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Published in:
PSM Biological Research

Publication date:
2018

Document Version
Publisher's PDF, also known as Version of record

Biological Research ISSN: 2517-9586 – An International Peer-reviewed Journal

Review Article 2019 | Volume 4 | Issue 1 | 6-16

Inter-Ethnic and Demic-Group Variations in Craniofacial Anthropometry: A Review

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Abstract
Craniofacial anthropometry plays an important role in facial structure. This review paper evaluates existing research surrounding population norms of studied facial parameters. The purpose is two-fold: (1) to determine variations in facial measurements due to demi-group or ethnic variations based on traditional (direct) caliper based and image based (indirect) anthropometric methods. (2) to compare where possible, measured facial parameters between referenced studies. Inter and intra-population variations in addition to sexual dimorphism of facial parameters such as the nose and eyes, singularly or in combination with one another, have been concluded. Ocular measurements have exhibited ethnic variations between males and females of the Saudi, Turkish, Egyptian and Iranian group. Moreover, demic variations are reported when the native language has been used a key criterion. It has been concluded that with the current state of migration and inter-demic marriages, the study of homogenous populations will prove difficult. Subsequently, this will result in ambiguous physical traits that are not representative for any one demic or ethnic population. In this paper, results for the following adult male and female populations have been discussed: African American, Azerbaijani, Caribbean, Chinese, Croatian, Egyptian, Italian, Iranian, Turkish, Saudi Arabian, Syrian and South African. The qualitative research presented serves as a knowledge base for learners and strikes up thought provoking concepts about the direction anthropometrical research is heading.

Keywords: Face, craniofacial, anthropometry, population data, demic-group, ethnicity.

Article Info

Open Access

Citation: Jilani, S.K., Ugail, H., Logan, A., 2019. Inter-Ethnic and Demic-Group Variations in Craniofacial Anthropometry: A Review. PSM Biol. Res., 4(1): 6-16.

Received: September 13, 2018

Accepted: October 14, 2018

Online first: October 15, 2018

Published: October 20, 2018

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INTRODUCTION

For many years, ancestral and demic-group categorisation has been an important foundation for human identification in a variety of disciplines. Numerous efforts have been made to amalgamate the use of craniofacial anthropometry and physical characteristics to correlate with ancestral and demic-group of humans. Craniometric studies are readily being used to evaluate populations for phenotypic variations. This review paper aims to evaluate existing literature on facial data surrounding population norms, of researched measurements in craniofacial anthropometry. The focus of this paper centres on ancestral and demic-group traits as explored variables, which have significant influencing power on craniofacial anthropometry and consequently impact facial architecture. The review qualitatively summarises evidence on the topic of ancestry and demic-groups within the discipline of craniofacial anthropometry and provides a direction for future study.

Craniofacial measurements are one of the mainstays of anthropological research and are used to establish an understanding of variations within the human face. The origins of anthropometry, in the context of human identification, initially resided in pseudoscientific methods (Gowland and Thompson 2013). This was driven by an interest in criminology - with an assumed connection between physical appearance and moral character (Wolfgang 1961; Twine, 2002).

In the 17^{th} century, the boundaries for demic classification were pinned on physiological characteristics, which broadly became an objective way to classify humanity (Stuurman, 2000). It was François Bernier who proposed the use of “racial” groups as a basis of human identification with his four categories: *Europeans, Far Easterners*, *Lapps* and *Blacks* (Bernier, 1684; Burgman, 2010). Work was later expanded upon by the introduction of facial profile angle measurements (Camper, 1792; Haller, 1971).

The motivation for this review is to provide a knowledge base for learners who are organising the wealth of anthropometric information and its applications across disciplines. The paper focuses on traditional anthropometric methods, which require the use of calipers, sliding gauges and measuring tape. Research published by Farkas et al., (2005) has been used as a benchmark that provides a comparison, where possible, of measured facial parameters. A non-invasive method of data collection is also discussed such as photo-anthropometry, with an aim to highlight the inter-ethnic and racial variations amongst facial data for human adults.

Race and Ethnicity

According to historians, the emergence of the term ‘race’ was in 1606 (Lieberman, 1975) and it is since then, that researchers began to create categories for human grouping. Racial categorisation has been an important foundation for human identification for many years. However, the history of categorising humans into subspecies based on anthropometry is mixed. Hence, the continued struggle with the complexity of the concepts of race and ethnicity (Afshari and Bhopal, 2002). Moreover, the total number of distinct races has not yet been definitively established.

