PHOTOGRAMMETRIC ANALYSIS OF FACIAL ATTRACTIVENESS IN MALAY MALAYSIAN WOMEN

DR AKMAL HISHAM MISWAN

DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SURGERY (PLASTIC SURGERY)

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I would especially like to thank Associate Professor Dr. Wan Azman Wan Sulaiman for being my supervisor and providing me the opportunity to study and explore this interesting subject of the human face, anthropometry, and attractiveness. I acknowledge that I may have tested your patience during my time here, but your consistent guidance, wisdom and editorial comments in your unique ways are something that I appreciate and will never be forgotten. Thank you.

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Last but not least, to all the women volunteers in this study, thank you for your willingness to be photographed and analyzed by an unknown plastic surgery trainee like I am. Thank you.

I dedicate this dissertation to my wife Siti Liyana Sheikh Yahya and my daughter Leah Elaika Akmal Hisham.

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LIST OF SYMBOLS, ABBREVIATIONS OR NOMENCLATURE

IAW	Indian American Women
KAW	Korean American Women
Kg	Kilogram
m^2	Square metre
MMW	Malay Malaysian Women
NAWW	North American White Women
°	Degree

ABSTRAK

Pengenalan Asian merupakan kumpulan etnik dengan kepelbagiaan latar belakang dan mempunyai ciri-ciri wajah yang berlainan diantara wajah kebanyakan dan wajah yang menarik. Tujuan kajian ini adalah untuk menentukan ukuran antropometri wajah wanita melayu Malaysia (MMW), membandingkan keputusan kajian ini berbanding wajah wanita kaukasia (NAWW), Neoclassical canons of facial proportions dan etnik-etnik Asian yang berlainan; serta menentukan kriteria anthropometri wajah yang menarik dikalangan MMW.

Metodologi Satu kajian keratan rentas membabitkan kaedah fotogrammetri telah dijalankan. Untuk bahagian pertama, kami mengumpul gambar depan dan sisi daripada sejumlah 103 sukarela MMW berusia 18 ke 35 tahun. Sebanyak 24 ukuran anthropometri dicatatkan untuk setiap wajah. Perbandingan kepada data norma NAWW dan facial canon proportions dikaji. Untuk bahagian kedua, 10 orang panel penilai membuat penilaian estetik untuk setiap wajah menggunakan 10-point Likert's scale. Perbandingan antara wajah menarik MMW (15% teratas) kepada wajah purata MMW (85% selebihnya), NAWW, dan kumpulan etnik yang lain dikaji.

Keputusan Neoclassical facial canons didapati tidak praktikal untuk kebanyakan wajah wanita melayu. Terdapat perbezaan yang signifikan diantara 20 daripada 24 ukuran antara wajah MMW dan NAWW. Wajah menarik MMW menunjukkan ketinggian 'total face', ketinggian 'lower face' dan kelebaran mandible yang lebih kecil berbanding wajah purata MMW. Perbandingan antara wajah menarik dan wajah purata MMW berbanding etnik-etnik yang lain menunjukkan kepelbagaian perbezaan yang signifikan.

Kesimpulan Penggunaan satu standard analisis bedasarkan piawaian populasi kaukasia atau kumpulan Asian yang lain adalah tidak praktikal untuk wanita melayu. Kajian ini memperincikan ukuran anthropometri wajah dan kriteria estetik untuk MMW. Data kajian ini boleh diaplikasikan sebagai rujukan untuk analisa wajah dikalangan wanita berkuturunan melayu.

ABSTRACT

Background Asians are a heterogeneous group with different average and attractive facial features between individual ethnicities. This study aimed to establish normative anthropometric measurements of the Malay Malaysian Women's (MMW) face, compare results with the standard for North American White Women (NAWW), the neoclassical canons of facial proportions and other Asian ethnicities; and quantitatively defined aesthetic facial features in the MMW.

Methods This is a cross-sectional photogrammetric study. In part 1 of this study, we obtained standardized frontal and lateral facial photographs of 103 MMW volunteers between the ages of 18 to 35. For each face, we measured 24 standard anthropometric parameters. We compared our results with the published NAWW norms and the facial canons proportions. In part 2 of the study, ten raters evaluated the photographs for aesthetics using a 10-point Likert's scale. Attractive MMW (top 15%) were compared with the average MMW (remaining 85%), NAWW, and other ethnicities.

