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A Cross-Sectional Study to Determine and Compare the Craniofacial Anthropometric Norms in a Selected Kenyan and Chinese Population

Une Étude Transversale Pour Déterminer et Comparer Les Normes Anthropométriques Craniofaciales Auprès de Populations Kéniane et Chinoise Sélectionnées

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Abstract

Background: Craniofacial anthropometry provides essential data for diagnosis and treatment planning, with the norms for many races having been investigated. The results reveal that facial morphometry varies greatly because of geographical, ethnic, and racial variations. This study aims to gather the normative anthropometric data and compare the differences in facial morphometry between the Kenyan population and that of the Chinese. **Methods:** Four vertical measurements (trichion–nasion, nasion–subnasale, subnasale–gnathion, and superaurale–subaurale) and 6 horizontal measurements (zygion–zygion, exocanthion–endocanthion, endocanthion–endocanthion, pupil-pupil, alare–alare, and chelion–chelion) were obtained manually from subjects with no craniofacial abnormality. **Results:** A total of 180 participants (90 Kenyans and 90 Chinese) were included. Among the Kenyans, males generally had greater dimensions in comparison to the Kenyan females with the exception of the upper third, lower third, and intercanthal, and interpupillary distances. Among the Chinese, there was a significant difference between the 2 genders with the exception of intercanthal distance. All measurements were greater in Chinese males in comparison to the females. Comparison between races shows that Kenyans had greater vertical measurements with exception of the ear length for both genders. The Chinese males had increased facial width and intercanthal distance, while the Chinese females showed increased intercanthal distance compared to Kenyans. Kenyans exhibited hyperleptoprosopic-type face, while Chinese exhibited mesoprosopic-type face, with none of the 2 groups conforming to the neoclassical canons. **Conclusion:** Kenyans generally have greater craniofacial measurements versus Chinese, except for the facial width and intercanthal distance for males and interorbital distance for females.

Résumé

Historique : L'anthropométrie craniofaciale fournit des données essentielles pour planifier le diagnostic et le traitement, et les normes de nombreuses races ont été explorées. Les résultats révèlent que la morphométrie change énormément en fonction des variations géographiques, ethniques et raciales. La présente étude vise à colliger les données anthropométriques normatives et à comparer les différences entre les morphométries faciales des populations kényane et chinoise. **Méthodologie :** Les chercheurs ont effectué quatre mesures verticales (trichion–nasion, nasion–point sous-nasal, point sous-nasal–gnathion et point superaural–point subaural) et six mesures horizontales (zygion–zygion, exocanthion–endocanthion, endocanthion–endocanthion, pupille-

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pupille, point alaire–point alaire, chélion–chélion) manuellement chez des sujets que ne présentaient pas d'anomalies craniofaciales. **Résultats :** Au total, 180 participants (90 Kényans et 90 Chinois) ont participé. Les dimensions étaient généralement plus grandes chez les Kényans que chez les Kényanes, à l'exception du tiers supérieur, du tiers inférieur et des distances intercanthale et interpupillaire. Chez les Chinois, on constatait une différence importante entre les deux sexes, à l'exception de la distance intercanthale. Toutes les mesures étaient plus grandes chez les hommes chinois que chez les femmes. La comparaison entre les races révèle que les Kényans avaient de plus grandes mesures verticales, à l'exception de la longueur des oreilles pour les deux sexes. Les hommes chinois présentaient une face plus large et une plus grande distance intercanthale, et les femmes chinoises, une plus grande distance intercanthale que les Kényans. Les Kényans avaient une face de type hyper-leptoprosope et les Chinois, une face de type mésoprosope, et aucun des deux groupes ne correspondait aux canons néo-classiques. **Conclusion :** En général, les Kényans ont des mesures craniofaciales plus grandes que les Chinois, sauf la largeur de la face et la distance intercanthale chez les hommes et la distance interorbitale chez les femmes.