Based on consensus, the term “*demic*” is considered to imply a geographical and genetic determination of a given population, whereas the definition of “*ethnicity*” appears to be more subjective (Science and Nature). It is important to keep in mind that both the definition and parameters within which *“demic”* and *“ethnicity”* are used may also be context dependent (Ali-Khan et al., 2011). Hence, the generalised definition of *demic* incorporates the physical characteristics of an individual, whereas *ethnicity* denotes the cultural aspects of an individual’s identity, such as nationality.

However, it must be noted that while our review explores demic and ethnic groups as variables which have significant influencing powers on craniofacial anthropometry, we do not provide our stand on the debate of defining the terms. Each of the study discussed as part of this reviews provides a varied explanation of the terms.

It must also be noted that the word *“gender”* is a social construct and can be perceived as subjective. While the use of the word *“gender”* is dependent on personal preference, the use of the word *“sex”* is an objective definition that allows the biological separation between males and females (Lorber and Farrell 1991). Hence, the word *“sex”* is used throughout the paper.

Anthropometry: A Direct Approach

Anthropometry offers a scientific foundation for evaluating the dimensions and proportions of the body (Burnett, 2000). Craniofacial anthropometry is a subcategory that comprises measurements and proportions of the head and the face (Kolar and Salter, 1997). This practice facilitates the characterisation and quantification of phenotypic variations: an observable and measureable trait produced because of specific gene expression (Nature).

Traditionally, researchers have employed calipers as well as 2-dimensional photogrammetry to obtain facial data. More recently, 3-dimensional laser scanning and digital 3-dimensional photogrammetry have been used (Li *et al.*, 2016). However, there does not appear to be a gold standard when it comes to collecting accurate and reliable data, it appears to be dependent on the researcher’s criteria.

Nasal Parameters

Milgrim et al. (1996) reported significant differences in nasal breadth measurements in individuals of different demic-groups. Subjects were separated according to their geographic area of origin: Central America and South America. For each subject, 18 nasal anthropometric parameters were measured manually. The data was compared with previously determined norms for the North American white female population (Farkas, 1994b) and the African American female population (Ofodile et al., 1993; Ofodile and Bokhari, 1995).

The Caribbean subjects demonstrated the greatest deviation from North American white participants and more closely resembled African-America anthropometric norms. Results from the Central and South American participants, on the other hand, were closest to the North American norms. The mean nasal breadth of the North American white females was 31mm, whereas the mean for South American females was 34.4 mm (Milgrim et al., 1996).

Ozdemir and Uzun (2015) investigated the nasal anthropometry for the male and the female Turkish population. In their experiment, 115 adults between the ages of 18 and 30 years old consented to have their body weight, height and 14 nasal parameters measured. One of the major findings was the significant variation in nasal shape between males and females within the same population. Further, the data confirmed that the nose is an informative facial feature for the determination of both sex and ethnicity, see Table 1.

Table 1. Comparison of mean reported values for the nasal measurements ± Standard Deviation (SD) for Turkish males and females. Sexual dimorphism (sex difference) has been indicated with a single asterisk (*) for males and a double asterisk (**) for females (Ozdemir and Uzun, 2015).

Measurements (mm)	Male (mean value ± SD)	Female (mean value ± SD)
Nasal bridge length (n – prn)	52.95 ± 5.40 mm *	47.81 ± 4.60 mm
Total nasal length (n – sn)	54.38 ± 4.60 mm *	50.90 ± 4.20 mm
Morphological width of the nose (al–al)	35.24 ± 2.70 mm *	31.59 ± 2.50 mm
Nasal tip protrusion (sn – prn)	22.81 ± 3.02 mm *	21.15 ± 2.56 mm
Anatomic nose width (ac – ac)	25.33 ± 3.30 mm	28.83 ± 3.02 mm **
Total nostril floor width (sbal – sbal)	17.63 ± 2.14 mm	20.63 ± 2.84 mm
Soft tip width of the nose (al–al)	21.99 ± 1.92 mm	24.03 ± 2.88 mm **
Right alar thickness	3.59 ± 0.72 mm	4.14 ± 0.85 mm **
Left alar thickness	3.71 ± 0.65 mm	4.21 ± 0.89 mm **

This study concluded that the mean values for nasal bridge length, total nasal length, morphological width of the nose and nasal tip protrusion recorded were higher in the Turkish male, relative to female, population. On the other hand, the mean values for the soft tip width of the nose, anatomic nose width (as indicated by alare (nostril) curvature), total nostril floor width and right and left alar thickness were higher in the female group (Ozdemir and Uzun, 2015). Overall, vertical measurements were greatest in males and horizontal measurements were greater in females.