Results The neoclassical facial canons were not found to apply to most of the MMW. We found significant differences between MMW and NAWW in 20 of 24 measurements ($p<0.05$). Attractive face in the MMW had a smaller total face height, smaller lower face height, and narrower mandible width compared to the average MMW. Comparing the normative and attractive MMW with other ethnicities indicated various interracial differences.

Conclusion Grouping this patient into a single Asian category or using analysis standards used for whites are impractical. This study detailed comprehensive facial anthropometric data and aesthetic criteria for this population. The values presented here could be used as a standard for facial analysis in women of Malay descent.

CHAPTER 1: INTRODUCTION

1.1 Introduction

Know the ideal beautiful normal. The eight principles in Millard's Principalization of Plastic Surgery(Millard, 1986) underlies many endeavors in facial attractiveness studies in our field. One main cue theorized to influenced facial attractiveness is that 'averageness is beauty'(Bashour, 2006a; Jones and Hill, 1993; Rhodes, 2006). Critics argued that attractive face is extraordinary, not ordinary or average. (Rhodes, 2006) Of course, the average and the attractive face vary according to race. Astute understanding of the facial relationship between normalcy and beauty is therefore paramount for facial plastic surgeons. The goal is not only to obtain an aesthetically pleasing result based on a single universal standard but one that is also congruent with the patients' ethnicity and gender-specific features.

Most commonly used methods to analyze facial aesthetics is direct anthropometry, pioneered by Farkas. Considered as the modern father of facial anthropometry, Farkas et al. have defined a complete set of facial measurements and studied objective facial aesthetic characteristics across different ethnicities,(Farkas *et al.*, 2005; Farkas *et al.*, 2008) ages(Farkas *et al.*, 2004), facial attractiveness(Farkas and Kolar, 1987) and various craniofacial deformities. (Farkas *et al.*, 2002) Another alternative method is photogrammetry, an indirect anthropometry measurement taken from standardized photograph. (Farkas and Deutsch, 1996; Nechala *et al.*, 1999) Farkas demonstrated that 26 of 62 obtainable landmarks on the facial photographs were reliable. (Farkas *et al.*, 1980) Other studies have also demonstrated the reliable measurements obtainable in photogrammetry. (Aksu *et al.*, 2010; Bishara *et al.*, 1995; Brons *et al.*, 2012) Despite the increasingly popular method of various three-dimensional technologies in recent

years(Celebi *et al.*, 2017; Galantucci *et al.*, 2016; Liu *et al.*, 2013; Oranges *et al.*, 2017), the photogrammetric technique remains an instrumental approach for practical purposes due to its accessibility, low cost, non-invasive and time-saving nature.

Farkas popularised the application of neoclassical canon, an ideal facial proportions indices derived from the work of Renaissance artists such as Durer, Leonardo Da Vinci, Bergmuller and Elsholts as a working guide for facial aesthetic analysis. (Farkas *et al.*, 1985) Over the last decades, his works triggered the impetus of research in facial anthropometry and proportional analysis conducted in various populations. (Al-Sebaei, 2015; Dawei *et al.*, 1997; Olusanya *et al.*, 2018; Porter, 2004; Salah *et al.*, 2014; Sepehr *et al.*, 2012; Zacharopoulos *et al.*, 2012) Although the consensus findings of these studies agreed that the neoclassical canons are a poor representative of the average or attractive facial proportions, Farkas et al. emphasized the purposefulness of the canons as a standard and screening method for investigating the differences among various populations. (Farkas *et al.*, 2000)

Two multicentre studies examining the facial anthropometric characteristics(Farkas *et al.*, 2005) and proportionality(Le *et al.*, 2002) showed a striking variation in facial morphology when various Asian ethnic groups were compared with North American norms. Interestingly, studies comparing Korean American(S. Choe *et al.*, 2004) and Indian American(Husein *et al.*, 2010) women judged to be attractive demonstrated many facial features of NAW women. While it may be true that western culture has influenced the aesthetic standard previously(Kwak, 2010), surgeons now acknowledged that Asian women still want to embrace their identities by optimizing their ethnic features rather than westernizing their appearances. (Gao *et al.*, 2018; Liew *et al.*, 2016). Gao et al. recently summarised differences in objective aesthetic criteria between Caucasian and East Asian female populations. They advocated that the aesthetic assessment of facial

attractiveness in Asian countries need to be ethnic-specified. (Gao *et al.*, 2018) Excellent pictorial example portraying the striking differences in facial features and aesthetic preferences between seemingly similar Asian ethnic groups, the Japanese and Korean was demonstrated in a survey by Dobke et al. (2006). (Dobke *et al.*, 2006)

