistently shows three findings: auricular dimensions are significantly larger in males than females across ethnic groups; primary auricular parameters increase progressively with age throughout life; and significant inter-ethnic differences exist, precluding reliable extrapolation of normative data between populations. Nigerian studies confirm these trends while revealing intra-national variation across Hausa, Igbo, Yoruba, and Urhobo groups. Machine learning approaches to sex estimation from pinna measurements have achieved accuracies exceeding 82%, enhancing forensic utility. Three-dimensional imaging and photogrammetry are increasingly replacing caliper-based measurement for accuracy and reproducibility.**

Conclusion: **Population-specific normative datasets are essential for forensic profiling, auricular reconstruction, and device design. The Nigerian evidence base, though growing, remains incomplete, warranting larger, ethnically stratified studies using standardised digital protocols.**

INTRODUCTION

The human auricle, commonly referred to as the pinna, occupies a distinctive and often underappreciated position in the broader landscape of human anatomical study. It is, in essence, the most visible component of the external ear — a complex structure comprising the helix-antihelical complex, the conchal complex, and the lobule — and its significance extends well beyond its sensory function of directing sound into the external acoustic meatus.[1,2] From an anthropometric standpoint, the auricle has attracted growing interest over the past four decades, owing to its demonstrable variability in shape, size, and orientation across individuals, sexes, age groups, and ethnic populations.[3] These features render it a potentially powerful instrument in forensic identification, clinical reconstructive surgery, and the ergonomic design of aural devices such as hearing aids and earphones.[4]

Anthropometry, broadly defined as the systematic measurement of the physical dimensions of the human body, has long been employed in medicine, physical anthropology, and forensic science to characterise and compare human populations.[5] When applied specifically to the external ear, it generates a body of normative data that serves several critical functions. For plastic and reconstructive surgeons, such data

provide the benchmarks necessary to guide auricular reconstruction in patients with congenital malformations such as microtia, or those who have suffered traumatic auricular loss.[6] For forensic specialists, the unique configuration of the ear — described by some scholars as being as distinctive as a fingerprint — offers a reliable biometric identifier, particularly useful in situations where fingerprint evidence is unavailable.[7,8] For manufacturers of aural devices, population-specific anthropometric data are indispensable in ensuring that products are ergonomically appropriate for their target users.[8]

Despite the growing body of literature on auricular anthropometry in diverse global populations — including Koreans,[10] Chinese,[10] Indians,[11] Italians,[10] Britons,[12] Germans,[13] and Sudanese Arabs[13] — there remains a notable paucity of population-specific data for sub-Saharan African populations, and particularly for Nigerians.[13] This gap is not merely academic. Given that auricular dimensions vary significantly across ethnic groups, the uncritical application of foreign anthropometric standards to Nigerian patients undergoing reconstructive procedures risks producing outcomes that are anatomically inappropriate and aesthetically unsatisfactory.[14] The present literature review therefore undertakes a critical synthesis of the existing evidence on auricular anthropometry with particular reference to age- and sex-related variation, its forensic and clinical applications, and the specific context of Nigerian and West African populations.

Anatomy and embryological development of the auricle

A thorough understanding of auricular anthropometry presupposes familiarity with the anatomy and developmental origins of the external ear. The pinna is composed of a framework of elastic cartilage, covered on both surfaces by tightly adherent skin, with the exception of the lobule, which consists of fibro-adipose connective tissue and contains no cartilage.[3] This structural distinction between the lobule and the rest of the auricle is clinically significant: the cartilaginous portions of the ear are more dimensionally stable over time, whereas the lobule — being composed of soft connective tissue — is more susceptible to gravitational elongation with advancing age and to the mechanical effects of ear piercing.[15]

Embryologically, the auricle begins to form between the fourth and sixth weeks of gestation. During this period, neural crest cells derived from the first and second pharyngeal arches interact with the overlying surface ectoderm, giving rise to six auricular hillocks — three from each arch — that gradually coalesce and migrate to form the definitive pinna.[3] The cartilaginous framework and connective tissue of the pinna are themselves of neural crest origin, while the auricular muscles are derived from cephalic mesoderm. The complex multi-source embryogenesis of the auricle explains, at least in part, why it is prone to a wide variety of congenital anomalies, ranging from minor morphological variants to severe malformations such as anotia and microtia.[16] It also explains why external ear anomalies are often associated with abnormalities in other structures that share embryological origins with the first and second pharyngeal arches, including the kidneys — a coincidence in embryogenesis that has been exploited diagnostically.[46]