Although a direct comparison of the mean total Turkish nasal length was not carried out, inter-ethnic and demic-group differences are noted across sexes when compared to the study with Farkas et al. (2005). Sex differences are noted within the following ethnic and demic groups: Azerbaijani males and females (55.90 mm and 52.30 mm respectively), Iranian (58.50 mm and 62.60 mm respectively), Hungarian (55.00 mm and 52.50 mm) and Italian males and females; 56.20 mm and 52.10 mm.

In summary, there is significant sexual dimorphism in nasal measurements, which results in an apparent difference in the shape and size of the nose. This contributes to the notion that anthropometric variations are widespread and that the underlying factors include race and ethnicity.

Ocular Parameters

Anthropometric evaluation of the eyes and the surrounding area has also been subject to considerable research. Wu et al. (2010) used 2-dimensional photographs to investigate periocular anthropometric measurements of Chinese university students from the Hunan Province. However, the method relied on the assumption that the face is flat when clearly, real faces contain depth differences. While the study may have been informative it is reasonable to suggest that the measurements were not a true and exact representation of the measured features.

Bukhari (2011) studied the characteristics of Saudi Arabian eyes. Six measurements were taken from the periocular region of 668 subjects who explicitly declared themselves as of 'pure Arabic descent' and were aged between 15-75 years old. The sex-specific mean values and the ± standard deviations (SD) for each investigated measurement are shown in Table 2.

Table 2. Periocular measurements for Saudi males and females. The *p*-value (Pearson chi-square) demonstrates the statistical effect of each sex for the measured regions (Bukhari, 2011).

Periocular Measurements (mm)	Male (mean value ± SD)	Female (mean value ± SD)	*p*-value
Horizontal palpebral aperture	30.8 ± 2.9 mm	29.5 ± 2.8 mm	0.016
Vertical palpebral aperture	10.2 ± 0.9 mm	10.1 ± 0.8 mm	0.081
Lid margin to skin fold distance	3.1 ± 2.2 mm	3.9 ± 1.8 mm	0.061
Upper lid crease height	9.6 ± 0.8 mm	9.6 ± 0.9 mm	0.695
Eyebrow height	9.1± 2.49 mm	10.9 ± 2.6 mm	0.001
Intercanthal distance	32.7 ± 2.8 mm	31.3 ± 3.5 mm	0.192

Even though the study did not compare measurements of Saudi Arabian eyes to other demic/ ethnic groups, it was successful in highlighting sex-based differences. The eyebrow height was larger amongst females, relative to males. The remaining measured values demonstrated a trend towards being higher in the male group, but this was not statistically significant.

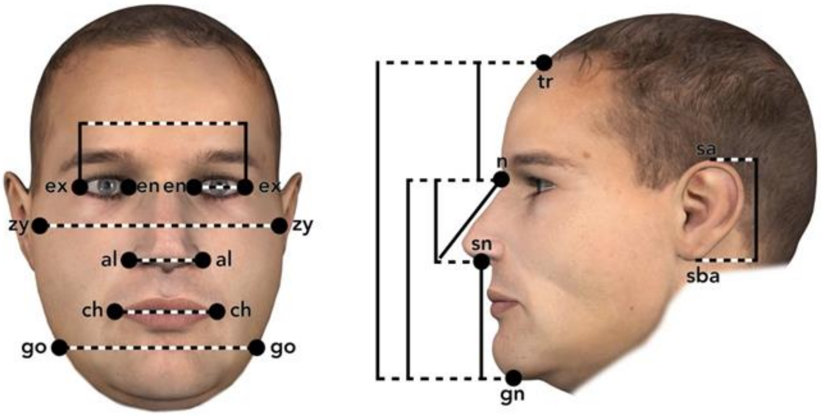
The mean height of the upper eyelid crease (9.6 mm for both Saudi males and females) was higher than the analogous value reported by Öztürk et al., 2006. Additionally, a difference between the Turkish and Saudi Arabian population was evident for the lid-margin-to-skin-fold-distance. The mean value was higher for both the Saudi males (3.1mm) and females (3.9mm) when compared to the Turkish (2.3mm and 2.1mm respectively).

