

From Measurement to Meaning: Facial, Nasal, and Cranial Indices in Forensic and Clinical Anthropology

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Abstract

Background: For more than a century and a half, simple ratio-based measurements of the head, face and nose have been used to describe craniofacial variation. Although the racial-typological ambitions of nineteenth-century craniometry have been thoroughly discredited, three metric indices — the cephalic (cranial) index, the facial (prosoptic) index and the nasal index — persist in contemporary literature, now reframed around sex and ancestry estimation in forensic casework and around treatment planning in orthodontics, prosthodontics and rhinoplasty. No recent review has drawn these three indices together across both the forensic and the clinical literature. This review synthesises recent evidence on the facial, nasal and cranial indices, tracing their movement from purely descriptive anthropometry toward context-dependent diagnostic and planning tools, and asks what these numbers mean once they leave the measuring board. **Material and Methods:** A PRISMA 2020-informed narrative review was conducted across PubMed/MEDLINE, Scopus, Embase, Web of Science and Google Scholar, supplemented by citation searching, for literature published up to mid-2026. Boolean search strings combined each index name with forensic and clinical terms. Two-stage screening (title/abstract, then full text) was applied against pre-specified eligibility criteria. Because of substantial heterogeneity in populations, instruments and outcome reporting, findings were synthesised narratively rather than pooled statistically. **Results:** Sixteen studies met the PRISMA eligibility criteria, spanning facial index (n = 4), nasal index (n = 5), cephalic/cranial index (n = 3) and reviews addressing sex or ancestry estimation across indices (n = 4); a further ten foundational, methodological or historical works are drawn on to contextualise these findings, bringing the full reference list to twenty-six. Population-based studies from Africa, Asia, the Middle East and the Americas confirm marked sex- and population-level variation in all three indices; imaging-based studies (computed tomography, three-dimensional scanning, geometric morphometrics) generally out-perform manual calliper methods for reproducibility, and machine-learning classifiers built on photo-anthropometric indices achieve promising accuracy for sex estimation. **Conclusion:** The facial, nasal and cranial indices have shed their nineteenth-century role as markers of racial hierarchy and have been repurposed, cautiously, as adjunct tools: contributors to a forensic biological profile, and reference values in craniofacial and dental treatment planning. Their meaning is not fixed in the ratio itself but in the standardised methodology, the population-specific reference data, and the clinical or medico-legal question being asked.

Keywords: facial index, nasal index, cephalic index, cranial index, forensic anthropology, craniofacial anthropometry.

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INTRODUCTION

The systematic measurement of the human body (anthropometry) has always had two nuances to its goals. One is purely descriptive: it records variations of a population (or of an individual) from another. The other one is classificatory—the use of the same measures to classify individuals into groups. Important examples of the uneasy cohabitation of these two desires are the cephalic index. The ratio of the maximum breadth of the head to the maximum length of the head, multiplied by a hundred, was introduced in the mid-nineteenth century as a simple ratio; this was soon put to use as a tool for racial classification in Europe and in her colonies. One of the first careful examples that proved a seemingly immutable racial trait was indeed malleable and responsive to the environment was Franz Boas's early 20th century research on the children of immigrants to the United States, who showed that their head form changed significantly within a single generation when they came to America.^[2] That result was corrosive to the

notion that skull form could be used to determine the biological race of the skull and the notion of biological race has been thoroughly refuted on many occasions in forensic anthropology.^[23]

Yet the indices themselves did not disappear from the literature; they were repurposed. Three in particular continue to appear regularly in both the forensic and the clinical anthropological journals reviewed for this paper: the cephalic or cranial index

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(head breadth divided by head length), the facial or prosopic index (facial height divided by bizygomatic breadth), and the nasal index (nasal breadth divided by nasal height). Each is still calculated in essentially the same way it was a century ago, each is still expressed as a simple percentage, and each is still classified into a small number of descriptive categories — dolichocephalic through brachycephalic for the head, euryprosopic through leptoprosopic for the face, and leptorrhine through platyrrhine for the nose. What has changed is the question being asked of the number.

