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Face Structure, Beauty, and Race: A Study of Population Databases Using Computer Modeling

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Prateush Singh, MBBChir, MA, MRCS; Paul Oregi, BSc; Shivani Dhar, MBBS; Eva Krumhuber, PhD; Ash Mosahebi, FRCS Plast, PhD, MBA; and Allan Ponniah, FRCS Plast, MSc

Abstract

Background: Understanding the differences in facial shapes in individuals from different races is relevant across several fields, from cosmetic and reconstructive medicine to anthropometric studies.

Objectives: To determine whether there are features shared by the faces of an aesthetic female face database and if they correlate to their racial demographics using novel computer modeling.

Methods: The database was formed using the "top 100 most beautiful women" lists released by "For Him Magazine" for the last 15 years. Principal component analysis (PCA) of 158 parameters was carried out to check for clustering or racial correlation with these clusters. PCA is a machine-learning tool used to reduce the number of variables in a large data set, allowing for easier analysis of the data while retaining as much information as possible from the original data set. A review of the literature on craniofacial anthropometric differences across ethnicities was also undertaken to complement the computer data.

Results: Two thousand eight hundred and seventy aesthetic faces formed the database in the same racial proportion as 10,000 faces from the general population as a baseline. PCA clustering illustrated grouping by latent space parameters for facial dimensions but showed no correlation with racial demographics. There was a commonality of facial features within the aesthetic cohort, which differed from the general population. Fourteen papers were included in the review which contained 8142 individuals.

Conclusions: Aesthetic female faces have commonalities in facial features regardless of racial demographic, and the dimensions of these features vary from the baseline population. There may even be a common human aesthetic proportion that transcends racial boundaries, but this is yet to be elucidated.

Level of Evidence: 5

5
Diagnostic

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Mr Singh is a plastic surgery registrar, Prof Mosahebi is a professor of plastic surgery, and Prof Ponniah is an associate professor of plastic surgery, Department of Surgery and Interventional Science, University College London, London, UK. Mr Oregi is a medical student, GKT School of Medical Education, King's College London, London, UK. Dr Dhar is an aesthetic physician, Department of Plastic Surgery, Royal Free Hospital, London, UK. Prof Krumhuber is a professor of experimental psychology, Department of Experimental Psychology, University College London, London, UK. Dr Mosahebi is a research section co-editor and a senior international editor for *Aesthetic Surgery Journal*.

Corresponding Author:
Mr Prateush Singh, Royal Free Hospital, Pond Street, London, NW3 2QG, United Kingdom.
E-mail: rmhkpsi@ucl.ac.uk

Studying the relationship between facial features and race is a topic spanning multiple disciplines, from aesthetic and reconstructive medicine to anthropology and computer science. Face structure, feature dimensions, and proportions have been used as identifiers of beauty and racial demographics, despite unclear understanding. This has led to the formation of assumptions about face structure, beauty, and race, which not only have repercussions for aesthetic and reconstructive surgery but is also a slippery slope politically and in the way we view each other as members of different genetic and geographical backgrounds, but of 1 human race.

Since time immemorial, we have sought to put forward the best versions of ourselves; to maximize our beauty. We all recognize facial beauty, but how to unpick the reflexive cognitive processes that lead to these judgments? This intuitive aesthetic sense results from an undetermined computational analysis.[1] In order to understand facial beauty, we have sought to classify it using neoclassical cannons. More dangerously, the concept of "Westernized" beauty standards has become an umbrella term, covering all features considered "ideal" for beauty, in combination with fair skin and hair. The concept of racial demographics, grouping individuals by their perceived biology physical traits, is outdated. People from all around the world are mixing and having children who do not have features of 1 demographic, but of many. Furthermore, if 1 looks into the diversity within such racial clusters, such as "Asian-Indian," it is hard to comprehend how a country with almost 1.5 billion people,[2] 20% of the world's entire population, could be considered 1 racial demographic. It shares land borders with 7 other nations: Afghanistan, Bangladesh, Bhutan, China, Maldives, Myanmar, Nepal, Pakistan, and Sri Lanka, with population features varying hugely within a country. Similarly with the United States of America and its history of diverse immigration, it cannot be clustered as "American." Instead, the use of racial demographic terms, such as "Asian Welsh" and "Black Welsh," by the Office for National Statistics[3] has become political, leading to unnecessary and inaccurate subdivision.

In this study, we use novel computer modeling on a newly developed aesthetic female face database to determine if there are common features shared by these faces and if they correlate at all to their racial demographics. We determine whether there are features shared within this cohort that differ from a general population face database. These models are based upon principle component analysis (PCA) of 3-dimensional (3D) morphable models (3DMMs)[4] produced by deep convoluted neural networks (DCNNs), such as generative adversarial networks (GANs).[5,6] Principal component analysis (PCA) is the linear model dimensionality reduction tool where each dimension captures 1 orthonormal basis (eigenvector) of the distribution ordered by magnitude.[7,8] These can be applied to 3DMMs, which are 3D models of faces produced from a collection of 2D images, from which data can then be extrapolated and measurements made (Figure 1). A DCNN is a commonly used machine-learning tool for identifying patterns in images and videos, using 3D neural arrangements mimicking the structure of an animal's visual cortex.[9] GANs are a type of DCNN that are able to create new examples that could have been generated based on commonalities and patterns in the original data set.[10]

Our models will illustrate the relationship of beauty and racial demographics within a cohort of beautiful faces, and when compared with the general population, and we perform a thorough literature review to identify if our findings are shared in the general population or if peer-reviewed "beautiful" faces from all demographics share features among themselves but differ from their racial demographic group.