While Farkas et al. (2005) did not record a complete list of ocular measurements, the intercanthal distances for each participant was recorded. A comparison of the recorded mean values ± SD reported by Bukhari (2011) with those of Farkas et al. (2005) demonstrated inter-ethnic and sex-specific differences. The Saudi population (male: 32.7 ± 2.8mm, female: 31.3 ± 3.5mm) showed a significant effect of sex when compared to the Iranian males and females (27.3 mm and 24.6 mm respectively). However, sex-specific variations were not dominant within the Egyptian males and females (31.8 mm and 30.9mm) nor the Turkish males and females (32.8mm and 31.7mm).

Facial Anthropometry

Leslie Gabriel Farkas compiled the first comprehensive craniofacial anthropometric atlas (Farkas and Munro, 1981). Although the study focused on the anthropometric application for oral/maxillofacial surgery, it provided a framework. This original anthropometric atlas was updated in 1994 with the comprehensive norms available for the Caucasian North American population (Farkas, 1994a). It was later expanded to include norms for the Chinese and African-American groups of varying ages.

Farkas and colleagues carried out the most comprehensive anthropometric study of facial morphology and facial parameters (Farkas *et al.,* 2005). Hailed as an example of pioneering craniofacial anthropometry work, the study compared 14 normative measurements of the face across multiple ethnic and demic groups. The 5 main regions of investigation included: Africa, Asia, Europe, Middle East, and North America.



Measurement	Reference Points
Forehead height	tr - n
Physiognomical face height	tr - gn
Morphological face height	n - gn
Lower face height	sn - gn
Nose height	n - sn
Inclination of nasal bridge and length of ear	sa -sba
Intercanthal distance	en - en
Biocular width	ex - ex
Eye fissure length	en - ex
Face width	zy - zy
Mandible width	go - go
Morphological nose height	al - al
Mouth width	ch - ch

Fig. 1. Measurements taken from fourteen anthropometric landmarks on the front (left) and profile (right) view of face. (*ex: exocanthion, en: endocanthion, zy: zygion, al: alare, ch: chelion, go: gonion, tr: trichion, n: nasion, sn: subnasale, gn: gnathion, sa: superaurale and sba: subaurale, see table below*) (adapted from Farkas et al., 2005).

The results show that the degree of agreement between measurements of the Egyptian, Turkish and Iranian groups and the North American Caucasian group is considerably greater for vertical (taken from profile), compared to horizontal (taken from the frontal view), measurements. In the three Middle Eastern male groups, all 7 vertical measurements were found to be comparable to that of the North American Caucasian group. For females however, it was only the Turkish group who shared comparable vertical values with the North American reference group.

The orbital region and nose height showed the greatest discrepancies in measurements across all the researched groups. This may be attributable to the finding that the nose was characteristically wide in both males and females of the Asian and African ethnic group. For the Middle Eastern group, however, the nose width was comparable to that of the North American Caucasians but differed significantly in nasal height.

Overall, this study provided a quantitative description of differences in facial anthropometry between the North American Caucasian population and different racial groups. However, the relatively small sample size (30 males and 30 females) limits the generalizability of the results. Moreover, there is limited description of the precise methods and methodology used to collect the anthropometric data.

Regarding the concept of demic and ethnicity, the study by Farkas et al. (2005) appears to outline demic as the geographic location of the participants (such as the Middle East) and then group the participants by ethnicity, such as Egyptian, Iranian and Turkish. This is one of the strengths of the study even though Egypt is within the African continent.

The results of Farkas et al. 2005 study were supported by a recent systematic review of 7 individual studies (including that of Farkas and co-workers) by Fang et al. (2011). This review analysed data from 27 ethnic groups and considered 11 linear facial measurements.

Inter-ethnic variability was described by 95% confidence intervals of individual measurements. A Bayesian hierarchical random effects model was created to approximate posterior means and 95% credible intervals (CrI) for each measurement by ethnicity/demic-group. While, linear contrasts were constructed to explore any inter-ethnic/demic facial variations.

Measurements were categorised into five degrees of variability: least variable, less variable intermediate, intermediate, more variable intermediate and most variable.

The results showed that greatest inter-ethnic variation was for the forehead height (measured tr – n) and intercanthal distance (en - en). Whereas, measurements of the mid face width (zy - zy) and exocanthion distance (measured right ex - left ex) showed the lowest degree of variability (Figure 2).