At birth, the auricle is proportionally smaller relative to the overall head, but it grows rapidly during infancy and early childhood, reaching what some authorities describe as its mature height at approximately twelve years of age in females and thirteen years in males.[18] Thereafter, the ear continues to grow, albeit at a much slower and more variable rate — a phenomenon that is now well-established in the literature and is thought to reflect continued elongation of the soft tissue components, particularly the lobule, under the influence of gravity and the progressive loss of dermal elasticity with age.[18]

Anthropometric parameters and methods of measurement

The anthropometric study of the external ear involves the measurement of a defined set of linear dimensions using either contact or non-contact methods. As illustrated in Figures 1 to 3, the principal parameters routinely assessed in the literature include: total ear length (TLE), measured from the most superior point of the helix to the lowest point of the lobule (Figure 1); total ear width (TWE), measured as the horizontal distance between the most anterior and most posterior points of the ear (Figure 1); total lobular length (TLL), taken from the midpoint of the intertragic notch to the inferior tip of the lobule (Figure 2); and total lobular width (TLW), measured as the transverse diameter of the lobule at its widest point (Figure 3).[5,20] From these primary measurements, secondary indices — including the auricular index (ear width divided by ear length, multiplied by 100) and the lobular index — may be derived to allow standardised comparison across populations.[21]

Historically, contact methods employing sliding Vernier calipers and rulers have been the standard approach, offering simplicity, reproducibility, and low cost.[6] However, the past decade has witnessed increasing adoption of non-contact digital methods, including photogrammetry, three-dimensional computed tomography, magnetic resonance imaging, and digital

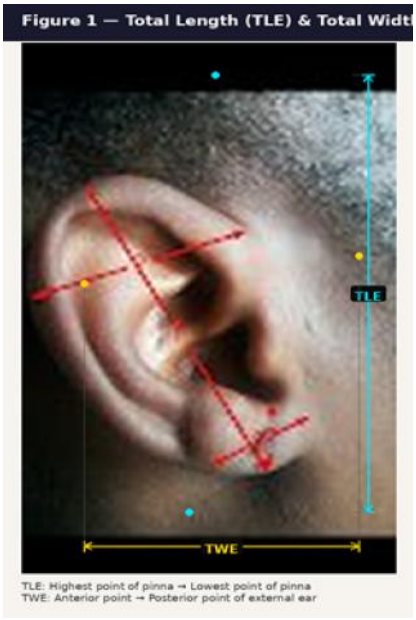


Figure 1: Total Length of Ear (TLE) and Total Width of Ear (TWE).
TLE is measured from the highest point of the pinna (superaurale) to the lowest point (subaurale). TWE is the horizontal distance between the most anterior (preaurale) and most posterior (postaurale) points of the external ear. Double-headed arrows indicate direction of measurement. Colour coding: cyan = TLE; gold = TWE.(Source:Aremu SK. Auricular anthropometry in South Western Nigeria populace: age and sex disparity, a tool for identification and auricular reconstruction among Nigerian Blacks. Int J Biomed Sci. 2019;15(3):91-97. doi:10.59566/IJBS.2019.15091)

photography with image analysis software such as ImageJ and Adobe Photoshop.[22] The index study under review employed an indirect photographic method, capturing standardised lateral and posterior images of the auricle using a high-resolution Sony Cyber-shot camera and analysing them with ImageJ software (v1.48) — an approach that minimises measurement error arising from pressure deformation of soft tissue and allows repeated measurements from archived images.

More recent investigations have explored even more advanced measurement technologies. Sowmya et al., writing in 2023, employed three-dimensional imaging for the morphometric assessment of the ear, highlighting the capacity of such technology to capture the complex three-dimensional topology of auricular structures in ways that flat photography cannot.[48] Similarly, a 2022 Thai population study made use of Vernier callipers to capture highly precise linear measurements across 524 subjects, underscoring the continued utility of contact methods in clinical settings where digital imaging infrastructure may be limited.[24] The choice of measurement method has implications for how data from different studies can be compared, and future research in resource-limited settings such as Nigeria would benefit from standardisation of photographic protocols to facilitate international comparison.