METHODS

A peer-reviewed database of aesthetic female individuals, with a global ethnic racial demographic distribution was developed. Annual "top 100 most beautiful women" lists are released by "For Him Magazine" magazine each year. These are peer reviewed by an internal panel and voted on by members of the public. For the past 20 years, these lists were compiled, duplicate entries were removed, and the latest entry was used if an individual had featured in more than 1 year's list. Miss Universe and Miss World are international competitions involving vigorous selection processes at the national and international level by panels of judges and public vote, of which an undeniable factor is physical beauty. For the past 15 years, lists of individuals of finalists were compiled. Once again, if a female appeared in multiple years, the duplicates were removed and either the latest entry was used, or in the case of winners, the latest year they won was used.

Duplications of names were removed, leaving a total of 2870 individuals. An online internet search was performed to obtain high-resolution photographs of each individual at the period of time when they were rated on one of these lists. Neutral poses in positions frontal, left oblique, right oblique, left lateral, and right lateral were downloaded. These images were screened for quality by 5 independent individuals to ensure high quality. Further information for each individual image was gathered in terms of perceived age, perceived ethnic origin as a racial demographic, facial expression, and angle of image. In order to make sure that there was consistency when deciding an individual's ethnic origin, 5 reviewers cross-reviewed each individual's photographs to make sure that all 5 agreed on the ethnic classification to be used. From these images, a 3DMM was trained to produce 3D reconstructions from 2D photographs, using ultraviolet (UV) mapping as the 3D modeling

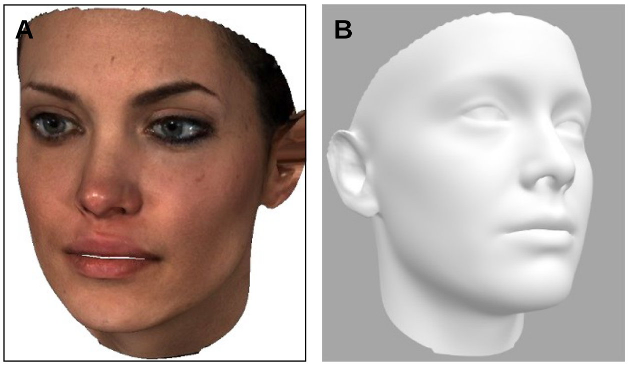

Figure 1. (A) The 3-dimensional (3D) reconstruction of 2-dimensional (2D) photograph with texture. (B) The 3D reconstruction of 2D photograph with shape alone.

process. A GAN was used as the DCNN to generate texture output for the UV mapping to create realistic 3D reconstructions.

A PCA analysis of 158 latent space parameters was performed and outcomes clustered to see if face structure within this 2870 face cohort illustrated any particular clustering of facial dimensions, and within any such clustering, if there was a correlation with racial demographic (Figure 2). Clustering can be defined as "The Task of Dividing the population or data points into a number of groups such that data points in the same group are more similar to other data points in the same group and dissimilar to the data points in other groups."[11] Latent space parameter are defined as representations of compressed data, allowing researchers to turn large, complex data sets into smaller, and simpler ones that are easier to analyze and draw conclusions from.[12]

A 3D space model was developed to determine how the mean beautiful face correlated to beautiful faces within the cohort using cluster centroids, and how this compared to a general population database of 10,000 faces (Figure 3). A cluster centroid can be defined as the center of a particular cluster, corresponding to the arithmetic mean of data values included in this cluster.[13]

This study sought and gained ethical approval from the University College London department of experimental psychology. An extensive review of the literature on the database PubMed (National Institutes of Health; Bethesda, MD) was carried out during May 2022. Boolean operators were used to devise the following search algorithm: ((facial structure) OR (facial shape) AND (race)). There were no limitations on the date of publication, but studies had to be written in English and focus exclusively on humans to be included. The references of studies that fulfilled the inclusion criteria were also screened to identify further relevant publications. All study types were eligible for inclusion except systematic and literature reviews, as well as any publications limited to an abstract. Publications were screened manually by 1