Like Wu et al. (2010), the systematic review by Fang et al. (2011) was restricted to 2-dimensional measurements. So, while the research successfully classified the degree of inter-ethnic variability, the results for features with 3-dimensional geometry (such as the nose) may be limiting.

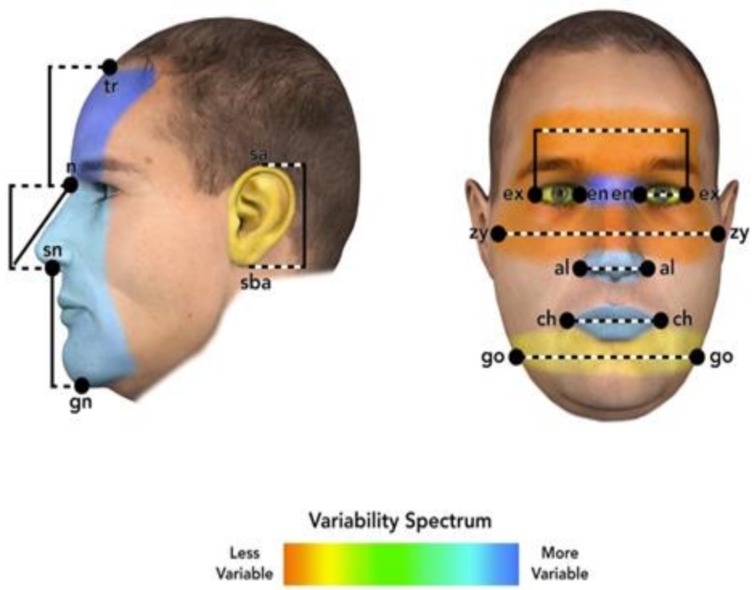


Fig. 2. Colour spectrum to demonstrate the regions of the face with the degree of inter-ethnic variability (Adapted from Fang *et al*., 2011).

Craniofacial Anthropometry

In 2007, Grbeša et al., set out to identify the most useful measurements for discriminating between the Syrian and Croatian population. With a sample of 400, equally split and representative of each population, four variables were analysed: Head length, head width, face width and total face height. Subsequently, the obtained data was then used to calculate the head index (HI) and face index (FI) as follows,

$$\boldsymbol{Head\ Index\ (HI)} = \frac{Head\ Width}{Head\ Length}\ x\ 100 \qquad (1)$$

$$\boldsymbol{Face\ Index\ (FI)} = \frac{Total\ Face\ Height}{Face\ Width}\ x\ 100 \qquad (2)$$

The head length (measured from glabella – opistocranion) of the Croatian population was found to be significantly higher (t-test $p < 0.001$) than that of the Syrian population. On the other hand, the head width (measured from eurion - eurion) of the Syrian population was significantly wider ($p < 0.0001$) than that in the Croatians (Grbeša et al. 2007).

The total face height (measured from nasion - gnathion) of the Croatian population was significantly longer ($p < 0.001$) than that in the Syrian population. The face width (measured zygion – zygion) showed no statically significant difference between the two investigated groups, ($p > 0.05$). The head index (HI) was significantly higher ($p < 0.001$) in the Syrian population, whereas the face index (FI), was significantly higher ($p < 0.001$) in the Croatian population. According to the head index the results indicated that Croatians had a dolicephalic head shape (long skull) but a brachycephalic head shape (short skull) prevailed amongst the Syrians. Additionally, according to the face index, it was concluded that the Croatians had a mesoprosopic (rounded) face shape whereas Syrians demonstrated a Euryprosopic (broad) face shape.

Research by Jahanshahi et al. (2008) provides a further example of inter-ethnic variations in head and face indicies. The authors investigated the normal range of face shapes in the native Fars and Turkman ethnic groups of Northern Iran. This study was motivated by the proposal that the 'Turkman' group previously emigrated from Central Asia, whereas the 'Fars' group of people are the native population of northern Iran.