Keywords
Chinese, craniofacial anthropometry, facial morphology, Kenyan African

Introduction

Craniofacial anthropometry provides data that are crucial during diagnosis and treatment planning for reconstruction surgery.[1-5] The value of these anthropometric measurements is accentuated in cases of bilateral trauma or disease, in which no contralateral point of reference can be used.[6] Several studies have established normative anthropometric measurements in some races/ethnicities.[7-16] However, there is scarce data from the African continent.[7,8,17-25] Studies reveal that facial norms of one population group differ in comparison to another when geographical, ethnic, and racial variations exist.[25,26] In light of this, it is necessary to note that there may be a high risk of poor surgical outcome if the norms are generalized across populations.[5]

The Chinese make up >1.5 billion of the world's population and are distributed across numerous countries. There are several reports that describe their craniofacial anthropometric norms.[25-31] Kenya in particular has a large Chinese population which requires the surgeons to tailor facial surgical procedures with respect to their ethnicity. One study evaluated sexual dimorphism for facial features within Chinese and African American populations[29], however, to date, there has been only one comparative study between the Chinese and the Kenyan populations.[7] This study compared their angular soft tissue dimensions, as seen in standard facial profiles. Their differences in facial morphology may influence the choice of treatment, but our knowledge is still limited. Therefore, this study aims to further gather the normative anthropometric data in order to assess the differences in facial morphometry between the Kenyan population and that of the Chinese.

Materials and Methods

This study was approved by the Kenyatta National Hospital–University of Nairobi Ethics and Research Committee. All measurements were conducted after the informed consent form was signed. A total of 180 participants were included in the study (age range of 21-35 years), of which 90 were local Kenyans and 90 were Chinese, recruited using a random sampling method. All subjects (1) had no history of craniomaxillofacial surgery, (2) had no orthodontic treatment, and (3) had class I occlusion. All measurements were made using a digital electronic sliding caliper (VINCA DCLA-0605). During data collection, the participants remained seated with the Frankfort horizontal plane parallel to the ground. Each measurement was taken twice by the same examiner and a third reading was taken by another examiner, thus enhancing intraexaminer and intraexaminer reliability. This methodology is adapted from the approach used by one coauthor.[14,15] A total of 10 measurements were carried out, which are summarized in Table 1. These parameters were adopted based on the advice of Leslie G. Farkas, MD, PhD, DSc, FRCSC., 25th March 2005 (personal communication) prior to his demise, who opined that they should be able to highlight/determine differences of any population studied, based on a minimum number of 35 subjects.

Four neoclassical facial canons, orbitonasal canons (en-en = al-al), orbital canon (en-en = en-ex), naso-oral canon (ch-ch = 1½ al-al), and nasofacial canon (al-al = ¼ zy-zy) were

Table 1. Landmarks Used for the Anthropometric Measurements.

Landmark	Definition
Vertical measurements	
Trichion *(tr)*–nasion *(n)*	Upper facial third
Nasion *(n)*–subnasale *(sn)*	Middle facial third
Subnasale *(sn)*–gnathion *(gn)*	Lower facial third
Superaurale *(sa)*–subaurale *(sba)*	Ear length
Horizontal measurements	
Zygion *(zy)*-zygion *(zy)*	Facial width
Exocanthion *(ex)*-endocanthion *(en)*	Eye width
Endocanthion *(en)*-endocanthion *(en)*	Intercanthal distance
Pupil *(p)*-pupil *(p)*	Interpupillary distance
Alare *(al)*-alare *(al)*	Nasal width
Chelion-chelion *(ch-ch)*	Mouth width