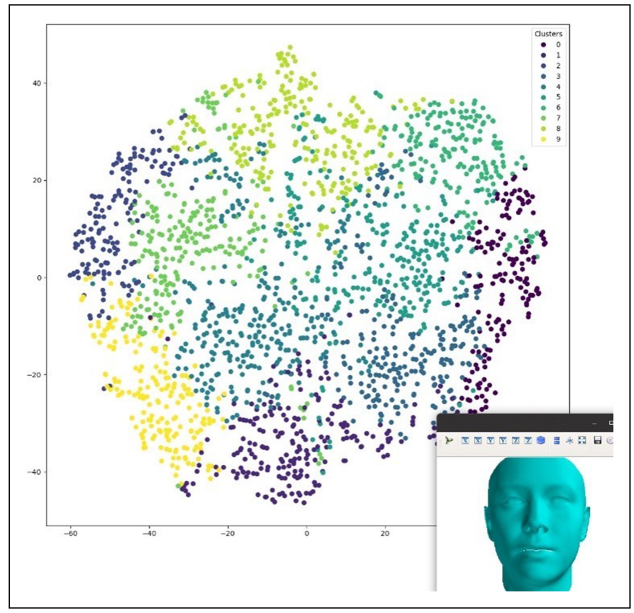

Figure 2. Clustering of faces based purely on principal component analysis (PCA) of structure by latent space parameters.

researcher (P.O.), and the final list of publications for inclusion as well as the data extracted was then reviewed by another researcher (P.S.). Data for the following variables were extracted and tabulated: author name(s), date and journal of publication, race(s) being assessed, and number of patients included.

RESULTS

The 2870 aesthetic female face database had a proportional representation of racial demographics as the baseline general population database of 10,000 faces. PCA clustering illustrated some grouping by latent space parameters for facial dimensions but there was no correlation with racial demographics within this clustering. Conversely, 3D space models using cluster centroids illustrated a clear commonality of facial features within the aesthetic face cohort, which differed from facial features of the general population. These findings showed us the following: Even if a particular aesthetic face showed enough shared common facial features to be considered part of its assigned racial demographic, the aesthetic faces also showcased and shared truly different facial proportions to those of a person from the general population. Furthermore, these differences also transcended beyond racial demographics. Therefore, these shared commonalities within the aesthetic cohort may well be the key behind the reflexive cognitive process underpinning our concept of beauty, as they were seemingly universally shared by individuals from all racial backgrounds.