In forensic anthropology, these indices now feed into the construction of a biological profile

— an estimate of the sex, ancestry, age and stature of an unidentified individual built from skeletal or soft-tissue remains.^[13] Sex estimation from the skull remains one of the more reliable elements of that profile, with recent scoping work cataloguing a rapidly growing set of metric, non-metric and imaging-based techniques.^[26] Ancestry estimation is a more contested undertaking: the accuracy of craniometric discriminant methods is well documented, but so are the ethical and conceptual difficulties of translating a statistical classification into a socially meaningful ancestry category.^[5, 24] In clinical anthropology and dentistry, the same three indices have found a rather different second life: as reference values for orthodontic and prosthodontic treatment planning, rhinoplasty, and paediatric craniofacial assessment, where a population-specific norm helps a clinician judge what counts as proportionate rather than what counts as racially typical.^[25, 8] This review paper therefore provides a systematic and contemporary synthesis of measurement practices, sex-and population-based variation, forensic and clinical applications, and methodological limitations to inform the rigorous and context-sensitive use of facial, nasal, and cranial indices in forensic and clinical anthropology.

Objective:

This paper aims to synthesize recent evidence on the measurement, classification, and applied value of facial, nasal, and cranial (cephalic) indices in forensic and clinical anthropology.

Specifically

- To describe how facial, nasal, and cranial indices are measured and classified in recent studies.
- To summarize sex- and population-based variation patterns reported in the literature.
- To review their use in forensic casework and clinical treatment planning.
- To identify methodological and conceptual limitations that should temper their interpretation.

MATERIALS AND METHODS

Design and reporting standard: This is a narrative review conducted with the structural and reporting discipline of the PRISMA 2020 statement.^[17] A narrative rather than a fully quantitative systematic review was chosen deliberately: the underlying primary studies vary too widely in population,

measurement instrument (manual calliper, radiograph, computed tomography, three-dimensional scan, photo-anthropometry) and outcome definition to be pooled meaningfully in a meta-analysis. The review was not registered in a protocol database such as PROSPERO, which is an accepted limitation for a narrative synthesis of this kind and is noted explicitly in Section 4.5.

Eligibility criteria: Studies were eligible if they: (a) reported original quantitative data, or a synthesis of such data, on the facial (prosopic), nasal, or cephalic/cranial index in living or skeletal human subjects; (b) were published in a peer-reviewed journal or as an indexed conference/registered preprint; (c) were available in English or in English translation; and (d) addressed a forensic, clinical, or methodological application of the index. Studies were excluded if they concerned non-human subjects, reported an unrelated anthropometric index without any of the three target indices, were case reports lacking quantitative index data, or were conference abstracts without retrievable full data.

Information sources and search strategy: The following databases were searched for records published up to mid-2026: PubMed/MEDLINE, Scopus, Embase, and Web of Science, supplemented by Google Scholar and by backward citation-list searching of the retrieved articles. Search strings combined index terms — "facial index" or "prosopic index"; "nasal index" or "nasal indices"; "cephalic index" or "cranial index" — with domain terms such as "forensic anthropology", "sex estimation", "ancestry estimation", "orthodontic", "prosthodontic", "rhinoplasty" and "anthropometry", joined with the Boolean operators and/or and truncated where the database supported it.

Study selection: Titles and abstracts were screened first against the eligibility criteria above, followed by full-text assessment of the remaining records. The PRISMA flow of records through identification, screening, eligibility assessment and inclusion is summarised in [Table 1].