Facial measurements were recorded with Martin spreading calipers from 808 male and female participants. The facial landmarks used to measure the face length were nasion (n) and gnathion (gn) and for the face width it was the zygion (zy). In addition, the Prosopic Index (PI) was also calculated as below:

$$\boldsymbol{Prosopic\ Index\ (PI)} = \frac{Face\ Length}{Bizygomatic\ Breadth}\ x\ 100 \qquad (3)$$

To determine morphological indices within each investigated group, a chi-square test was used, whereas for the comparison of the recorded measurements, Student's *t*-test (p= 0.05) was used. The mean and standard deviation of the Prosopic Index (PI) amongst the Turkman males was 87.25% ± 5.18%, whereas for the females it was 81.48% ± 5.28%. In contrast, the mean and standard deviation of the Prosopic Index (PI) for the Fars males and females were 88.22% ± 5.21% and 84.48% ± 5.85%, respectively. As a result, the dominant type of face shape for both the native Fars and Turkman females was found to be euryprosopic, 37.7% and 51.7%.

While, the dominant type of face shape in both native Fars and Turkman males was Mesoprosopic (44% and 38.4%, respectively). As reported by Jahanshahi et al. (2008), these findings appear to agree with the conclusions reported by Farahani and Emami (1993).

It has been suggested that environmental factors and nutritional habits of specific populations may also contribute to variations in facial morphology (Singh, 1970; Seren and Seren, 2009). Djordjevic et al. (2016) investigated the contributions of the environment and genetics on facial morphology using 1380 3D images of female twins. The research concluded that 70% of phenotypic variations is a direct result of genetics, facial height, nasal height, width and prominence, lip prominence and inter-ocular distance. Environmental factors dominated mandibular ramus (ascending part of the lower jaw), height and horizontal facial asymmetry.

Traditional methods of assessing facial parameters rely upon physical measurements, which require somewhat invasive measuring procedures. It could be argued that this is the most valid method due to the real-life nature of these measurements. However, this carries the risk of potential errors (e.g. observer error, poor measurement repeatability). These traditional methods of data collection have largely been surpassed by with non-invasive methods, such as photo anthropometry, which is a metric-based facial image analysis tool. Photo anthropometry involves the extraction of facial measurements regarding facial landmarks from front and/or profile images.

An Indirect Approach

Roelofse et al. (2008) analysed photographs of 200 South African males to quantify the distinguishing aspects of facial morphology within this population. A key criterion for inclusion in the study was 'Bantu' as the native language. This enabled the researchers to separate the Black South African participants from the 'Khoisan' (a distinct ethnic group of South West Africa), Indians and White South Africans. The measurements used to assess the participants are presented in table 3.

Digital sliding calipers were used to assess directly the marked facial landmarks from each participant's image. Each image of the participants was divided into the upper, middle and lower region and the frequencies of occurrence for the various metric and morphological traits were determined, for each region of the face.

Intra-observer variability measurements were calculated using intra class correlation (ICC); this meant that any measurement close to 1 was classed as being the most reliable. Intra-observer variability was assessed for 30 images, which were re-measured by a trained facial identification analyst. The ICC for both the researcher and the trained facial analyst were 0.8389 and 0.9989 respectively, falling within the required boundary, showing reliability in results and robustness in method.

The study elucidated most and least prevalent morphological features within a given, sex-specific group. The common features included the absence of a nasolabiale fold and a flat 'v' shaped cupids bow, whereas uncommon features included rounded face shape, deep philtrum and an upturned septum tilt. However, an important outcome of the Roelofse et al. (2008) study was the identification of intra-population variation in facial morphology within a given sex- specific population.

Table 3. Metric values and numerical classification used for facial assessment (Roelofse et al. 2008).