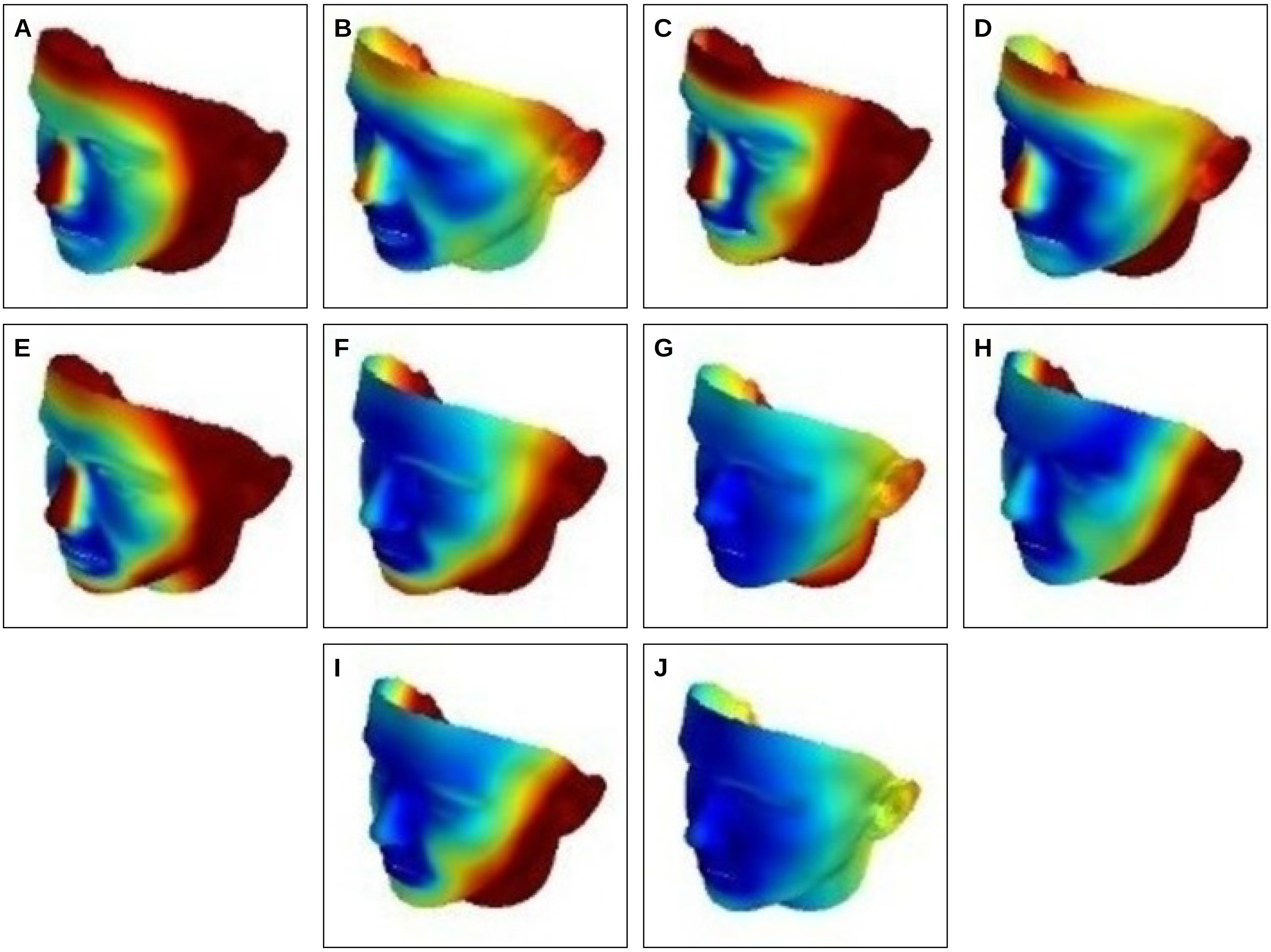

Figure 3. (A–E) These cluster centroids are compared to the mean face of an individual from the general public, with blue indicating no difference, and red being >2 mm difference. These calculations are by 3-dimensional (3D) space and not latent space. (F–J) These are cluster centroids compared to the mean beautiful face from our database. Blue indicated no difference and red showed over 2 mm difference.

For the literature review, a total of 1256 publications were identified, of which 11 fulfilled the inclusion criteria. The references of the articles were then screened, leading to the addition of a further 3 publications to the review.[14-27] A total of 8142 patients were included in the review, of which 4635 were males and 3507 were females. The most commonly reported race/ethnicity was Caucasians with 3094 patients, followed by African Americans with 1570 individuals.

In these studies, 2 East Asian populations, Chinese and Koreans, were found to generally have wider and shorter noses than Caucasians, as well as a greater endocanthion distance and more pronounced nasolabial angles. Both Asian populations also had a larger middle than upper third of the face, whereas the opposite was true in White patients, who also had narrower faces than Asians. African Americans exhibited shorter, wider noses as well as narrower jaws than Caucasians and Koreans. African Americans also showed greater facial features than Caucasians across all measurements except for bigonial breadth, bitragion coronal arc, and head breadth. Hispanics showed larger facial measurements than Caucasians but were found to have shorted heads and noses and reduced nasal protrusion.

Ethnically, similar populations found in different countries showed a smaller degree of differentiation, as Malaysian Chinese (MC) and Singaporean Chinese only had significant differences in intercanthal distance, head height, and nasal tip protrusion, but in no other facial features. A similar phenomenon was seen between Han Chinese and Tibetans, who were only found to have relevant differentiation in their brow ridge and lower mandibular region. However, ethnically diverse countries, such as Malaysia, exhibited significant differences between separate ethnic groups. MC and Malaysian Malay patients had significantly different upper, middle, and total face height measurements, while MC and Malaysian Indian patients had different upper and middle facial heights as well as interzygion distance. The only measurement which was not found to be significantly different between these populations was lower face height. Interestingly, ethnic groups found geographically halfway between other distinct populations, such as Uyghurs relative to Han Chinese and Europeans, also showed facial structures that would fit in the middle of the spectrum, with Europeans and Han Chinese at each end.

Kleisner et al assessed different ethnic groups within Africa and also found substantial differences between pastoralists and farmers in the Sahel/Savannah belt, groups that had historically lived isolated from each other. The faces and noses of pastoralists were vertically longer and narrower, while farmers had wide, oval faces with short and wide noses. Farmers also had smaller eyes, fuller lips, and exhibited a bigger lower facial third when compared to the upper third.[21] Two populations which likely had similar origins, Caucasians from Hungary and from Texas, were found to have significant differences in the following features. Hungarian females exhibited more prominent mandibles, noses, lips, and upper foreheads, as well as smaller eyes, interocular distances, and subnasal and malar regions. Hungarian males also had prominent noses and lips, but their mandibles were shown to be smaller than those of White Texans.[26] Several papers also assessed whether the facial features of other ethnicities fit in the parameters of the neoclassical cannons of beauty.[24,25] Both Koreans and African Americans had facial features that generally did not fit within these parameters and the latter only fit within Canon VI, that of orbital proportion. This canon postulates that eye fissure length should be equal to intercanthal distance, which was the case in 11.9% of African American patients. The major findings and characteristics of the papers included in this review are summarized in Tables 1 and 2.

DISCUSSION

Our results study a novel peer-reviewed, international, “beautiful” female face database and illustrate that there are commonalities within their facial dimensions, as show using latent space parameter analysis through PCA and 3D space models using cluster centroids, and that these do not correlate with the racial demographic of those individuals. This thereby suggests that beautiful faces have enough features that identify them as from that racial demographic but share enough features among each other that transcend physical features from each racial demographic group. Furthermore, the features that they share are different from those of the baseline population. We can surmise then that although racial demographic classifications are becoming outdated with the increasing mixing of peoples from all around the world, there are undeniably commonalities among racial demographic groups which are shared among those individuals, and differ in general, when compared to other groups. The danger arises when trying to overgeneralize, or over politicize particular groups. Furthermore, there is a clear difference between the most beautiful faces within these demographics, and as these features seem to be shared pan demographically, there may be a pattern or aesthetic common ground that may come to light with further modeling; something that would reveal the pathway to ideal facial aesthetics.