To date, studies conducted on the Malaysian population were undertaken solely by the dental and orthodontic discipline. These studies had a limited sample size(Ngeow and T Aljunid, 2009; Othman *et al.*, 2016), restricted to the nasolabial region(Al-Khatib *et al.*, 2012) and lack of gender and racial discrimination(Alam *et al.*, 2015). Malaysia is a multi-racial country with a total population of 32.4 million in the year 2018. The Malay population is the largest ethnic group in Malaysia which is estimated to be about 69.1% of the total population. (DOSM, 2018) Although their origin is debatable, the current Malay descendants purportedly reside across a wide geographical area from Southeast Asia, mainly in Malaysia, Indonesia, Singapore, Southern Thailand, and Brunei up to Sri Lanka, South Africa and the Christmas and Cocos Islands of Australia. (Deng *et al.*, 2015; Milner, 2008)

Comprehensive anthropometric measurements, aesthetic and proportional analysis in the style of L.G Farkas on Malay populations is still missing in the literature. Given the tremendous increase in demand for facial aesthetic procedures in Southeast and East Asia(Liew *et al.*, 2016), which is also a trend observed in Malaysia, a standard for facial analysis for this population is urgently needed.

1.2 Objectives

1.2.1 General Objectives

To determine the attractive facial anthropometric features in Malay Malaysian Women (MMW)

1.2.3 Specific Objectives

1. To established normative facial anthropometric values for MMW and Compare with the North American White Women's standard
2. To determine the validity of neoclassical facial canons and their variations in MMW
3. To compare the facial regions that contribute to a significant difference between the attractive face and the average face in MMW
4. To compare the measurement between the attractive face in MMW with; (1) the NAWW and other Asian ethnicities, namely, the Korean and the Indian women.

CHAPTER 2: MANUSCRIPT

Title Page

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Abstract

Background Asians are a heterogeneous group with different average and attractive facial features between individual ethnicities. This study aimed to establish normative anthropometric measurements of the Malay Malaysian Women's (MMW) face, compare results with the standard for North American White Women (NAWW), the neoclassical canons of facial proportions and other Asian ethnicities; and quantitatively defined aesthetic facial features in the MMW.

Methods This is a cross-sectional photogrammetric study. In part 1 of this study, we obtained standardized frontal and lateral facial photographs of 103 MMW volunteers between the ages of 18 to 35. For each face, we measured 24 standard anthropometric parameters. We compared our results with the published NAWW norms and the facial canons proportions. In part 2 of the study, ten raters evaluated the photographs for aesthetics using a 10-point Likert's scale. Attractive MMW (top 15%) were compared with the average MMW (remaining 85%), NAWW, and other ethnicities.

Results The neoclassical facial canons were not found to apply to most of the MMW. We found significant differences between MMW and NAWW in 20 of 24 measurements ($p<0.05$). Attractive face in the MMW had a smaller total face height, smaller lower face height, and narrower mandible width compared to the average MMW. Comparing the normative and attractive MMW with other ethnicities indicated various interracial differences.

Conclusion Grouping this patient into a single Asian category or using analysis standards used for whites are impractical. This study detailed comprehensive facial anthropometric data and aesthetic criteria for this population. The values presented here could be used as a standard for facial analysis in women of Malay descent.

Level of Evidence: Level IV, cross-sectional study

Keywords: Attractive, Average, Malay Women, Neoclassical Facial Canons, Photogrammetry

Introduction

Know the ideal beautiful normal. The eight principles in Millard's Principalization of Plastic Surgery(1) underlies many endeavors in facial attractiveness studies in our field. One main cue theorized to influenced facial attractiveness is that 'averageness is beauty'(2-4). Critics argued that attractive face is extraordinary, not ordinary or average. (4) Of course, the average and the attractive face vary according to race. Astute understanding of the facial relationship between normalcy and beauty is therefore paramount for facial plastic surgeons. The goal is not only to obtain an aesthetically pleasing result based on a single universal standard but one that is also congruent with the patients' ethnicity and gender-specific features.