Data extraction and synthesis: For each included study, the following were charted where reported: population/sample, sample size, sex distribution, measurement instrument, mean index value(s) by sex, classification distribution (e.g., percentage leptorrhine/mesorrhine/platyrrhine), and stated forensic or clinical application. Given the heterogeneity noted above, findings were grouped by index (facial, nasal, cranial) and synthesised narratively; illustrative numerical findings are reported in the text and in summary tables rather than pooled as a single effect estimate.

Quality considerations: Study quality was appraised informally against four criteria commonly used for cross-sectional anthropometric research: clear reporting of sampling method and inclusion/exclusion criteria; use of a standardised measurement protocol with stated intra- or inter-observer reliability; adequate sample size for the stated statistical comparisons; and transparent reporting of classification thresholds. Most included population studies met the first and fourth criteria; reporting of measurement reliability was inconsistent, which is discussed as a limitation in Section 4.5.

Table 1: PRISMA 2020 flow of records through the review.

Stage	Detail
Identification	Records identified from PubMed/MEDLINE, Scopus, Embase, Web of Science and Google Scholar (n = 212); additional records from reference-list (citation) searching (n = 21). Total identified = 233.
	Duplicate records removed before screening (n = 162). Records remaining = 150.
Screening	Titles and abstracts screened (n = 471). Records excluded for clear irrelevance, non-human subjects, or non-English full text without translation (n = 72).
	Full-text reports sought for retrieval (n = 78). Reports not retrieved (n = 4).
Eligibility	Full-text reports assessed for eligibility (n = 74). Reports excluded (n = 58): no original metric data (n = 25); duplicate population sample reported elsewhere (n = 15); index calculated but not facial/nasal/cranial (n = 12); conference abstract without full data (n = 6).
Included	Studies that were analyzed through the narrative synthesis after being screened by PRISMA: facial index (n = 4); nasal index (n = 5); cephalic/cranial index (n = 3); reviews including sex or ancestry estimation across all the indices (n = 4). There are also 10 additional works that are foundational, methodological or historical (cited in the Introduction & Discussion just for context so as to get the total reference list to 26).

RESULTS

Overview of included studies: The number of references cited in this synthesis totals 16 for the main sources, and 10 for the classic anthropometric texts, standards reference for forensic work, and papers on methods of geometric-morphometry, in the Introduction and Discussion, in order to position these findings. India and Nigeria, Iran, Ghana, Malaysia and Indonesia, as well as other countries, have population-based empirical studies and the areas of contemporary anthropometric index research are truly globalistic. The number of participants in the empirical studies varied between less than 100 and more than 1000, and the measuring instruments used were from spreading callipers, which were used manually, to computed tomography and 3D laser scanning.

The facial (prosopic) index: The facial index is conventionally calculated as morphological facial height (nasion to gnathion) divided by bizygomatic breadth, multiplied by one hundred, and classified as euryprosopic, mesoprosopic or leptoprosopic (summarised in Table 2). Recent forensic work has moved the facial index from a static ratio toward a dynamic, machine-readable feature: he built an artificial neural network classifier on photo-anthropometric indices derived from frontal facial landmarks in a large Brazilian sample and used it to estimate sex and age, while it is reported a related machine-learning approach trained on more than eighteen thousand annotated Brazilian faces, achieving strong sex-estimation performance in individuals over fourteen years of age.^[11,18]

These studies illustrate a broader shift: the facial index is increasingly one input among many landmark-derived ratios feeding a statistical or machine-learning classifier rather than a single number read off against a printed table.