Categorizing by racial demographic has been used universally, utilizing the knowledge that different racial groups often show a degree of differentiation in their facial morphology. The advent of modern computer technology and advances in imaging techniques have allowed researchers to create mathematical models to quantify and compare these differences, as well as create “average” facial meshes that can be used as references. These differences in facial morphology are thought to be present very early in individual’s lifetimes and may even be present at birth.[28] This is particularly relevant for individuals born with craniofacial defects such as cleft lip and palate or craniosynostoses, as differences in facial growth patterns across ethnicities can have an impact on surgical planning and technique.[29] Understanding these differences will allow clinicians to better plan operative reconstructive plans, and ensures that the aesthetic result will better fit within a patient’s ideal facial parameters.

The use of these reconstructive programs has also allowed us to identify certain craniofacial features found more prevalently in individuals with facial defects. It has been shown that patients who have undergone a cleft lip and/or palate repair still exhibit certain soft-tissue deformities when compared with a control group, particularly in the nasofrontal region.[30] The facial shape of unaffected parents who have children with cleft lip and palate has also been shown to display significant differences compared to the general populations.[31] Understanding whether these variations occur more often in different ethnicities or subpopulation groups may help further classify treatment options depending on a patient’s ethnic origin and stratify service provision, and be extrapolated to all other aspects of congenital deformity and reconstruction.

While important to study particular anatomical regions within the face, 1 must not forget to consider the face in its entirety, as this is how we each perceive facial morphology. For example, Chinese individuals in general have wider noses than Caucasians, but this increase in width is blended by the proportionately increased intercanthal distance, resulting in harmonious facial proportions. Another example would be the width of the mouth relative to

Table 1. General Characteristics of Papers Included in the Literature Review

Author	Title	Journal	Race/ethnicity	Patient information
Sim et al (2000)	Comparison of the aesthetic facial proportions of Southern Chinese and White women	*Arch Facial Plast Surg*	Southern Chinese	100 adult females, aged 18–40
Liew (2016)	Consensus on changing trends, attitudes, and concepts of Asian beauty	*Aesth Plast Surg*	Asian	N/A
Ngeow and Aljunid (2009)	Craniofacial anthropometric norms of Malays	*Singapore Med J*	Malaysian Malays	100, 50M:50F aged 18–25
Grbesa et al (2007)	Craniofacial characteristics of Croatian and Syrian populations	*Coll Antropol*	Croatian and Syrian	200 of each ethnicity, 50:50 M:F, aged 18–24
Zhuang et al (2010)	Facial anthropometric differences among gender, ethnicity, and age groups	*Ann Occup Hyg*	Caucasian, African American, Hispanic, and other (mainly Asian)	3997, aged 18–66, 2543M:1454 F. 1886 Caucasians, 1223 African Americans, 538 Hispanic, 350 other
Farkas et al (2005)	International anthropometric study of facial morphology in various ethnic groups/races	*J Craniofac Surg*	Caucasian, African American, Asian, and Middle Eastern	1470, aged 18–30, 750M:720F. 780 Caucasians, 180 Middle Eastern, 300 Asians, 210 African Americans
Alam et al (2015)	Multiracial facial golden ratio and evaluation of facial appearance	*PLoS One*	Malaysian Chinese, Malaysian Malay, and Malaysian Indian	286, aged 18–25, 150F:136M, 100 Malaysian Chinese, 100 Malaysian Malay, 86 Malaysian Indian
Kleisner et al (2019)	Nomadic pastoralists and sedentary farmers of the Sahel/Savannah Belt of Africa in the light of geometric morphometrics based on facial portraits	*Am J Phys Anthropol*	Pastors were Arab, Fulani, Tuareg, Farmers included Chadic speakers Nilo-Saharan, and Niger-Congo speakers	473, aged 12–80, 304M:169F. 61 Arab, 180 Fulani, 29 Tuareg, 129 Chadic, 19 Niger-Congo, 55 Nilo-Saharans
Strom et al (2012)	Skin and bones: the contribution of skin tone and facial structure to racial prototypicality ratings	*PLoS One*	Caucasian, African American, and Korean	113, 61F:52M, 39 Caucasian, 28 African American, and 48 Korean
Al-Barakati (2011)	Soft tissue facial profile of adult Saudis. Lateral cephalometric analysis	*Saudi Med J*	Saudi Arabian	61, 31M:30F, mean age of 23
Porter (2004)	The average African American male face: an anthropometric analysis	*Arch Facial Plast Surg*	African American	109, aged 18–30, all male
Choe et al (2004)	The Korean American woman's face: anthropometric measurements and quantitative analysis of facial aesthetics	*Arch Facial Plast Surg*	Korean American	72, 18–35, all female
Gor et al (2010)	Three-dimensional comparison of facial morphology in white populations in Budapest, Hungary, and Houston, Texas	*Am J Orthod Dentofacial Orthop*	Caucasian from Hungary and Houston	200, 50M:50F, equal split across locations
Guo et al (2014)	Variation and signatures of selection on the human face	*J Hum Evol*	Han Chinese, Tibetans, Uyghur, and European	400 Han Chinese, 200M:200F, aged 17–25, 169 Tibetans, 100M:69F, aged 15–22, 89 Europeans, 57M:32F, aged 17–57, 303 Uyghurs, 200F:103M, aged 17–25