Most commonly used methods to analyze facial aesthetics is direct anthropometry, pioneered by Farkas. Considered as the modern father of facial anthropometry, Farkas et al. have defined a complete set of facial measurements and studied objective facial aesthetic characteristics across different ethnicities,(5, 6) ages(7), facial attractiveness(8) and various craniofacial deformities. (9) Another alternative method is photogrammetry, an indirect anthropometry measurement taken from standardized photograph. (10, 11) Farkas demonstrated that 26 of 62 obtainable landmarks on the facial photographs were reliable. (12) Other studies have also demonstrated the reliable measurements obtainable in photogrammetry. (13-15) Despite the increasingly popular method of various three-dimensional technologies in recent years(16-19), the photogrammetric technique remains an instrumental approach for practical purposes due to its accessibility, low cost, non-invasive and time-saving nature.

Farkas popularised the application of neoclassical canon, an ideal facial proportions indices derived from the work of Renaissance artists such as Durer, Leonardo Da Vinci, Bergmuller and Elsholts as a working guide for facial aesthetic analysis. (20) Over the last decades, his works triggered the impetus of research in facial anthropometry and proportional analysis conducted in various populations. (21-27) Although the consensus findings of these studies agreed that the neoclassical canons are a poor representative of the average or attractive facial proportions, Farkas et al. emphasized the purposefulness of the canons as a standard and screening method for investigating the differences among various populations. (28)

Two multicentre studies examining the facial anthropometric characteristics(5) and proportionality(29) showed a striking variation in facial morphology when various Asian ethnic groups were compared with North American norms. Interestingly, studies comparing Korean American(30) and Indian American(31) women judged to be attractive demonstrated many facial features of NAW women. While it may be true that western culture has influenced the aesthetic standard previously(32), surgeons now acknowledged that Asian women still want to embrace their identities by optimizing their ethnic features rather than westernizing their appearances. (33, 34). Gao et al. recently summarised differences in objective aesthetic criteria between Caucasian and East Asian female populations. They advocated that the aesthetic assessment of facial attractiveness in Asian countries need to be ethnic-specified. (34) Excellent pictorial example portraying the striking differences in facial features and aesthetic preferences between seemingly similar Asian ethnic groups, the Japanese and Korean was demonstrated in a survey by Dobke et al. (35)

To date, studies conducted on the Malaysian population were undertaken solely by the dental and orthodontic discipline. These studies had a limited sample size(36, 37), restricted to the nasolabial region(38) and lack of gender and racial discrimination(39). Malaysia is a multi-racial country with a total population of 32.4 million in the year 2018. The Malay population is the largest ethnic group in Malaysia which is estimated to be about 69.1% of the total population. (40) Although their origin is debatable, the current Malay descendants purportedly reside across a wide geographical area from Southeast Asia, mainly in Malaysia, Indonesia, Singapore, Southern Thailand, and Brunei up to Sri Lanka, South Africa and the Christmas and Cocos Islands of Australia. (41, 42)

Comprehensive anthropometric measurements, aesthetic and proportional analysis in the style of L.G Farkas on Malay populations is still missing in the literature. Given the tremendous increase in demand for facial aesthetic procedures in Southeast and East Asia(33), which is also a trend observed in Malaysia, a standard for facial analysis for this population is urgently needed.

The aims of this study are fourfold: (1) to established normative facial anthropometric values for Malay Malaysian Women (MMW) and compare with the North American White Women's (NAWW) standard, (2) to assess the validity of neoclassical facial canons and their variations in MMW, (3) to identify the facial regions that contribute to a significant difference between the attractive and the average face in MMW, and (4) to compare the measurement between the attractive face in MMW with the NAWW and other Asian ethnicities, namely, the Korean and the Indian women.