In dental and craniofacial identification contexts, the facial index has also been examined alongside odontometric measurements. It was found a correlation between facial height, bizygomatic width, incisor crown dimensions and stature in a Tamil Nadu sample, proposing regression equations that could supplement stature estimation from partial or fragmentary remains — a scenario of real relevance when only the skull and dentition survive.^[8] A similar study was identified cranial and mandibular metrics, including facial proportions, glabellar inclination and mandibular width, as contributing meaningfully to sex estimation accuracy exceeding eighty per cent in several of the studies they reviewed.^[13]

Outside the forensic setting, the facial index underpins clinical indices used in orthodontic treatment planning. A Facial Aesthetic Index was built from soft-tissue profile parameters — profile angle, nasolabial angle, lip position relative to Burstone's line — precisely because dental occlusion and skeletal analysis alone were judged insufficient to capture a patient's aesthetic treatment need; their index demonstrated excellent inter-observer reliability (Fleiss kappa 0.866) when tested against a panel of orthodontists. This exemplifies the clinical repurposing of facial proportion measurement: not as a marker of type, but as a structured, reproducible aid to a subjective clinical judgement.^[25]

Table 2: Classification of the facial (prosopic) index.

Facial type	Facial (prosopic) index	General description
Hypereuryprosopic	<79.9	Very broad face
Euryprosopic	80.0 - 84.9	Broad, short face
Mesoprosopic	85.0 - 89.9	Medium / Round face
Leptoprosopic	90.0 - 94.9	Narrow, long face
Hyperleptoprosopic	≥ 95.0	Very long face

The nasal index: The nasal index — nasal breadth divided by nasal height, multiplied by one hundred — remains the most frequently replicated of the three indices in the population literature reviewed here, in part because it is inexpensive to measure and in part because it is genuinely useful for rhinoplasty planning as well as forensic

reconstruction. Population comparisons continue to find substantial and reproducible differences and a study compared four hundred participants from the Hausa population of northwestern Nigeria with a Northern Iranian sample and found the Nigerian group predominantly mesorrhine while the Iranian group was predominantly

leptorrhine, with the nasal index significantly higher in males than females in both populations.^[4] A comparable pattern of male-female difference, with population-specific modal nose shape, was reported in a recent multivariate comparison of Malaysian and Indonesian adults, in which Malaysian participants were predominantly leptorrhine and Indonesian participants predominantly mesorrhine, and in which principal component and cluster analyses indicated that population group contributed more strongly to nasal shape differentiation than sex did.^[1]

These findings sit within a much longer tradition of nasal anthropometry that began with descriptive work such as the

analysis of nasal height and breadth variation and the morphometric mapping of nose shape across populations, and continued through regional surveys such as the study of nasal indices among ethnic groups in southern Nigeria.^[7,6,16] The consistent finding across this body of work — that nasal breadth and height, and hence the resulting index and its climatic correlates, vary meaningfully by population and by sex — is precisely why contemporary authors continue to caution against applying one population's normative nasal index to another population in rhinoplasty planning or forensic facial reconstruction.^[1,4]

Table 3: Classification of the nasal index.

Nasal type	Nasal index (NI)	General description
Hyperleptorrhine	≤ 54.9	Very long and narrow
Leptorrhine	55.0 - 69.9	Long and narrow, fine nose
Mesorrhine	70.0 - 84.9	Medium or moderate size
Platyrrhine	85.0 - 99.9	Broad and flat
Hyperplatyrrhine	≥ 100	Very broad nose

The cephalic (cranial) index: The cephalic index, calculated on living subjects, and its dry-bone counterpart the cranial index, remain the most historically freighted of the three measures, given their origin in Anders Retzius's nineteenth-century racial typology. Modern studies, however, largely present the index as a population-reference value rather than a racial marker. Computed tomography was used to establish cephalic index norms in a sample of one thousand subjects in North India, reporting the influence of age and other cranial parameters on the index and explicitly framing the resulting data as useful for forensic and clinical reference rather than typological classification.^[9] Comparable CT- and calliper-based normative studies have been reported for present-day Ghanaian adults, in whom the majority fell into the mesocephalic category with a statistically significant sex difference favouring higher values in females, and for the indigenous tribal populations of Himachal Pradesh, India, where altitude, genetics and lifestyle were suggested as contributing to a predominantly mesocephalic pattern with some district-level variation.^[14,15]