Age-related variation in auricular dimensions

One of the most consistently reported findings across auricular anthropometric studies is that ear dimensions increase with advancing age. This trend has been documented in populations as diverse as Italians, Japanese, Germans, and North Americans, and appears to hold regardless of sex or ethnic background — although the rate of growth and the specific parameters most affected may vary considerably across these groups.[13,14,19,20] The pattern of age-related auricular growth is not uniform: the ear reaches its mature height relatively early in adolescence, but continues to grow in length and width — particularly the lobule — well into old age.[18]

Niemitz *et al.,* in a large cross-sectional study of a German population, demonstrated that human ears grow throughout the entire lifetime according to complicated and sexually dimorphic patterns.[19] This finding was corroborated by Asai *et al.'s* often-cited Japanese study, which found a positive correlation between ear length and age across the lifespan.[26] In the Italian context, Sforza *et al.* documented age- and sex-related changes in auricular dimensions across a broad age range, finding that all primary parameters increased with age, with the most pronounced changes occurring in the lobule.[27] Ferrario *et al.,* also working with an Italian cohort, similarly reported progressive increases in auricular height and width from adolescence through to mid-adulthood, a trajectory broadly consistent with findings in other populations.[13]

In the South-West Nigerian population examined in the index study, all four measured parameters — TLE, TWE, TLL, and TLW — demonstrated a consistent increase in mean values from Group A (ages 10–20) through to Group D (ages 41–50) for both right and left ears. The mean TLE for the right ear in Group A was 49.20 ± 1.48 mm, rising to 54.75 ± 2.42 mm in Group D. Standard deviations remained relatively low across most groups, suggesting reasonable intra-group homogeneity, with the exception of the right TLE in Group D. These findings are broadly consistent with those reported by Barut and Aktunc in a Turkish paediatric population,[28] by Farkas *et al.* in a landmark growth study of the ear,[29] and more recently by Rani *et al.,* who in 2021 examined ear anthropometry in a North Indian population and found all measured parameters to increase significantly with age.[30]

Farkas *et al.* previously reported bilateral asymmetry between left and right ears in children, noting that this asymmetry tended to diminish in adulthood.[29] By contrast, Alexander *et al.* and Sforza *et al.* found good bilateral symmetry in adult populations.[1,27] The findings of the index study are in agreement with the latter: bilateral measurements in the South-West Nigerian cohort were closely matched, with the pattern of age-related change essentially identical on both sides of the ear. This bilaterally symmetric growth trajectory in adults has important implications for reconstructive surgery, where the contralateral ear is typically used as a template.



Figure 2: Total Lobular Length (TLL).
TLL is the vertical distance from the midpoint of the base of the intertragic notch to the lowest point (tip) of the lobule. The pink double-headed arrow indicates the measurement span. Key anatomical landmarks — the intertragic notch and lobule tip — are marked with filled circles and labelled..(Source:Aremu SK. Auricular anthropometry in South Western Nigeria populace: age and sex disparity, a tool for identification and auricular reconstruction among Nigerian Blacks. Int J Biomed Sci. 2019;15(3):91-97. doi:10.59566/IJBS.2019.15091)

Sex-related variation and sexual dimorphism

Sexual dimorphism in auricular dimensions is another finding that has been replicated with remarkable consistency across the global literature. In the vast majority of populations studied, males are found to have larger ears than females — greater in total length, total width, and lobular dimensions — a difference that appears to be present from childhood and persists across the lifespan.[6,13,14] The biological basis of this dimorphism is generally attributed to the differential secretion of growth hormones in males and females during adolescence, which drives differential somatic growth across multiple body systems.

In a study of North Indian adults, Purkait and Singh documented significantly larger auricular dimensions in males compared to females across all measured parameters.[6] Bozkir et al. similarly reported higher mean values for total ear length and width in male Turkish adults.[31] Eboh's study of Urhobo people in Southern Nigeria found statistically significant sexual dimorphism in pinna length and width, with males consistently exceeding females.[32] Ekanem et al.'s study of adult Nigerians resident in Maiduguri, North-Eastern Nigeria, likewise reported that all measured auricular parameters were significantly larger in males than in females.[33] These findings from Nigerian sub-populations are particularly salient, contextualising the results of the index study within the broader Nigerian anthropometric literature.

The index study of the South-West Nigerian population confirmed statistically significant sexual dimorphism in total ear length for both right ($P = 0.001$) and left ($P < 0.001$) ears, with males recording higher mean values than females — a finding consistent with the preponderance of the global evidence. Total lobular length was also significantly greater in males. The results for total ear width (TWE) and total lobular width (TLW) were, however, more nuanced: females demonstrated a significantly higher TWE for the right ear ($P = 0.001$), while males had significantly greater left TWE ($P < 0.05$). For TLW, males had significantly higher values on the right, while females had significantly higher values on the left ($P = 0.013$). These asymmetries in sex-related dimorphism across laterality and specific parameters underscore the importance of analysing bilateral data separately rather than pooling them.