Index	Calculation	Classification
Forehead size index	$100 \times (\frac{\mathrm{G-Tr}}{Gn-V})$	*Low*: ≤ 21.9, *Intermediate*: 22-28 and *High*: ≥ 28.1.
Facial index	$100 \times (\frac{\mathrm{Gn-N}}{Zy-Zy})$	*Short, wide*: ≤ 78.9, *Intermediate:* 79 - 92.9 and *Long, Narrow*: ≥ 93.
Intercanthal index	$100 \times (\frac{\mathrm{En-En}}{Ex-Ex})$	*Close*: ≤ 36.9, *Intermediate:* 37 – 46 and *Far apart*: ≥ 46.1
Nasal index	$100 \times (\frac{\mathrm{Al-Al}}{N-Sn})$	*Narrow:* ≤ 54.9, *Intermediate:* 55 - 99.9 and *Wide:* ≥ 100
Nasofacial index	$100 \times (\frac{\mathrm{N-Sn}}{Gn-N})$	*Short:* ≤ 37.9, *Intermediate*: 38 – 46 and *Long*: ≥ 46.1
Nose-face width index	$100 \times (\frac{\mathrm{Al-Al}}{Zy-Zy})$	*Narrow:* ≤31.9, *Intermediate:* 32 - 36 and *Wide:* ≥ 36.1
Lip index	$100 \times (\frac{\mathrm{Ls-Li}}{Ch-Ch})$	*Thin:* ≤ 34.9, *Intermediate:* 35 - 44.9 and *Thick:* ≥ 45
Vertical mouth height index	$100 \times (\frac{\mathrm{Ls-Li}}{Gn-N})$	*Low, thin:* ≤ 15.9, *Intermediate*: 16 - 22 and *High, Thick*: ≥ 22.1
Upper lip thickness index	$100 \times (\frac{\mathrm{Ls-Sto}}{Ls-Li})$	*Thin*: ≤ 31.9, *Intermediate*: 32 – 44 and *Thick*: ≥ 44.1
Lower lip thickness index	$100 \times (\frac{\mathrm{Li-Sto}}{Ls-Li})$	*Thin*: ≤ 51.9, *Intermediate*: 52 - 62 and *Thick*: ≥ 62.1
Mouth width index	$100 \times (\frac{\mathrm{Ch-Ch}}{Ex-Ex})$	*Narrow*: ≤ 54.9, *Intermediate*: 55 - 66 and *Wide*: ≥ 66.1
Chin size index	$100 \times (\frac{\mathrm{Li-Gn}}{Gn-N})$	*Short*: ≤ 19.9, *Intermediate*: 20 - 29 and *Long*: ≥ 29.1

A limitation of this study is that the participants ranged in age from 20 to 40 years. It seems likely that some participants may be balding which would significantly affect the identification of landmark location, particularly of the trichion. Further, the facial norms identified for this specific population may not be representative of those for all Black South African males, so there is a need to create a more inclusive facial anthropometric database.

Akhter et al. (2014) carried out photo anthropometric analysis for 100 Christian, Garo-speaking adult females of Bangladesh. Three vertical facial parameters were measured: facial height, nasal length and total vermilion height. The mean values ± SD were: 16.88 cm ± 1.11, 4.53 cm ± 0.36 and 1.63 cm ± 0.23 cm respectively. While these measurements were taken directly from the photographed images, they were converted into actual size (with an aim to ensure robust results) by using a physically measured variable between two angles of the mouth (measured chelion to chelion). The measurement used to convert the photographs to their actual size, was incorporated within Adobe Illustrator.

The mean value of the facial height for the female Garo population was 16.88 cm, which is smaller than that for the Caucasian female population of North America, Czech Republic and Azerbaijan (Farkas et al., 2005). The mean nasal length for a Garo female was found to be 4.53 cm, which is smaller than that for a Mongoloid Korean American population, in addition to Caucasoid female populations from Bulgaria, Germany and North America (Farkas et al., 2005; Akhter et al., 2014). Finally, the mean total vermilion height for the Garo female population was 1.63 cm which is smaller than that for the Mongoloid Korean American female population (Choe et al., 2004) but greater than that for a Mongoloid Chinese female population (Du et al., 2008).

Summary

Two major areas have been investigated: (1) anthropometry, including feature specific anthropometric analysis, facial anthropometry and craniofacial anthropometry and (2) photo-anthropometry, image-based facial analysis. The proposed stand for the definitions of the terms 'demic/demic-group' and 'ethnicity', are dependant on the researcher and the context of the study. However, keeping that in mind, the proposed definitions are broadly aligned with the view that demic is a geographic and genetic determinant with a biological basis, and ethnicity is subjective.

Anthropometric Databases

The availability of face-specific measurement data relevant to the similarities or dissimilarities between different populations is essential for building a reliable database. In general, most studies have recruited populations of adults who are free from known medical conditions or a history of facial trauma. In addition, the participants are required to be of a non-mixed heritage. Such specific selection criteria enable these studies to establish facial norms which are uncontaminated by any external influences. The use of such databases would not be limited to human categorisation, since progression can occur for fields such as medicine, surgery (to treat post-traumatic facial disfigurement), and forensic science.

Increases in migration have enhanced the need for a multi-racial and ethnic facial database. Not only is migration associated with a geographical shift, but the transition introduces the opportunity for heterogeneity through intermarriage. As a result, it is expected that future populations will feature differences in facial morphology and measureable facial parameters across multiple ethnic and/ or racial lines. Hence, the need for a universal facial database. A particularly important aspect of this prospective database will be the specification of various subcategories of human grouping, which are not presently well defined.