Methodology

Subjects

We obtained ethical approval from the ethical committee of the University Sains Malaysia (USM/JEPeM/17080364). We conducted a cross-sectional study on 103 Malay Malaysian Women aged 18 to 35 years old. Subjects were volunteers consisted of staff, students, patients and attendees at the Hospital Universiti Sains Malaysia. The requirement for inclusion were Malaysian women of the Malay descent up to two generations (determined based on the verbal declaration of the volunteers measured) with normal body mass index (BMI) between 18.4 to 24.9 kg/m^2. History of craniofacial deformities, trauma or surgery excluded volunteers from this study. We obtained informed consent from all subjects.

Photographs Acquisition

Participants were digitally photographed using a full-frame camera with 5-axis image stabilizer mounted with a prime 85 mm lens and an on-camera bounce flash unit (Sony α7 II camera; Sony FE lens; and Sony HVL-F32M flash; Sony Corp, Tokyo, Japan). We obtained the photograph in frontal and left lateral views using a standard technique, against a chromakey blue background. Subject stood at 1.2 m from the lens, adopting a neutral facial expression with a gently closed lip. All photographs were obtained in a natural head position (NHP). We kept the camera horizontal along the axis of the NHP via the aid of multiple grid line function on the LCD screen. This function coupled with the 5-axis stabilizer technology negate the need for camera fixation with a stand. One vertical (bilabial height) and one horizontal (mouth width) measurements were taken directly from each volunteer using a vernier caliper for calibration of measurements.

Anthropometric Landmarks

The photographs were studied using Adobe Photoshop CC software (Adobe Systems Inc., San Jose, Ca, USA). We identified twenty-three facial landmarks (**Fig. 1**) and calculated 24 standard anthropometric measurements for each photograph (Table 1). The photographs and measures were all undertaken by the principal investigator (AH). After three months, the same investigator repeated all measurements after the initial assessment. Intra-examiner reliability was assessed using the Intraclass Correlation Coefficient (ICC). The range of Cronbach's coefficient alpha between the measurements was excellent ranging from 0.91 to 0.99.

We compared the results with the previously published standard for NAWW(43). Next, we determined the occurrence of the canon proportion in MMW as well as its variations from the canons. A canon was considered valid only when the value did not exceed 1mm measurements as outlined by Farkas(20) (**Fig. 2**).

Attractiveness Score

Ten raters evaluated the frontal and left lateral views of each face through an online survey form presentation (Google Inc, Mountain View, CA, USA). The form was set to shuffle in a non-sequential order of images for each rater. The raters scored the photo series individually, according to their aesthetic perception using a 10-point Likert scale system adopted from Bashour(44) as follow: 10 = extremely attractive; 9 = very attractive; 8 = attractive; 7 = mildly attractive; 6 = neutral plus; 5 = neutral minus; 4 = mildly unattractive; 3 = unattractive; 2 = very unattractive; and 1 = extremely unattractive.

We calculated the means of the ratings for each set of photographs for each judge. We categorized the top 15% highest scoring faces (n=16) as the attractive MMW face and the remaining 85% (n=87) as the average MMW face. The total sample hereon is referred to as normative MMW. We correlated the attractiveness scores with anthropometric measurements. Data between these two groups were analyzed using the paired t-test. We compared our findings with those reported earlier for NAWW(43), Indian American women (IAW)(31) and Korean American women (KAW)(30).

The mean age of the raters was 37 (range, 33 – 44) and consisted of five male and five females. Six raters were plastic surgeons and residents, and four were laypersons with no plastic surgery training (to simulate the public) comprising of lecturer, nurses and research assistant from the department of plastic surgery. There were six Malay judges, two Malaysian Chinese and two Malaysian Indian.

Statistical Analysis

Descriptive statistics for each measurement were computed for the MMW subjects. We compared the anthropometric measurements of our sample with those of previously published studies by using mean and standard deviation. The unpaired t-test with Welch's correction was used when the variances were unequal; otherwise, the unpaired t-test was used. Proportional differences between MMW and NAWW were calculated using the two-tailed Fisher's exact test or Pearson Chi-square test, wherever applicable. Statistical analyses were performed on SPSS version 24 (SPSS Inc, Chicago) for the raw data of MMW, and Microsoft Excel 365 (Microsoft Corp., Redmond, Wash.) for the comparison with available summary data (mean, standard deviation and sample size) from other studies (30, 31, 43). A value of $p < 0.05$ was considered statistically significant.