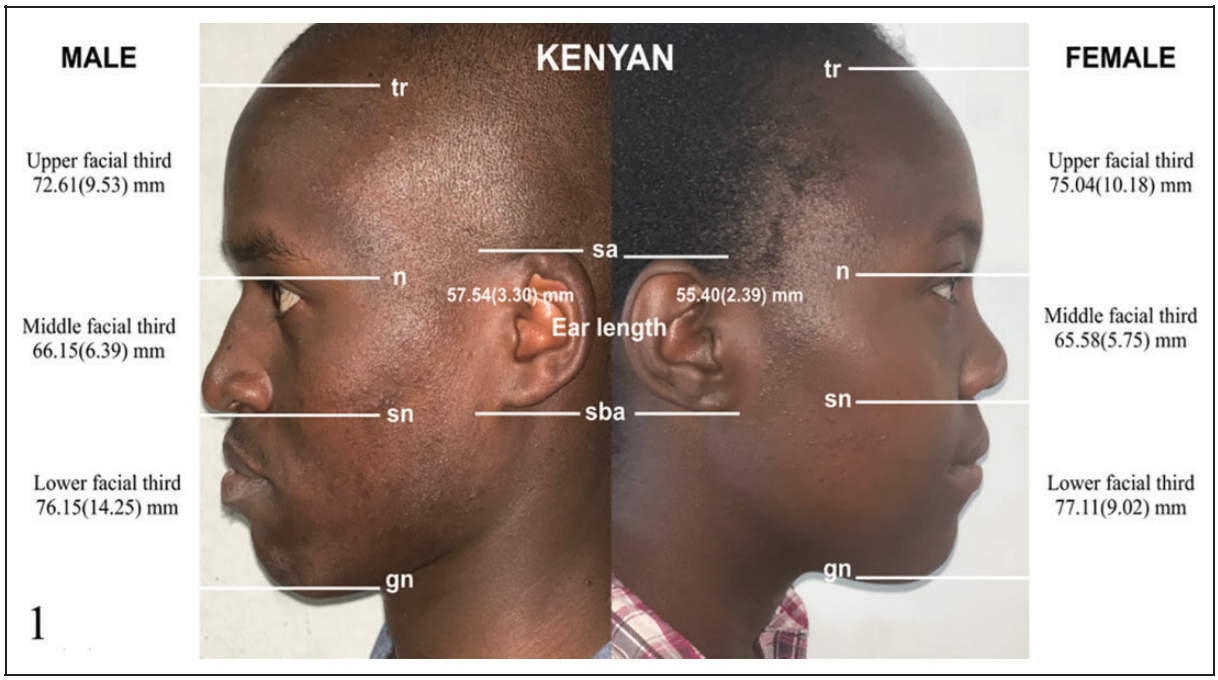

Figure 1. Normative vertical anthropometric measurements for both Kenyan males and females, mean (SD). Measurements of the upper and lower facial thirds were greater in females, while middle facial third and ear length were greater in males. There is significant sexual dimorphism in the ear length. *Independent *t* test, $P = .0008$.

calculated. In addition, 3 different proportion indices were also derived, namely:

i. Facial index $= \frac{n-gn}{zy-zy} \times 100$.
ii. Lower face − face height index $= \frac{sn-gn}{n-gn} \times 100$.
iii. Nasal index $= \frac{al-al}{n-sn} \times 100$.

The statistical analysis was carried out using SPSS (IBM statistics version 26), and descriptive statistics were computed. Independent *t* tests were used to compare means of the measurements between gender and race. A *P* value of <.05 was considered as statistically significant.

Results

The anthropometric measurements in this study were obtained from 45 Kenyan males (KM), 45 Kenyan females (KF), 40 Chinese males (CM), and 50 Chinese females (CF). A comparative analysis of KM and KF is summarized in Figures 1 and 2. Most measurements were similar between gender ($P > .05$), with the exception of the ear length and facial width. In general, KM had greater dimensions in comparison to the KF, with exception of the upper third, lower third, intercanthal distance, and interpupillary distance. The normative anthropometric measurements for the CM and CF are summarized in Figures 3 and 4. The results revealed significant differences with the exception of intercanthal distance ($P = .32$). Otherwise, all measurements were greater in the CM.

Comparison of both populations show that the Kenyans had significantly greater vertical measurements ($P < .05$) with the exception of the ear length (Table 2). With regard to horizontal measurements, facial width and intercanthal distance were the only 2 parameters greater in CM, while all other measurements were greater in KM. In the case of females, similarity was noted solely in the intercanthal distance (Table 2). Except for the facial width, all horizontal measurements were found to be significantly greater in the KF.

Most subjects were found to have low conforming to the neoclassical canons. Neoclassical facial canons found most frequently to be valid in Kenyan was the nasofacial canon (38.9%), followed by the orbitonasal canon (36.7%) and orbital canon (20.8%). The least frequent was the naso-oral canon (2.4%). In Chinese, the most valid canon was the orbital canon (22.2%), nasofacial canon (21.1%), and orbitonasal canon (17.8%), while the least common was the naso-oral canon (1.2%). As for the 3 different proportion indices, it was found that Kenyans had a facial index of 107.2%, lower face–face height index of 53.8%, and nasal index of 68.5%, while the Chinese had lower values of 88.5%, 52.6%, and 64.7%, respectively.