Inter and Intra-Population Variations

It seems clear that variations in facial measurements are prevalent regardless of whether populations are categorised by demic or ethnic origin. Importantly, there is also considerable variation within populations when comparing face data for a specific feature such as the nose. The nose provides clues for the investigated population and demonstrates dimorphism in both shape and its associated measurements (Ozdemir and Uzun, 2015).

While intra-population variation is present within the Turkish population, significant inter-population differences have been identified for nose length (e.g. Turkish males have shorter noses, relative to males of Azerbaijani, Iranian and Portuguese descent). Conversely, Turkish males demonstrate longer noses compared to Vietnamese, Egyptian and Slovak males. Differences have also been identified for Turkish females who have a shorter nose in comparison to Azerbaijani, Iranian and Egyptian females, but longer when compared to Croatian and African American females (Farkas et al., 2005).

Ethnic and/or demi variations plus sexual dimorphism are not limited to just the nasal parameters, differences have also been noted in the ocular region. Ocular measurements have exhibited ethnic variations between males and females of the Saudi, Turkish, Egyptian and Iranian group.

Population variations have also been noted when native languages have been used as a key inclusion criterion for participants of specific ethnic groups. Studies that have used this criterion identified significant inter-population variability, demonstrating that even when external variables (such as participant population and sex) are controlled, inter-ethnic variation remains (Roelofse et al., 2008; Akhter et al. 2014).

However, there is the need to standardise methods of data collection and measurement recording. A gold standard for collecting anthropometric data would enable a more reliable comparison of facial parameters across different demic-group, ethnicities and sexes.

Deficiencies of Anthropometric Analysis

Typically, participants are asked to maintain a neutral facial expression and a standard anatomical position, as per the researcher's requirement. Small deviations, however, are likely and changes in facial expressions and involuntary movements can be a source of error.

A further deficiency is the selection of participants considered to be representative of the target demic/ethnic group. The number of participants may be limited by the demographics of the available population. So, while the method of data collection may be robust, the sample size may preclude generalisation of the results to a wider population.

The only study on a universal scale which was inclusive of a diverse range of demic and ethnic groups, was carried out some time ago (Farkas et al., 2005). As a result, the acquired facial data could now be out-dated. Moreover, it is evident that it will become increasingly difficult to study "pure" populations due to increased migration and interracial offspring. While it is becoming more problematic to categorise populations it is still valuable to identify differences in respect to morphology and facial measurements, especially for disciplines which rely on identification (Durtschi et al., 2009; Waters, 2000).

Finally, it is assumed that the parents of the participants who partake in these studies are "pure" with no possibility of recessive genetic facial characteristics. This issue may become significant with time: amidst large-scale migration, where all populations will inevitably see shifts to a greater or lesser extent in their genetic make-up, albeit over many generations and shift away from previously established norms.

CONCLUSION

The ethnic or the demic heritage of an individual is a determining factor of the physical appearance of the face. The results of this review support the notion that differentiation of populations using facial measurements is possible. Key norms for each population could be established with more comprehensive data. However, there is a need for standardisation of anthropometric methods, which would facilitate direct comparisons.

Population definition is one of the greatest problems. Many variables could be used to define a population, such as geography and native language. While the use of native language as a selection criterion for participants does have a strong relationship with geographical distribution, this is not absolute.

In fact, for some native languages the correlation with geographical location is poor. Widely-spoken international languages may give little information to infer geographic origin or broad ethnic/ demic classification. Geographic definitions can be particularly artificial, often with no genetic association.

If it is possible to define a practical number of ethnic or demic groups, a meaningful and presumably large, dataset would need to be collated for each group. This would allow the measurements that show the greatest and least diversity to be determined and the "signatures" for each group, if any, to be established.

There is a clear need for large-scale studies and data collection from people of a wide range of different populations. This includes studies of facial measurements, which deviate from the 'ideal' and normative anthropometric values. It may be that once sufficient data is collected, a smaller number of groups emerge which are defined purely on facial measurements. It is also possible that greater understanding of inter-ethnic differences in facial morphology would allow individuals to be categorised as belonging to a specific group with a certain degree of confidence. This would be of great advantage to professionals from law enforcement and would provide scientific objectivity.

CONFLICT OF INTEREST

All the authors have declared that no conflict of interest exists.

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