intercanthal distance. This proportion is thought to be less relevant as individuals do not look at the mouth and eyes at the same time. Instead, mouth width should be considered relative to the width of the lower face, at a ratio of 40%.[14]

Understanding how individuals from different racial backgrounds age can also aid aesthetic surgeons when performing rejuvenation therapies. A recent study found that Black females reported less severe facial aging than females from Hispanic, Asian, and Caucasian backgrounds.[32] Black individuals also tend to suffer from upper face aging, such as brow ptosis and rhytids later in life due to the increased thickness of their skin.[33] Photoaging is also reduced in this racial group due to the increased melanin production compared to individuals from Caucasian backgrounds.

A future avenue of research is the study of facial morphology in mixed-race individuals, as their facial features may not necessarily correspond to any of the racial groups they originate from. This is particularly important in today's highly globalized and connected worlds, where individuals from different geographic and racial origins are coming together at a rate previously unseen in human history. Given that neoclassical beauty cannons have already been shown to be inadequate for individuals from non-Caucasian backgrounds,[34] researchers will need to come

Table 2. Summary of Findings From Literature Review

Publication title	Main findings
Comparison of the aesthetic facial proportions of Southern Chinese and White women	• Ideal mean width–length of nose was 1.1 in Southern Chinese compared to 0.7 in Whites • Mean nasiolabial angle was 87.8° with a range of 55°-108°, while the ideal in Whites is 90°-120° • Relative proportions of horizontal thirds in Chinese were upper third in 31.4%, and both middle and lower third in 34.3% • 76% of Chinese had a nasal width greater than intercanthal distance, compared to 37.9% in Whites • 96% of Chinese had an intercanthal distance greater than eye width, compared 51.5% in Whites • 61% of Chinese had lip width which corresponded to ideal measurements in White females, while 31% had narrower lips and 8% were wider • Chinese females had a Simmons tip nasal ratio of 1.5 and a Baum ratio of 3.0, while the ideal ratios in White females are 1.0 and 2.8, respectively • Supratarsal creases of Chinese eyelids were 6 mm from the eyelash margin, which is much lower than in White females
Consensus on changing trends, attitudes, and concepts of Asian beauty	• Increased bitemporal, bigonial, and byzygomatic width in Asians, leading to wider forehead, lower face and midface, respectively • Asians also found to have retruded foreheads and orbital rims, making eyelids heavier and puffier and the forehead flatter and slanted backwards • Asians had lower nasal and anterior nasal spine deficiency, leading to a flat, short nose, and wider intercanthal distance • Medial maxilla retrusion found in Asians, resulting in a concave midface and perialar recession • Retrusion of pyriform margin leading to perioral protrusion in Asians • Bimaxillary protrusion and a hypoplastic mandible were also found in Asians, leading to a retruded chin
Craniofacial anthropometric norms of Malays	• Three measurements were found to be statistically significant between Malay and Singaporean Chinese • Head height and intercanthal distance were lower in Malay Chinese • Protrusion of the nasal tip was higher in Malay Chinese • All other differences in measurements were not statistically significant
Craniofacial characteristics of Croatian and Syrian populations	• Head width was statistically significantly higher in Syrians • Head width was statistically significantly higher in Croatians • Face width was not statistically significantly different • Total face height was statistically significantly higher in Croatians • Head index, calculated as head width/head height, was statistically significantly higher in Syrians • Facial index, calculated as face height/width, was statistically significantly higher in Croatians
Facial anthropometric differences among gender, ethnicity, and age groups	• African Americans had shorter, wider and shallower noses than Caucasians • African Americans had larger measurements across all facial features except bigonial breadth, bitragion coronal arc, and head breadth, which had no significant difference • Hispanics had 14 facial features significantly larger than Caucasians, while their nose protrusion, height, and head length were significantly shorter • Group known as other had larger and wider faces and noses
International anthropometric study of facial morphology in various ethnic groups/races	• Only Croatian males and Iranians had foreheads that were significantly smaller than North American White used as comparison • Mouth width was significantly larger in 33.3% of Hungarian males and significantly smaller in 36.7% of Vietnamese males • Tonga males' ear length was smaller than North American White in 40% • Lower face height in Hungarian and Slovakian females was significantly smaller • Italians, Slovaks, Singaporean Chinese, Vientnamese, Japanese, and Thais from both sexes had significantly larger mandibles, whereas Portuguese individuals from both sexes had significantly smaller mandibles • Face height was greater in Iranian females whereas it was smaller in Egyptian females • Intercanthal width and eye fissure length were smaller in Iranians, while biocular width in males was larger and smaller in females • Eye fissure length was also greater among both sexes of Singaporean Chinese, Vietnamese females, and Thai and Japanese males • Biocular width was greater in both sexes of Zulus, Afro-American males and females, and Angolan females • Nose height was greater among Greeks, Turkish, and Portuguese females and both Iranian sexes, but shorter in Hungarian females • Nose width was greater in both sexes of Thais, Singaporean Chinese, Vientamese, and Japanese, as well as in 3 African ethnic groups and male Tongans • Nasal height was smaller in both male and female Indians
Multiracial facial golden ratio and evaluation of facial appearance	• Significant difference between MC and MM, and between MC and MI for upper face height and total face height • Middle face height was also significantly different between MM and MC • Significant difference between MC and MI for Zygion to Zygion • No racial difference for lower face height
Nomadic pastoralists and sedentary farmers of the Sahel/Savannah Belt of Africa in the light of geometric morphometrics based on facial portraits	• Pastoralists had vertically prolonged and narrow faces, whereas farmers" faces were rounder and oval-shaped. • Pastoralists also had longer but narrower noses, thinner lips, and larger eyes • Farmers had shorter and wider noses, fuller lips, and smaller eyes • Farmers had bigger lower faces and smaller upper faces