Discussion

Facial normative (and aesthetic) analysis is the primary step in treatment planning for patients who require orthognathic and craniofacial reconstructive surgery.[22] Numerous methods of obtaining anthropometric data have been described such as indirect anthropometry that includes photogrammetry and 3D scanning photogrammetry.[32] However, despite the

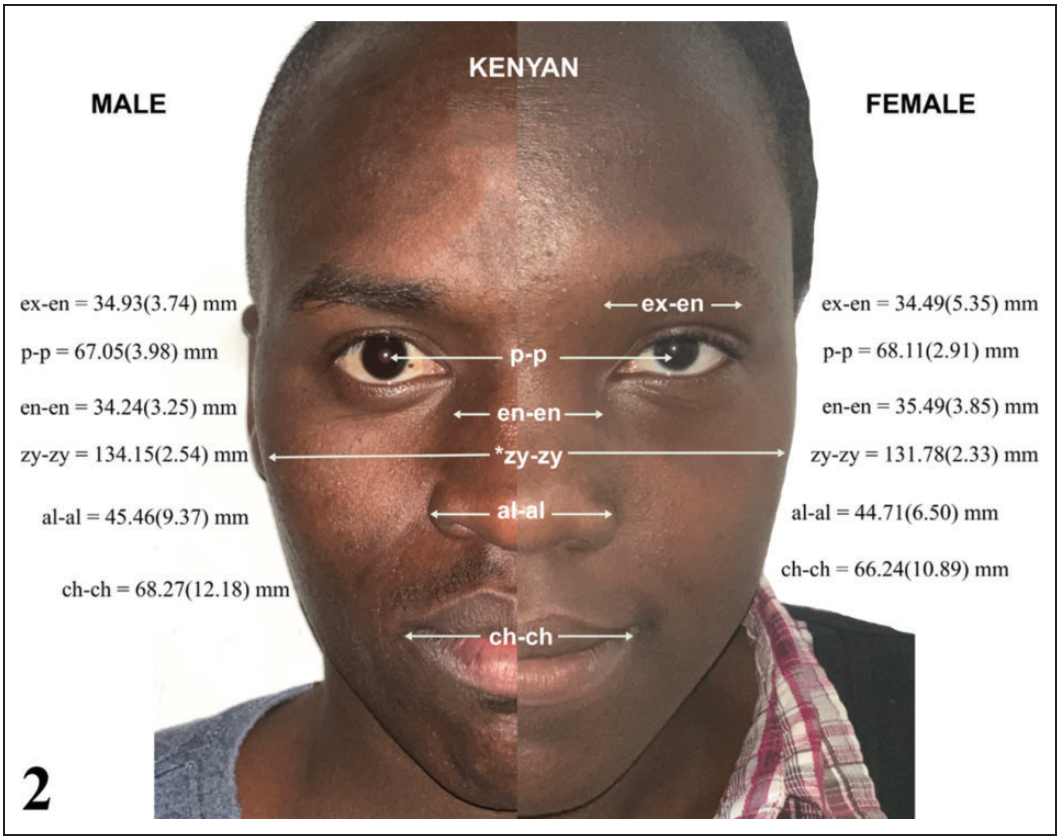

Figure 2. Normative horizontal anthropometric measurements for both Kenyan males and females, mean (SD). There is sex dimorphism in only the face width, with measurements being significantly greater in males. *Independent *t* test; $P = .0001$.