Fakorede *et al.,* in a 2021 cross-ethnic Nigerian study comparing Hausa, Igbo, and Yoruba populations, reported that whilst sexual dimorphism was present across all three groups, the degree of dimorphism was not uniform, and sex classification accuracy using ear morphometrics was only moderate.[34] This conclusion resonates with findings from Murgod *et al.'s* Indian study, which achieved sex estimation accuracy of 69.3% in males and 72% in females using ear dimensions,[21] and from Rani *et al.'s* discriminant function analysis, which achieved an overall accuracy of 82.1%.[30] More recently, machine learning approaches to sex estimation from pinna anthropometry have shown considerably greater promise: a 2025 study reported that the K-Nearest Neighbour algorithm achieved an accuracy of 0.825 and a ROC value of 0.882 in sex prediction from pinna measurements,[50] suggesting that computational techniques may substantially enhance the forensic utility of auricular biometrics.

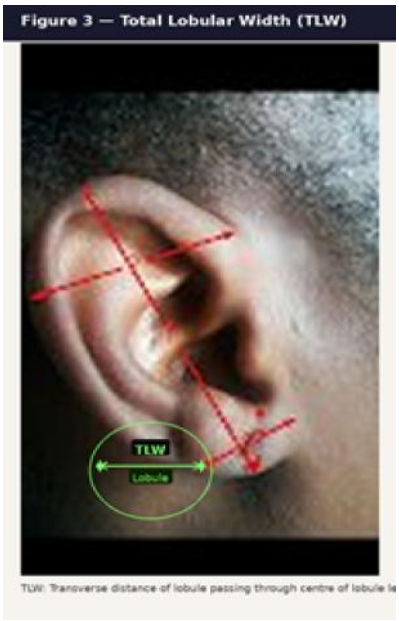


Figure 3: Total lobular width (TLW).
TLW is the transverse (horizontal) distance across the lobule, measured at the midpoint of the lobule length. The green double-headed arrow indicates the measurement axis. An oval outline demarcates the lobule region. This parameter shows significant sexual dimorphism with notable bilateral asymmetry in some populations..(Source:Aremu SK. Auricular anthropometry in South Western Nigeria populace: age and sex disparity, a tool for identification and auricular reconstruction among Nigerian Blacks. Int J Biomed Sci. 2019;15(3):91-97. doi:10.59566/IJBS.2019.15091)

Ethnic and population-specific variations

Beyond age and sex, ethnic and population background constitutes a third major axis of variation in auricular anthropometry. This is a point of considerable practical importance, particularly in the context of designing prosthetics and aural devices for diverse populations. The pioneering work of Abeysekera and Shahnavaz in 1989 illustrated this vividly: earpieces designed for American males were found to be a satisfactory fit for only 95% of Germans, 75% of French, 60% of Italians, 45% of Japanese, and a mere 10% of Thai individuals.[35] This cross-national incompatibility of auricular devices — a consequence of population-specific differences in ear morphology — makes the case for population-specific anthropometric databases impossible to dismiss.

Comparative studies have consistently demonstrated significant inter-ethnic differences in auricular dimensions. Europeans tend to have larger ear dimensions than East Asians.[9] Within Asia, Wang *et al.'s* computed tomography-based study of Han Chinese populations in Northern China found distinct differences from Japanese and Indian norms.[9] Purkait's longitudinal Indian study found that Indian men had smaller auricles than Caucasians or Japanese, particularly in terms of length relative to width.[10] Within Africa, sub-regional differences have also been reported: Ekanem *et al.'s* North-Eastern Nigerian data differed appreciably from those reported by Eboh for Southern Nigeria, suggesting meaningful intra-national variation that militates against the application of even Nigeria-wide normative data across all sub-populations.[32,33]

The multi-ethnic Nigerian study by Fakorede *et al.* represented a significant advance in documenting within-Nigeria variation, comparing ear morphology across the three major ethnic groups — Hausa, Igbo, and Yoruba — and confirming that meaningful morphological differences exist between them.[34] Analogous findings have emerged from elsewhere in sub-Saharan Africa: a study of the Kalabari people of Rivers State, Nigeria, reported ear dimensions that were distinct from those documented in Northern Nigerian populations, emphasising the need for ethnicity-specific rather than merely nation-specific normative data.[47] A 2022 study of the Sundanese ethnic group in Indonesia further reinforces the global consensus that anthropometric data from one ethnic population cannot be reliably extrapolated to another, even within the same country.[36]