Results

Part 1

Anthropometric facial measurements in MMW and norms for NAWW are summarized in Table 2. A statistically significant difference was found in 20 of 24 measurements. The four nonsignificant measurements were forehead height 1, midface height 1, intercanthal width and nasolabial angle.

Differences in the frequencies of the neoclassical facial canon and its variations among the MMW and NAWW are shown in Table 3. All five facial proportions were statistically different between these two groups. The only canons that were found to be valid to any degree in MMW were the orbital canon proportion (38%) and orbitonasal canon proportion (7%). The direction of variation from the canon whether it is larger or smaller was used to stratify each case of not-valid neoclassical facial canons.

Facial trisection canon. The validity of this canon was not confirmed in either MMW or NAWW. There was small validity between two section facial height when compared to the lower face; 2% with nasal height and 6% with forehead height 2. However, none conform to the trisection of facial height described for this canon. Among the trisections, the nose height in the middle section was the smallest in both groups. Concerning the nose-forehead height, the differences were identical in both groups. In the forehead-lower face height relationships a higher forehead than the lower face was seen more often in MMW (73%) and none in the NAWW.

Orbitonasal proportion canon. The valid canon was seen in only 7% of the MMW as compares to 41% in NAWW. In the MMW the leading canon variation demonstrated greater nose than intercanthal width (92%), surpassing the frequency in NAWW (38%).

The less frequent canon variation with wider intercanthal than nasal width was found more often in NAWW (21%) than in MMW (1%).

Orbital proportion canon (en-en = al-al). The valid canon was found more frequent in MMW (38%) than in NAWW (33%). The variation with wider the eye fissure length than intercanthal distance was dominant in MMW (37%) but less frequent in NAWW (16%). The opposite variation was dominant in NAWW (52%) but found in only 25% of MMW.

Nasooral proportion canon. The valid canon was not seen in MMW but present in 20% of the NAWW. In MMW, the $1^{1/2}$ nasal width larger than the mouth width (90%) variation dominated over NAWW (19%). The canon variation in which the mouth width greater than $1^{1/2}$ nasal width was dominant in NAWW (60%) compared with MMW (10%).

Nasofacial proportion canon. This canon revealed the greatest differences between the races. A valid canon was not found in MMW but present in 37% of the NAWW. In none of the MMW was the nose width smaller than 25% of the face width, whereas in NAWW it was a dominant canon variation (39%). In the entire MMW subjects, the nose width was greater than 1/4 of the face width whereas in NAWW it occurred only in 24%.

Part 2

The mean ± SD score of the 103 subjects was 5.18 ± 0.79 (range 3.2 – 7.0). Bivariate analysis revealed four measurements with a weak correlation but statistically significant correlation with higher attractiveness scores: lower face height, nasal height, upper lip height and nasofrontal angle (Table 4, **Fig. 3**). In comparison between the attractive MMW and the average MMW, three features revealed significant differences: total face height, lower face height and mandible width (Table 5).

Comparison of anthropometric measurements between the MMW and the IAW revealed that 19 of 23 measurements were statistically different (Table 6). In comparing the attractive MMW with the IAW, only 10 of 23 measurements were different. These ten measurements had also been different from when comparing the normative MMW with IAW. Of the nine measurements that became nonsignificant, seven measurements were very similar to the IAW norms: total face height, forehead height 2, lower face height, midface width, eye fissure width, nasal width and lower lip thickness (Table 7).

When the MMW were analyzed with the KAW norms, only 15 measurements were available for comparison. Significant differences were found in 11 of 15 measurements (Table 6). Comparing the attractive MMW with the KAW, 2 of the 11 measurements became nonsignificant: nasal length and nasal width, and both measurements were nearly identical to the KAW norms (Table 7).

When the MMW sample was analyzed with NAWW, 20 of 24 measurements were statistically different. In comparing attractive MMW with NAWW, only 11 of 24 measurements were different. All the 11 differences had also been different when comparing the normative MMW with NAWW. Of the nine measurements that became nonsignificant in the attractive group, seven measurements moved closer to the white norms: total face height, forehead height 2, midface height 2, eye fissure width, eye fissure height, mouth width and upper lip height (Table 7).