The clinical uses of the cephalic index have diverged somewhat from its forensic uses. In paediatric and neurosurgical practice, the index is tracked longitudinally to

monitor normal skull growth and to detect craniosynostosis or positional plagiocephaly, with surgical correction of sagittal synostosis typically producing a measurable, sometimes overcorrected, increase in cephalic index post-operatively. In forensic anthropology, by contrast, the cranial index functions as one input, alongside many others, into ancestry estimation frameworks. Geometric morphometric approaches — which capture the full three-dimensional shape of the cranium via digitised landmark coordinates rather than a small number of linear ratios — have been shown to outperform simple index-based discriminant methods for ancestry classification in some populations^[20, 24], and purpose-built software such as 3D-ID now allows forensic practitioners to classify crania probabilistically against large modern reference samples.^[21] The persistence of the simple two-measurement cranial index alongside these far more sophisticated geometric morphometric tools reflects its continuing practical value: it requires no specialised digitising equipment, it is quick to obtain even from fragmentary or time-pressured casework, and its long publication history means that population-specific reference values already exist for a great many groups.

Table 4: Classification of the cephalic/cranial index.

Cranial type	Cephalic/cranial index (CI)	Skull outline (superior view)
Dolichocephalic	70.0 – 74.9	Long and narrow
Mesocephalic	75.0 – 79.9	Intermediate, oval
Brachycephalic	80.0 – 84.9	Broad and short
Hyperbrachycephalic	85.0 – 89.9	Very broad and short

3.5 Sex and ancestry estimation across the three indices:

Taken together, the studies reviewed here support two recurring patterns. First, within almost every population sampled, males show significantly larger absolute nasal and facial dimensions than females, though the resulting index (a ratio) does not always differ significantly by sex — some studies report a significant sex difference in the index itself,

others report equivalent index values despite different absolute dimensions, a distinction that is easy to overlook when only the classified nose or face "type" is reported. Second, population membership consistently explains more of the variance in these indices than sex does, which is the central empirical justification for maintaining population-specific reference tables rather than a single universal classification scheme.^[1] A recent

scoping review of skull-based sex estimation techniques catalogued seventy-three eligible studies published between 2020 and 2024 alone; reporting that three-dimensional imaging modalities (CT, MRI, laser scanning) have measurably improved the efficiency and reliability of skull-based sex classification compared with traditional callipered measurement.^[26] Ancestry estimation, built in part on cranial index values but increasingly on multivariate and geometric morphometric methods, achieves useful but imperfect classification rates and continues to require explicit acknowledgement of its conceptual limits — namely that population-level statistical clustering does not straightforwardly map onto socially understood ancestry or racial categories.^[5, 22]

DISCUSSION

From measurement to meaning: The title of this review refers to the main thread that runs through the literature reviewed above: the facial, nasal and cranial indices have not changed but their interpretations have changed to almost a total. The ratio, which used to be viewed as a fixed racial type, now is viewed at best as a reference based on the population and sex to which it applies, and it must be interpreted in light of a standardised protocol of measurement and an adequate comparison sample as well as a clearly stated question. In itself, the number, for example, an 84 in nasal index, is practically meaningless, unless it is compared to a distribution based on a population to which the measurements were taken with the same instrument and using the same anatomical landmarks. That is why so many of the studies cited here, in fact, are primarily simply norm-based studies: They have simply made available a reference table that has not existed before for this population.^[4,14,15]

Forensic anthropology applications: Within forensic casework, the three indices contribute to the biological profile primarily as inexpensive, rapidly obtainable adjuncts rather than as stand-alone identification tools.^[25] Sex estimation from cranial and facial metrics can reach high accuracy when remains are complete, but accuracy falls with fragmentary or taphonomically altered material, which is exactly the circumstance in which forensic anthropologists are most often asked to work.^[13,26] Ancestry estimation is the more conceptually fraught of the two tasks: even where discriminant function or geometric morphometric methods achieve respectable classification rates, the field has had to reckon publicly with the history of using cranial measurement to naturalise racial hierarchy, and contemporary practitioners are expected to report ancestry estimates as probable population affinities rather than certainties, and to avoid overstating conclusions when only partial skeletal evidence is available.^[5,23]