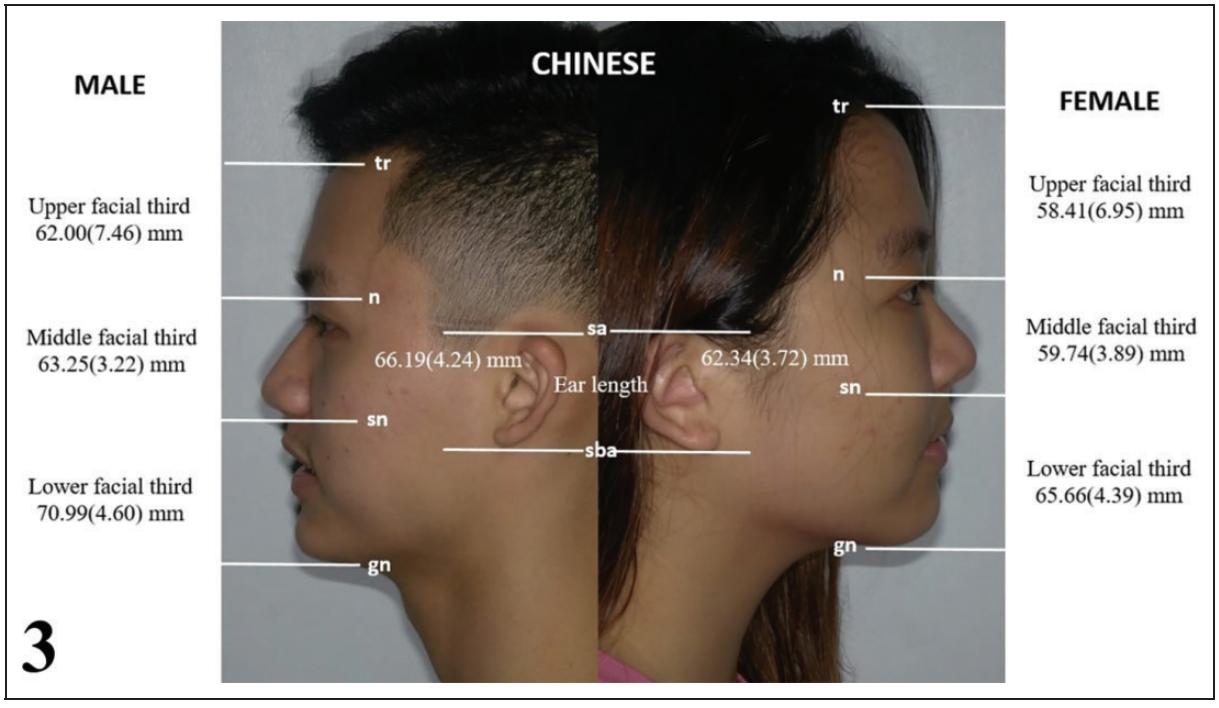

Figure 3. Normative vertical anthropometric measurements for both Chinese males and females, mean (SD). There is sex dimorphism in all parameters, with measurements being significantly greater in males. *Independent *t* test; $P = .0001$.