In 2022, Khobkhun[23] did a study on the Thai population, in which ear height, width, lobular height, and lobular width were measured in 524 subjects, providing additional evidence for population specificity: Thai ear dimensions differed from both Western and other Asian norms, and the authors explicitly recommended that their findings be used as a reference for auricular reconstruction procedures in Thai patients.[23] This recommendation parallels the argument advanced in the index South-West Nigerian study — namely, that Nigerian plastic surgeons and forensic practitioners should base their work on locally derived normative data rather than on imported standards that may systematically misrepresent the populations they serve.

Forensic applications of auricular anthropometry

The forensic applications of auricular anthropometry are multifaceted and have attracted substantial scholarly interest. The ear's uniqueness as a biometric identifier — comparable to the fingerprint in terms of individual specificity — has long been recognised in the forensic literature.[7] Ear prints left at crime scenes, particularly on glass or door surfaces where a perpetrator has pressed an ear to listen for activity, can potentially be matched to suspects.[37] The characteristic morphological features of the auricle — the precise contour of the helix, the presence or absence of Darwin's tubercle,

the shape and attachment of the lobule, the degree of concha depth — create a configuration that is virtually unique to each individual and remains relatively stable through adulthood.[21]

Krishan *et al.,* in a 2019 study that has been widely cited in the subsequent forensic literature, established that morphological variations of the human ear can be used reliably for personal identification, providing a systematic framework for documenting and comparing auricular morphological features.[49] Ahmed and Omer's study of a Sudanese population demonstrated that sex could be estimated from anthropometric ear measurements with a degree of accuracy that was forensically useful, thereby extending the application of auricular anthropometry from identification to biological profiling.[2] More recently, Rani *et al.'s* 2021 discriminant function study achieved an overall sex classification accuracy of 82.1% using ear measurements alone, a figure that compares favourably with other biometric approaches used in forensic contexts.[30]

The forensic utility of ear morphometry is not, however, without its limitations. Fakorede *et al.'s* 2021 Nigerian study found that sex estimation accuracy using ear parameters was only moderate when applied to multi-ethnic samples, highlighting the risk of misclassification when population-specific thresholds are not used.[34] Furthermore, factors such as age-related changes in lobular dimensions, the mechanical effects of ear jewellery on lobule morphology, and the potentially confounding influence of auricular piercings on earprint analysis all introduce variability that must be accounted for in forensic applications.[15,36] The emerging field of computational auricular biometrics — using machine learning algorithms applied to digital images — offers a promising avenue for enhancing accuracy and reducing reliance on subjective morphological assessment.[50]

The forensic significance of auricular anthropometric databases extends beyond individual identification. Robust population-specific normative data allow forensic pathologists and anthropologists to make probabilistic assessments about the likely age, sex, and ethnic origin of unidentified remains — contributing to what forensic anthropologists term the biological profile. In the Nigerian context, where forensic investigation infrastructure has historically been limited, the contribution of studies such as those by Ekanem, Eboh, and Fakorede to building this evidence base is particularly valuable.[32,33,34]

Clinical and surgical applications

The clinical applications of auricular anthropometry are diverse and span several medical specialities. In plastic and reconstructive surgery, normative data on auricular dimensions are essential for planning procedures intended to restore the ear's form following congenital malformation, trauma, or tumour excision. Auricular reconstruction — particularly total reconstruction for microtia — is among the most technically demanding procedures in plastic surgery, and its success depends critically on the surgeon's knowledge of the dimensions and proportions of the normal ear in the specific population being treated.[24,42] Microtia, a congenital malformation characterised by incomplete development of the auricle, occurs with a prevalence of approximately one to two per ten thousand births and varies across ethnic populations.[42] Auricular reconstruction typically employs autogenous costal cartilage — carved to replicate the complex three-dimensional form of the normal auricle — and requires accurate knowledge of the target dimensions.[43] In bilateral cases, where no contralateral ear is available as a template, population-specific anthropometric norms become the sole available guide.[24] A 2022 study published in the Journal of Craniofacial Surgery specifically addressed this problem, providing baseline anthropometric data for ear reconstruction — including total ear height, ear width, and auricular projection — in a cohort of 524 subjects, framing these data explicitly as reference standards for surgical planning.[24]