Table 2. Continued

Publication title	Main findings
Skin and bones: the contribution of skin tone and facial structure to racial prototypicality ratings	• Compared to Koreans, White faces had a longer distance between upper and lower eyelid, reduced jaw width, smaller eye and eyebrow separation, larger mouth, and horizontal eye width • When compared with Korean faces, Black faces had smaller jaw width, wider and shorter noses, smaller eye and eyebrow separation, larger mouth width, and horizontal eye width • White faces had wider jaws, thinner lips, lower eyebrows, and narrower noses than Black faces
Soft tissue facial profile of adult Saudis. Lateral cephalometric analysis	• Saudi males were found to have a statistically significantly greater facial convexity angle • Males from this group also had significantly more protrusive upper and lower lips, greater mentolabial sulcus, longer lower facial height, and a larger incisor exposure below the upper lip than Caucasians • Saudi females also had a significantly greater facial convexity angle, as well as a lower vertical height depth ratio • Saudi females had a greater nasolabial angle, more protruding lower lips, greater incisor exposure, and longer lower facial height
The average African American male face: an anthropometric analysis	• Of 24 measurements, 21 were different from the North American Caucasian standard • Greatest differences were that African Americans had shorter nasal length but greater alar width, shorter nasal tip protrusion, wider nasal root, and more acute nasolabial angle • Only Cannon VI of neoclassical beauty pertained to African Americans, which is orbital proportion • Oval was the most common shape for the nasal base in 49.5%, followed by trapezoidal in 40.4% • Nostrils were vertically orientated in over half of all patients • Upper and middle face of African Americans was also shorter than Whites • African American females also had larger foreheads than White females • In both sexes, the middle third of the face is shorter than the upper and lower thirds, which were roughly equal
The Korean American woman's face: anthropometric measurements and quantitative analysis of facial aesthetics	• 24 of 26 anthropometric measurements taken showed statistically significant differences between Korean and White females • Only 1% of Koreans had an equal distance between endocanthions and from alare to alare, whereas these 2 measurements were equal in White females in 41% of individuals • Interendocanthial distance was greater than interalar distance in 61% of cases in Koreans, whereas in Whites, it was 21%. • Korean females were also more likely to have a greater interendocanthial distance than the distance between endocanthion and exocanthion compared to White females (100% and 52%, respectively) • Korean females were more likely to have a cheillon-to-cheillon separation smaller than 1.5 × interalar distance, whereas the opposite was true for White females • Interalar distance being greater than 0.25 × of zygion-to-zygion distance was more common in Koreans, whereas the opposite was true in White females • Both Korean and White females had a smaller upper face than the lower third • The middle third of Korean faces was larger than the lower third in the majority of patients, whereas the opposite was more common in White faces. • A larger middle than upper third of the face was the norm in 90% of Korean females, whereas in White females, the middle third was smaller in 93% of patients. • Korean females had wider faces and greater interocular distance on average (139 vs 130 mm and 36.9 mm vs 31.8 mm, respectively) • The nasofrontal and nasofacial angle was also greater in Koreans (136.8° vs 134.3° and 32.3° vs 29.9°, respectively) • However, Korean females also had smaller mean eye fissure length (27.3 mm vs 30.7 mm). • Nasolabial angle was more acute in Korean females (92.1° vs 104.2°). • The nose of Koreans was wider at the base and nasal root (35.5 mm vs 31.4 mm and 21.1 mm vs 18.4 mm, respectively) • Nevertheless, Korean females had thinner ala (4.5 mm vs 5.3 mm), and shorter columella and alar length (7.6 mm vs 11.5 mm and 29.9 mm vs 31.5 mm, respectively) • Lastly, Korean females had a similar mouth width to White females, but Korean lips were thicker than the White norm (19.1 mm vs 18.1 mm)
Three-dimensional comparison of facial morphology in white populations in Budapest, Hungary, and Houston, Texas	• Hungarian females had a larger mandibular body and ramus, and more prominent nose, lips, and upper forehead • Hungarian females were also found to have smaller interocular distance, smaller eyes, malar regions, and subnasal areas • Hungarian males had more prominent noses, brows, malar regions, and upper lips • These males had smaller mandibles, chins, and eyelids
Variation and signatures of selection on the human face	• The cheeks, brow area, and nose were the most prominent differentiating features between Europeans and Han Chinese in both sexes • The differences in the cheek were explained due to changes in relative position and orientation relative to the whole face rather than shape • The strongest interlandmark differentiators were the naso-endocanthion and pronasale-alare • Cheeks, nose, and eye sockets showed high differentiation between Uyghurs and Han Chinese • There was a smaller degree of differentiation between Tibetans and Han Chinese, limited to the brow ridge and lower mandibular region • Nasal differences of Uyghurs or Europeans with Tibetans and Han Chinese were due to nasal height and nasal protrusion • Uyghurs were halfway between East Asians and Europeans, with East Asians showing recessive nose dorsum while Europeans had a prominent nasal bridge • East Asian nose also had a broader base