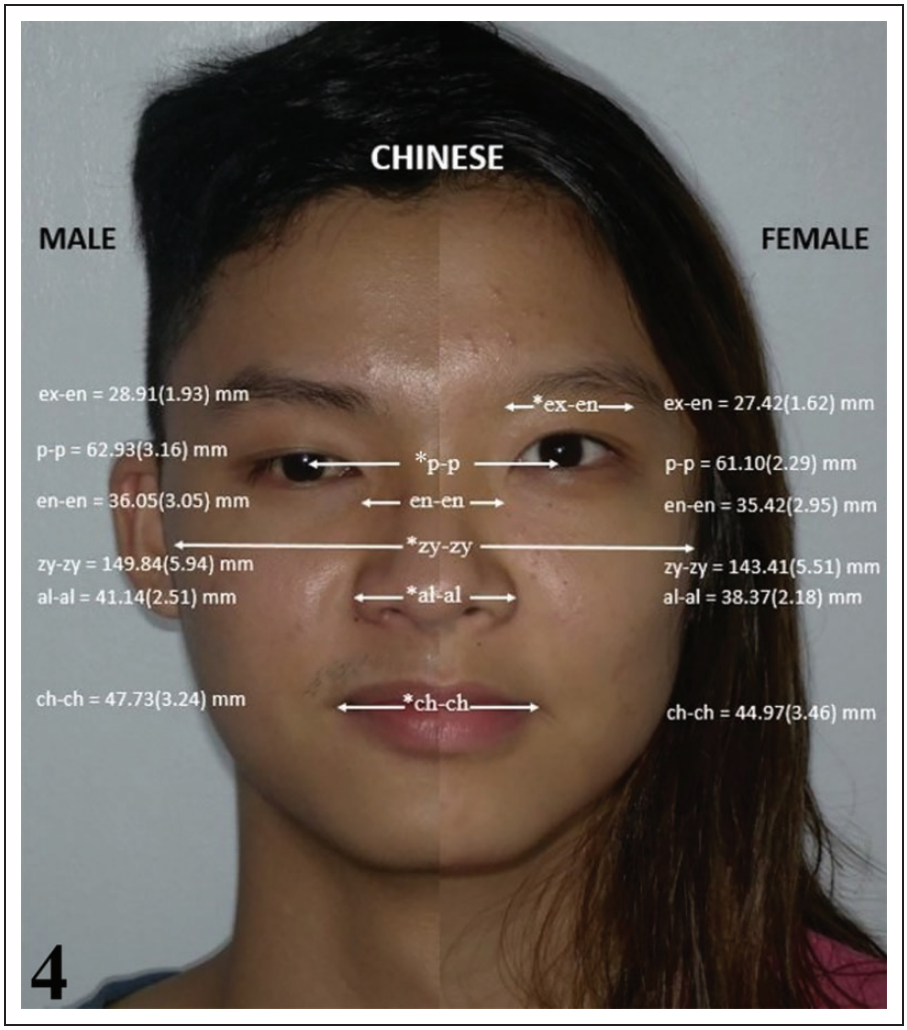

Figure 4. Normative horizontal anthropometric measurements for both Chinese males and females, mean (SD). There is sex dimorphism in all parameters except for the intercanthal distance (*Independent *t* test; $P = .32$), with all measurements being significantly greater in males.

Table 2. Comparison of the Mean Anthropometric Values Between Kenyans and Chinese Young Adults.

	KM, mean (SD)	CM, mean (SD)	*P* value (95% CI)	KF, mean (SD)	CF, mean (SD)	*P* value (95% CI)
Vertical measurements						
Upper third *(tr-n)*	72.61 (9.53)	62.00 (7.46)	.0001	75.04 (10.18)	58.41 (6.95)	.0001
Middle third *(n-sn)*	66.15 (6.39)	63.25 (3.22)	.0113	65.58 (5.75)	59.74 (3.89)	.0001
Lower third *(sn-gn)*	76.15 (14.25)	70.99 (4.60)	.0314	77.11 (9.02)	65.66 (4.39)	.0001
Ear length *(sa-sba)*	57.54 (3.30)	66.19 (4.24)	.0001	55.40 (2.39)	62.34 (3.72)	.0001
Horizontal measurements						
Facial width *(zy-zy)*	134.15 (2.54)	149.84 (5.94)	.0001	131.78 (2.33)	143.41 (5.51)	.0001
Eye width *(ex-en)*	34.93 (3.74)	28.91 (1.93)	.0001	34.49 (5.35)	27.42 (1.62)	.0001
Intercanthal distance *(en-en)*	34.24 (3.25)	36.05 (3.05)	.0100	35.49 (3.85)	35.42 (2.95)	.9205
Interpupillary distance *(p-p)*	67.05 (3.98)	62.93 (3.16)	.0001	68.11 (2.95)	61.10 (2.29)	.0001
Nasal width *(al-al)*	45.46 (9.37)	41.14 (2.51)	.0059	44.71 (6.50)	38.37 (2.18)	.0001
Mouth width *(ch-ch)*	68.27 (12.18)	47.73 (3.24)	.0001	66.24 (10.89)	44.97 (3.46)	.0001

Abbreviations: CF, Chinese females; CM, Chinese males; KF, Kenyan females; KM, Kenyan males.

advances in technology, factors such as errors in analysis software, movement of the subject during the scanning process, and the high cost of equipment render direct (manual) anthropometry as being the most practical and cost-effective method of obtaining such information.[11] In the current study, numerous anthropometric parameters included were adopted from the study by Olusanya et al.[17] These parameters also concurred with the advice from an authority (Farkas) and

helped reduce contact time with subjects in view of the COVID-19 pandemic that was raging at the time of the study. All measurements were obtained manually following the methods described by Farkas, with echo training provided by one of the coauthor to the team based on his previous working experience with Farkas.[33] Landmarks that required confirmation, if any, were discussed via electronic communication prior to the commencement of the study.