Anthropometric data also inform the diagnosis of congenital conditions associated with auricular anomalies. Down syndrome is associated with characteristic changes in auricular morphology, including reduced ear length and altered proportions of auricular components — changes that have been documented and quantified by Sforza et al. using three-dimensional morphometric techniques.[39] Similarly, aneuploidy conditions have been associated with measurable reductions in ear length detectable in the second trimester, a finding that has been proposed as a potential screening marker.[40] The diagnosis of congenital ear abnormalities as an indicator of possible urinary tract malformations — the so-called auriculo-renal association — further illustrates the diagnostic significance of auricular morphology.[46]

In otolaryngology and audiology, anthropometric ear data are important for the design and fitting of hearing aids, earphones, and other aural devices. As demonstrated by the earpiece compatibility findings of Abeysekera and Shahnavaz,[35] devices designed without reference to population-specific

morphometric data will inevitably be ill-fitting for significant proportions of the target population, with consequences for both comfort and performance. The emergence of high-fidelity personalised hearing aids and custom-moulded earphones has intensified the demand for detailed, population-specific auricular datasets — a demand that studies of the type reviewed here are well placed to meet.

Methodological considerations and limitations

Critical evaluation of the auricular anthropometric literature requires attention to a number of methodological considerations that affect the comparability and generalisability of findings. First, the choice of measurement method — contact versus non-contact, direct versus indirect — has implications for both accuracy and reproducibility. Contact methods using Vernier calipers are widely used and accessible but are susceptible to soft tissue deformation and inter-rater variability. Indirect photographic methods avoid tissue deformation but introduce their own sources of error, including parallax distortion and variation in camera positioning.[22] Three-dimensional imaging methods such as CT and structured light scanning offer the highest dimensional accuracy but are more costly and technically demanding.[23]

Second, sampling considerations significantly affect the representativeness of normative datasets. The index study enrolled 200 subjects — 100 males and 100 females — from the South-West Nigerian population, covering an age range of 10 to 50 years and distributed across four decade-spanning age groups. While this sample size is comparable to many studies in the literature, it is insufficient to capture the full demographic and sub-ethnic diversity of South-West Nigeria, which encompasses multiple distinct ethnic groups. Future studies would benefit from larger, more deliberately stratified samples.

Third, the exclusion criteria applied in auricular anthropometric studies have a substantial impact on the resulting normative values. The index study appropriately excluded individuals with congenital ear disease, craniofacial injury, infectious ear conditions, and prior ear surgery — exclusions that are standard in the field and necessary to ensure that the data reflect normal auricular anatomy. The additional requirement of informed verbal consent — or parental consent for participants under 16 — was in keeping with ethical best practice. The adoption of the Frankfurt horizontal plane as the standardised head position for photography ensured consistency of image capture and is commendable.

CONCLUSION

Auricular anthropometry has important applications in forensic identification, reconstructive surgery, clinical diagnosis, and the design of aural devices. Existing evidence consistently shows that ear dimensions vary by sex, age, and ethnicity, making population-specific reference values essential. For Nigeria, locally derived normative data provide a more reliable basis for clinical and forensic practice than foreign standards. Although studies from different Nigerian populations have established an important foundation, comprehensive, ethnically stratified national reference data are still needed to support accurate assessment and improve patient care.[32,33,34]

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Conflict of interest

The author declares no conflict of interest.

Data availability

All data supporting the conclusions of this review are derived from published studies cited in the reference list. No novel primary data were collected. The predefined protocol document and standardised data extraction proforma are available from the corresponding author on reasonable request.

Author contributions

SKA conceptualised and designed the study, conducted the literature search, performed data analysis and interpretation, and drafted the manuscript. SKA critically revised the manuscript for important intellectual content and approved the final version for submission. SKA agrees to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Disclosure of artificial intelligence-assisted technologies

During the preparation of this manuscript, AI-assisted language tools were used solely to assist with language refinement and clarity of expression. All content was critically reviewed, verified, and approved by the author, who accepts full responsibility for the accuracy, integrity, and originality of the published work.

REFERENCES

1. **Alexander KS,** Stott DJ, Sivakumar B, Kang N. A morphometric study of the human ear. J Plast Reconstr Aesthet Surg. 2011;64(1):41–47.