MC, Malaysian Chinese; MI, Malaysian Indian; MM, Malaysian Malay.

up with new ways of studying facial beauty with new combinations of proportions. This can be complicated in subjective studies by upbringing and self-identification. There is evidence to suggest that cultural assimilation affects an individual's judgment of facial beauty. This means that individuals who do not reside or were not born in their ethnic country of origin, such as Korean Americans may have different views on what makes a face attractive than individuals from the same ethnicity who have only lived in Korea.[35] It is currently unknown how much cultural assimilation affects our judgment, but we do know that this influence needs to be considered when creating these new cannons. Additionally, it may be difficult to find enough interracial individuals who identify as being from the same ethnic origin, as these individuals may not even agree with previous classifications of their background.

There could be a concern that the database might not be a true representation of various ethnic beauty ideals, a potential limitation worth mentioning. We believe that the following factors introduce the sufficient variability to ensure that our database is representative of diverse ethnic backgrounds. Firstly, 3 different competitions were used, each of which would have had different sets of judges over the 20 or 15 years for which we compiled data. Secondly, these females who have won these competitions have been considered to be universally beautiful. Lastly, the reviewers then reviewed each individual and marked down their ethnic origin, which ensured proportionate representation of ethnic groups within our database. Despite not being entirely ideal, this method does introduce the objectivity and consistency needed to compile such a database.

Further limitations of this study include a limited size database, 2870 and 10,000, which cannot be reliably extrapolated for the entire world population, but is an insightful start nonetheless. Furthermore, creating 3D reconstructions from 2D photographs is a reliable methodology but is not as perfect as using real-time 3D photographs; though creating this 3D photograph database of the same individuals over the past 20 years would be impossible, so this technique allows us to carry out this study. The strength of the literature review is limited by the body of evidence available. Many of the papers did not assess facial morphology using the same methods, as some used photogrammetry instead of direct anthropometry. The computer programs used to analyze facial features were also not standardized across studies. Finally, the definition and classification of separate ethnicities and races may not have been the same in different studies, leading to discrepancies in how individuals were classified. And studies comparing aesthetic databases to general populations for facial dimensions, beauty, and race using PCA and 3D space models are limited to our study alone. Despite the complicated conceptual and mathematical nature of the tools used, ultimately we believe that this paper set out to answer relatively straightforward questions, albeit through a completely novel approach using advanced computer modeling methods. It has laid the groundwork for further studies to use these modeling methods not only for theoretical purposes, but also potentially in a translational manner with real patients at some point in the future.

CONCLUSIONS

Aesthetic female faces have commonalities in facial features among each other, regardless of the racial demographic. The dimensions of these features vary from that of a baseline population. There is evidence that individuals from different racial demographics share features among themselves that can be used to separate them from individuals of other racial demographics. There may be a common aesthetic pattern of human faces that transcends racial demographics, which will need more work to elucidate.

Gaining a better understanding of the differences in facial structure across individuals from different races is allowing clinicians to provide increasingly tailored treatment options to their patients based on their individual facial parameters. However, this understanding has also shown us that neoclassical beauty cannons are no longer fit for purpose when using them to judge facial beauty in non-Caucasians. We therefore need to understand how variations in aesthetic subunits interact with each other in our increasingly diverse human population, in order to come up with new standards of facial beauty which are applicable for all humans. This will allow patient-specific tailoring of aesthetic or reconstructive practice that will allow for aesthetically pleasing results while conserving the dimensions of features that reflect racial and ethnic origin.

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