Facial anthropometric data for the North American and European white populations are widely reported,[33] but these data cannot be generalized to all ethnic populations. Hence, an attempt has been made to obtain international anthropometric data of various ethnic groups/races in 2005.[25] From a clinical point of view, it is difficult to establish "normal" from "abnormal" in the face owing to the wide range of parameters such as age, gender, ethnicity/race, or cultural desires.[22] As some of the anthropometric norms of Kenyan[7,8] and Chinese [25,28,29,34,35] have been reported, the present study instead decided to compare their craniofacial norms over 4 vertical and 6 horizontal parameters with the aim to complement previous findings. These normative data were chosen as they can be recalculated to derive the neoclassical canon as described by Olusanya et al.[17] However, in our subjects, most of them were found to not conform with the neoclassical canons, in agreement with a previous finding from Kenya.[8]

Three different proportion indices were calculated from the measurements obtained. The facial index revealed that Kenyan faces were long and narrow (hyperleptoprosopic-type), while that of the Chinese were short and broad (mesoprosopic-type). The lower face–face height index was found to be relatively similar between the 2 groups, while the nasal index revealed that the ratio of the nasal breadth to its height was greater for Kenyans than the Chinese. The significant difference in facial index is an important facial feature that is ethnically related. In contrast, the last proportion provides more concise features that are especially useful when reconstructing a defective nose of the Kenyan or Chinese.

One study comparing the facial morphologies of the Kenyan against North American whites and American African reported obvious differences against the former population and less marked difference against the latter population.[8] Similarly, studies comparing the facial morphologies of the Chinese population against different races reported obvious differences to that of the Greek (Caucasian)[28] and African American.[28] Although there is a study that compared the anthropometric data of the African American and Chinese,[29] it is unsure if these findings can be extrapolated to the Kenyan population. The current findings thus provides more accurate data applicable to the African continent.

In general, the current findings reported slightly larger measurements in 6 parameters than that reported by Virdi et al earlier.[8] The intrapopulation analysis between the KM and KF revealed similarity between the 2 genders with the exception of the ear length and facial width. This is in contrast to that reported on African American and Nigerian, whereby males generally manifested greater anthropometric measurements, except for the mouth width in Nigerians.[17,29] The existence of these variations indicates geographical and perhaps genetic differences among Africans; in addition, the American Africans may have mixed genetic heritage due to their historical background. These differences shall be taken into account during aesthetic and reconstructive surgery on the faces of Kenyans.[36] On the other hand, a similar analysis between the CM and CF revealed significant differences between anthropometric measurements of the 2 groups. In accordance with other studies,[25,37] the CM face may be described as being larger than that of the CF face, which lies in contrast to the findings in the Kenyan cohort.

The observation of significant anthropometric differences in nearly all facial parameters between the 2 races studied supports the fact that substantial facial variation exists between different races/ethnicities.[5,10,26,36] This finding is also in agreement with the finding by Liu et al,[29] who reported that the American Africans have larger facial height and width in comparison to the Chinese, except for the intercanthal width and middle third face height. In this study, the greatest differences were found in the measurements of the upper third, lower third, facial width, and mouth width, which were all greater in the Kenyan cohort, while the smallest difference was in the middle third and the intercanthal distance.

All in all, the current anthropometric data should be given due consideration during pre-and postsurgical assessment of patients to ensure satisfactory outcome.[36] It may offer a guide in analysis of the face for the surgeons practicing in Africa and those elsewhere who happen to receive patients of these 2 ethnicities requesting facial enhancement surgery.

Conclusion

The present study provides direct comparison of craniofacial norms of the Kenyan and Chinese over 4 vertical and 6 horizontal parameters. Kenyans generally have greater craniofacial measurements versus Chinese, except for the facial width and intercanthal distance for males and interorbital distance for females. They exhibited hyperleptoprosopic-type face, while the Chinese exhibited mesoprosopic-type face. Gender-wise, KM generally had greater dimensions in comparison to the KF, with the exception of the upper third, lower third, and intercanthal and interpupillary distances. All measurements were greater in CM in comparison to the females with the exception of intercanthal distance.

Declaration of Conflicting Interests

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