Clinical anthropology applications: In clinical practice the same three indices serve rather different, generally less contentious, purposes. Orthodontists use facial proportion indices to structure aesthetic treatment-need assessments that dental occlusion analysis alone cannot capture.^{[25];} prosthodontists and restorative dentists use facial and dental proportion relationships to plan the width and length of

anterior restorations so that a prosthesis harmonises with a patient's existing facial architecture; rhinoplasty surgeons rely on population-specific nasal index data to avoid imposing an aesthetic norm drawn from one ethnic group onto a patient from another; and paediatricians and neurosurgeons track the cephalic index longitudinally as a simple, non-invasive screening measure for abnormal skull growth. In each of these clinical uses, the index functions as a working reference range rather than as a marker of identity, and its clinical value depends heavily on having population-appropriate normative data rather than a single universal cut-off.

Emerging technologies: One general conclusion from the reviewed studies is the movement of this measurement from manual callipers to a two dimensional measurement to computed tomography, to 3D surface scanning and to a computational analysis. Geometric morphometrics, as it was originally developed, represents the whole shape of the cranium or face as a series of landmark coordinates instead of a few linear ratios, and is always superior at classifying the sex and ancestry of crania or faces than traditional index-based discriminant methods. Directly from photo-anthropometric landmark data, machine-learning classifiers have been developed to go one step further and have been used with promising accuracy for sex and age estimation from the frontal facial view of photographs.^[19,24] It is important to note, however, that these more advanced techniques have not superseded the simple index; rather the two have been used side by side with the classical index being the preferred method where time or resource constraints make it more convenient to use, and the geometric morphometric or machine-learning method being used where extra precision is justified and the equipment is available.^[11,18]

Limitations: This review has the limitations inherent to any narrative synthesis. It was not registered prospectively, its search was not exhaustive of every regional or non-English-language journal in which population-specific anthropometric surveys are sometimes published, and the heterogeneity of measurement protocols, sample sizes and reported outcomes across the included studies precluded a quantitative meta-analysis. Publication bias toward statistically significant sex or population differences cannot be excluded. Reporting of intra- and inter-observer measurement reliability was inconsistent across the primary studies, which limits confidence in the precision, as opposed to the direction, of some reported differences. Finally, because many of the population surveys reviewed here are single-centre, cross-sectional convenience samples, their reference values should be applied cautiously outside the sampled population.

Future directions: Three developments would meaningfully strengthen this literature. First, a standardised, openly published measurement protocol — specifying landmark definitions, instrument type and required observer-reliability reporting — would make population comparisons genuinely comparable rather than merely juxtaposed. Second, larger, multi-ethnic and longitudinally sampled reference databases, ideally collected using three-dimensional imaging, would allow the field to move from isolated single-population surveys toward a cumulative, queryable evidence base. Third, as machine-learning and geometric morphometric methods become more widely

available, validation studies that directly compare their performance against the classical index within the same sample, and that explicitly report the ethical constraints on ancestry estimation, would help clarify where the simple index remains adequate and where more sophisticated methods are genuinely required.

CONCLUSION

Both facial and nasal and cranial indices have come a long way since their inception as means of racial determination. The answers to the questions are unchanged, but the questions being asked and the protections around the answer, are not. In this PRISMA-informed review, synthesising sixteen main studies and ten supporting foundation and method studies, these indices now serve as reference values for populations, in addition to a more comprehensive forensic biological profile or clinical treatment plan. Their enduring usefulness is only in the extent of rigor with which they are produced, the appropriateness of the comparison group, and the candor with which the limits are reported. When read this way, it is almost as though it has been from measurement to meaning.

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