Discussion

A standard for analysis of the Malay women face has long been lacking. Grouping this patient into the Asian category or using analysis standards used for whites are impractical. This study corroborates the distinct differences between the MMW face and the NAWW. Furthermore, we elucidated the differences between MMW and two other Asian races, the Indian and the Korean women objectively. We used these particular studies for comparison because of its similar methodologies, involving photogrammetric measurements; and the relatively identical set of anthropometric measurements and sample size with our study. Besides, we observed an increasing influenced in the mainstream media from Korea and India over the last decades, not only in Malaysia but globally. We aimed to analyze the aesthetic criteria of MMW in comparison to these two races.

In comparison with the NAWW, the MMW faces had a longer total face height, a longer forehead height 2, a smaller midface, a smaller lower face, a narrower midface, and a wider lower face. The MMW eyes were wider and larger but had a lesser canthal tilt. The MMW nose demonstrated a shorter nasal length, a shorter nasal height, a wider alar width, a wider nasofrontal angle, and nasofacial angle. The mouth width and upper lip height were greater, but the upper lip was thinner while the lower lip was thicker than the NAWW.

The racial differences revealed by this study were unsurprising. The Asian face has a different osseochondrous scaffold and soft tissue thickness than the Caucasian faces. The lower face of MMW demonstrates a typical feature of Asian facial structure classified anthropologically as brachycephalic or mesocephalic structure, with a widened mandibular arch and resulting in broad appearing lower facial skeleton(32). In comparing with the white, our findings of a wider nose and lower face width were similar to previous Asian facial analysis studies(5, 29). Interestingly, a greater eye fissure length and mouth width were unique findings in our sample compared to various Asian groups studied by Le et al. and Farkas et al. Although it is true that facial morphology differences in various Asian ethnicities exist, these differences, however, could also be contributed by the limited number of subjects(5) and lack of gender disparity between men and women(29) in these studies. Additionally, these studies obtained measurements using direct anthropometry techniques while our study used photogrammetric measurements. We acknowledged that the two techniques are different; both are validated and comparable when standardized. (11, 12, 15, 45)

The neoclassical canons of facial proportion fit better to the white faces but seldom pertained to the MMW subjects. In white, four of the five neoclassical canons were valid. In MMW, only two canons revealed validity: 39% of MMW validated the orbital canon, and only seven subjects validated the orbitonasal canon. The frequencies of canon variations were also significantly different between the two races.

On visual examination, these differences were contributed primarily by the quality of the relationship between the wide nose with the eye, mouth, and face in MMW. In the canon comprising of the nose width (orbitonasal, nasofacial and nasoral), the wider nose of MMW was the primary cause of significant differences in frequencies of the leading canon variations. Most MMW has noses that are wider than the recommended canon proportions for the mouth, intercanthal and midface. These findings are similar to other Asian studies(29-31) and African American young adults(28).

Additionally, the quality of the relationship between the forehead and lower face height in MMW contributed to the apparent disharmony in MMW face. The forehead-lower face height relationship with a greater forehead than the lower face height was found more frequent in MMW. The opposite was true for the entire sample of NAWW. Other Asian studies involving the Chinese and Vietnamese(29), Korean(30) and Indian(31) showed a lower face height greater than that of the forehead as the dominant variation. Only in Thai subjects(29) showed a similar finding with our study.

In comparing with the IAW and KAW, all the facial measurements were significantly different between MMW and both Asian races. Interestingly, almost all the mean value for MMW face falls in between the Korean and the Indian groups. The forehead height, midface height, lower face height, and midface width was smaller than the Korean, but all were greater than the Indian. The total face height was also greater than the Indian group. Findings from a recent genetic study revealed that the genetic identity of Malay comprises a melange of entity from multiple ancestries which include East Asian and South Asian among others, with most of the admixture events took place 175 to 1500 years ago,(42) could be one possible explanation of this finding

Orbital measurements showed that MMW has a significantly wider eye fissure than both IAW and KAW. Intercanthal width was identical to IAW but significantly smaller than the KAW. Eye fissure height was also significantly greater in MMW than the IAW. It is worth to highlight that MMW has a larger and wider eye compared to other ethnicities. The eye fissure height and width (11.2 mm and 31.9 mm, respectively) of MMW fell within the range of beautiful Asian eyes measurements (10-12.5 mm for eye fissure height and 30-34 mm for eye fissure width)(34).