2. **Ahmed AA,** Omer N. Estimation of sex from the anthropometric ear measurements of a Sudanese population. Leg Med (Tokyo). 2015;17 (5):313–319.
3. **Van De Water TR,** Staecker H. Otolaryngology: Basic Science and Clinical Review. New York: Thieme; 2005.
4. **Deopa D,** Thakkar HK, Prakash C, *et al.* Anthropometric measurements of external ear of medical students in Uttarakhand region. J Anat Soc India. 2013;62(1):79–83.
5. **Coward TJ,** Scott BJ, Watson RM, Richards R. Laser scanning of the ear identifying the shape and position in subjects with normal facial symmetry. Int J Oral Maxillofac Surg. 2000;29(1): 18–23.
6. **Purkait R,** Singh P. Anthropometry of the normal human auricle: a study of adult Indian men. Aesthetic Plast Surg. 2007;31(4):372–379.
7. **Tatlisumak E,** Yavuz MS, Kutlu N, *et al.* Asymmetry, handedness and auricle morphometry. Int J Morphol. 2015;33(4):1542–1548.
8. **Jung HS.** Surveying the dimensions and characteristics of Korean ears for the ergonomic design of ear-related products. Int J Ind Ergon. 2003;31(6):361–373.
9. **Wang B,** Dong Y, Zhao Y, *et al.* Computed tomography measurement of the auricle in Han population of north China. J Plast Reconstr Aesthet Surg. 2011;64(1):34–40.
10. **Purkait R.** Progression of growth in the external ear from birth to maturity: a 2-year follow-up study in India. Aesthetic Plast Surg. 2013;37(3):605–616.
11. **Sharma A,** Sidhu NK, Sharma MK, *et al.* Morphometric study of ear lobule in northwest Indian male subjects. Anat Sci Int. 2007;82(2):98–104.
12. **Gualdi-Russo E.** Longitudinal study of anthropometric changes with ageing in an urban Italian population. Homo. 1998;49(3):241–259.
13. **Ferrario VF,** Sforza C, Ciusa V, *et al.* Morphometry of the normal human ear: a cross-sectional study from adolescence to mid-adulthood. J Craniofac Genet Dev Biol. 1999;19(4):226–233.
14. **Brucker MJ,** Patel J, Sullivan PK. A morphometric study of the external ear: age- and sex-related differences. Plast Reconstr Surg. 2003;112(2):647–652.
15. **Azaria R,** Adler N, Silfen R, *et al.* Morphometry of the adult human earlobe: a study of 547 subjects and clinical application. Plast Reconstr Surg. 2003;111(7):2398–2402.
16. **Nathan N,** Latham K, Cooper J, *et al.* Anthropometry of the external ear in children with cleft lip and palate compared with age-matched controls. J Craniofac Surg. 2008;19(5):1391–1395.
17. **Ito I,** Imada M, Ikeda M, *et al.* A morphological study of age changes in adult human auricular cartilage with special emphasis on elastic fibres. Laryngoscope. 2001;111(5):881–886.
18. **Niemitz C,** Nibbrig M, Zacher V. Human ears grow throughout the entire lifetime according to complicated and sexually dimorphic patterns: conclusions from a cross-sectional analysis. Anthropol Anz. 2007;65(4):391–413.
19. **Shireen S,** Karadkhelkar VP. Anthropometric measurements of human external ear. J Evol Med Dent Sci. 2015;4(59):10333–10338.
20. **Agnihotri G,** Singh D. Craniofacial anthropometry in newborns and infants. Iran J Pediatr. 2007;17(4):332–338.
21. **Murgod V,** Angadi P, Hallikerimath S, Kale A. Anthropometric study of the external ear and its applicability in sex identification in an Indian population. Aust J Forensic Sci. 2013;45(4):431–444.
22. **Farkas LG.** Anthropometry of the normal and defective ear. Clin Plast Surg. 1990;17(2):213–221.
23. **Khobkhun P,** Pungrasmi P, Suwajo P, et al. An anthropometric study of the external ear in the Thai population. J Plast Reconstr Aesthet Surg. 2022;75:1417–1423.
24. **Bahþi Ý,** Orhan M, Kervancýoðlu P, *et al.* External ear anthropometry of healthy Turkish young adults. J Craniofac Surg. 2023;34(8):e799–e803.
25. **Cho E,** Won JY, Park MH, *et al.* Anthropometry of the external ear in Korean adults: a multicenter study. J Korean Med Sci. 2025;40:e107.
26. **Asai Y,** Yoshimura M, Nago N, Yamada T. Why do old men have big ears? BMJ. 1996;312 (7030): 582.
27. **Sforza C,** Grandi G, Binelli M, *et al.* Age- and sex-related changes in the normal human ear. Forensic Sci Int. 2009;187(1–3):110.e1–110.e7.
28. **Barut C,** Aktunc E. Anthropometric measurements of the external ear in Turkish primary school students. Aesthetic Plast Surg. 2006;30(2):255–259.
29. **Farkas LG,** Posnick JC, Hreczko TM. Anthropometric growth study of the ear. Cleft Palate Craniofac J. 1992;29(4):324–329.
30. **Rani D,** Krishan K, Sahani R, *et al.* Variability in human external ear anthropometry: anthropological and forensic applications. Clin Ter. 2021;172(6):531–541.
31. **Bozkir MG,** Karakas P, Yavuz M, Dere F. Morphometry of the external ear in our adult population. Aesthetic Plast Surg. 2006;30(1):81–85.

32. **Eboh DEO.** Morphological changes of the human pinna in relation to age and gender of Urhobo people in Southern Nigeria. J Exp Clin Anat. 2013;12(2):68–74.
33. **Ekanem AU,** Garba SH, Musa TS, Dare ND. Anthropometric study of the pinna among adult Nigerians resident in Maiduguri metropolis. J Med Sci. 2010;10(6):176–180.
34. **Fakorede ST,** Adekoya KO, Fasakin TP, *et al.* Ear morphology and morphometry as potential forensic tools for identification among Hausa, Igbo and Yoruba populations of Nigeria. Bull Natl Res Cent. 2021;45:1–9.
35. **Abeysekera JD,** Shahnavaz H. Body size variability between people in developed and developing countries and its impact on the use of imported goods. Int J Ind Ergon. 1989;4:139–149.
36. **Boesoirie SF,** Handayani R, Gatera VA, *et al.* Determination of the difference between men and women anthropometry auricles using photo-grammetric method in Sundanese ethnic group. Clin Cosmet Investig Dermatol. 2022;15: 2133–2141.
37. **Verma P,** Sandhu HK, Verma KG, *et al.* Morphological variations and biometrics of ear: an aid to personal identification. J Clin Diagn Res. 2016;10(5):ZC138–ZC142.
38. **McKinney P,** Giese S, Placik O. Management of the ear in rhytidectomy. Plast Reconstr Surg. 1993;92(5):858–866.
39. **Sforza C,** Dellavia C, Tartaglia GM, Ferrario VF. Morphometry of the ear in Down syndrome subjects: a three-dimensional computerized assessment. Int J Oral Maxillofac Surg. 2005;34 (5):480–486.
40. **Lettieri L,** Rodis JF, Vintzileos AM, *et al.* Ear length in second-trimester aneuploid fetuses. Obstet Gynecol. 1993;81(1):57–60.
41. **Farkas LG.** Anthropometry of the Head and Face. 2nd ed. New York: Raven Press; 1994.
42. **Adamson PA,** Litner JA. Otoplasty technique. Facial Plast Surg Clin North Am. 2006;14(2):79–87.
43. **Brent B.** Auricular repair with autogenous rib cartilage grafts: two decades of experience with 600 cases. Plast Reconstr Surg. 1992;90(3):355–374.
44. **Nagata S.** Modification of the stages in total reconstruction of the auricle: part I. Grafting the three-dimensional costal cartilage framework for lobule-type microtia. Plast Reconstr Surg. 1994;93(2):221–230.
45. **Nagata S.** Modification of the stages in total reconstruction of the auricle: part II. Grafting the three-dimensional costal cartilage framework for congenital microtia. Plast Reconstr Surg. 1994;93(2):231–242.
46. **Kohelet D,** Arbel E. A prospective search for urinary tract abnormalities in infants with isolated preauricular tags. Pediatrics. 2000;105(5):e61.
47. **Oladipo GS,** Amasiatu VC, Naterebo D. Sex estimation using auricular dimensions among the Kalabari ethnic group in Nigeria. J Int Res Med Pharm Sci. 2017;11(2):66–71.
48. **Sowmya MV,** Mehrotra D, Mohammad S, *et al.* 3D assessment of ear morphology. J Oral Biol Craniofac Res. 2023;13(5):622–629.
49. **Krishan K,** Kanchan T, Thakur S. A study of morphological variations of the human ear for its applications in personal identification. Egypt J Forensic Sci. 2019;9:6.
50. **Söylemez E,** Tokgöz Yýlmaz S. Pinna anthropometry in sex estimation: a machine learning-based approach. Northwestern Med J. 2025;5(2):77–84.