On analyzing the nose, the three linear measurements showed significant differences between MMW and the two Asian groups. MMW nose is significantly smaller in nasal height and nasal length than the KAW, but greater in both measurements than the IAW. The Nasal width was significantly wider in MMW than both KAW and IAW. MMW has an identical nasofrontal angle measurement but significantly larger nasolabial angle than both groups. The mouth width similar to those of the MMW was observed in IAW and KAW. The lower lip thickness is similar to the KAW but significantly greater than the IAW. The MMW has a significantly greater upper lip height but significantly smaller upper lip thickness than the IAW.

After establishing that the anthropometric measurements of the MMW subjects did not fit the NAWW norms, we stratified the subjects by facial attractiveness using a panel of Malaysian judges (n=10) from three main races in Malaysia, comprising of surgeons and laypersons. Researchers have found that there is a high level of agreement on rating attractiveness across ethnic groups, sexes, and ages. (2) It is therefore not our aimed to evaluate the influence of individual characteristics of the judges on their rating of facial aesthetics. Additionally, Kiekens et al. reported that a panel of seven laypersons and/or orthodontists is sufficient to attain reliable results in the aesthetic evaluation of adolescent faces. (46)

Statistical analysis revealed a positive correlation between the measurements and the attractiveness score concerning nasal height and nasofrontal angle but a negative correlation to lower face height and upper lip height. In other words, the judges preferred MMW face with a greater nasal height and nasofrontal angle, but smaller lower face height and upper lip height. However, comparing the attractive MMW with the average MMW showed only three significantly different measurements: total face height, lower face height, and midface width.

These trends did not reflect the features showing a statistically significant correlation between the attractiveness scoring and anthropometric measurements. This could be due to the smaller number of attractive subjects (n = 16) used in the correlation analysis. We postulate that a larger sample size of the attractive group can help to increase the statistical power to truly detect the differences between the two MMW groups and further approximate the overall correlation trend analysis.

In this study, a composite of attractive MMW faces demonstrated a face with smaller total face and lower face height; and narrower mandible width in comparison to the average MMW faces. These features were consistently found in the attractive faces of the Han Chinese women(47), Korean beauty pageant(48) and Italian beauty pageant(49). The normative and attractive Malay women face all had significant differences in various anthropometric measurements with the NAWW, the KAW, and the IAW. This study suggests that Malay women share the same definitions of beauty with other ethnicities in a particular facial area but maintains their criteria in another area. The results offer clear evidence of the need for separate norms and aesthetic criteria for Malay Malaysian women.

It is ambitious to conclude that the aesthetic criteria presented in this study represent the true standard of facial beauty for Malay women. This study analyzed only one cue (averageness) that have been proposed to influence facial attractiveness. The symmetry, sexual dysmorphism, and neoteny cues, as well as skin texture, were not assessed in our study. Nevertheless, averageness is thought to be the leading cue in judging facial beauty(2). Bashour concluded from his findings and that of other studies that any composite of greater than 16 faces suffice to serve as a template for facial surgery of that population(2). Of course, the composite made up of more attractive faces is more attractive.

In our study, we presented the average measurements of 103 MMW subjects. From this sample, we extracted and analyzed the 16 most attractive faces in our sample of Malay women. To our knowledge, this study is the first to provide a comprehensive anthropometric and aesthetic analysis of the MMW face. **Fig. 4** demonstrated selected anthropometric measurements of the attractive MMW face that we hope could be an essential starting point for facial analysis and treatment planning for women of Malay descent.

Conclusion and Recommendation

Facial measurements and proportionality in MMW are significantly different from NAWW standard, the neoclassical canons and even with other Asian ethnicities. Facial analysis based on Caucasian features or a single Asian database is unreliable guides for our sample. Attractive face in the Malay women exhibits a smaller total face height, smaller lower face height, and narrower mandible width. Further study with a larger sample size of the attractive group would elucidate more features that are distinctly different between the attractive and average face. Nevertheless, this is the first investigation detailing comprehensive anthropometric data and aesthetic criteria in Malay women. The values presented here could be used as a standard for facial analysis in women of Malay descent.

Compliance with Ethical Standards All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee (USM/JEPeM/17080364) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflict of interest The authors declare that they have no conflicts of interest.

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