

Photogrammetric Facial Analysis of Attractive Korean Entertainers

Seung Chul Rhee · Eun Sang Dhong ·
Eul Sik Yoon

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Abstract

Background The authors have developed a new digital photogrammetric method of facial analysis known as balanced angular and proportional analysis (BAPA). Using BAPA, the authors analyzed the faces of attractive Korean entertainers.

Methods The BAPA approach involves 28 landmarks and 14 measurements (10 proportional and 4 angular measures). Standardized mean angular values of famous entertainers are referred to as recommended aesthetic mean angles (RAMA) and the mean proportional values as the recommended aesthetic mean proportions (RAMP). In this study, 30 frontal views of famous Korean entertainers (15 men and 15 women) were collected from Internet Web pages, and the data analyzed using V-ceph. A *t* test (with the significance level set at a *p* value of 0.05) was performed to analyze male versus female comparisons.

Results Significant between-group differences ($p < 0.05$) were found for P-lower face, P-eye height, P-lip, P-inte-angle, and the mandibular contour in the frontal views. Famous Korean female entertainers differ from famous male entertainers. The women have a shorter lower face, larger eyes, smaller lips, and a more slender and oval shape of the mandibular soft tissue contour.

Conclusions The authors insist that facial analysis should take into consideration racial, ethnic, and gender differences. The BAPA approach is a new practical and simple method for photogrammetric facial analysis. Using the authors' method, more advanced and automated computer systems for analyzing human faces may be developed.

Keywords Attractiveness · Facial analysis · Photogrammetry · Racial difference · Sexual dimorphisms

The analysis of the human face is a science and an art requiring both aesthetic and anthropologic tools. Many direct and indirect studies of facial beauty have been performed [1–3]. Some studies have addressed such fundamental issues as the perception of attractiveness [4], transition in trends regarding the attractive face [5], factors influencing the determination of facial attractiveness [6], differences among races [7], and ethnic characteristics of average or attractive faces [8–13].

In general, we know that an attractive or beautiful face varies according to time, ethnicity, race, gender, and personal preferences. However, no ideal photogrammetric method exists that can be applied to any race. Considering these limitations of conventional methods for facial analysis, the authors have introduced a simple and practical method for photogrammetric soft tissue facial analysis known as balanced angular and proportional analysis (BAPA).

Materials and Methods

The author reported a preliminary photogrammetric study [14] and clinical application [15] of photogrammetric

S. C. Rhee (✉)
Department of Plastic and Reconstructive Surgery, KEPCO
Medical Foundation, Hanil General Hospital, 388-1, Ssangmoon
3-Dong, Dobong-Gu, Seoul 132-703, Republic of Korea
e-mail: webmaster@beautyportal.co.kr

E. S. Dhong · E. S. Yoon
The Medical Science Research Center of Korea University,
Aesthetic and Plastic Surgery Institute, Korea University Ansan
Hospital, Seoul, Republic of Korea

profile analysis, named Balanced Angular Profile Analysis. The same method was used to standardize the photogrammetric reference data of famous Korean entertainers. Photographs of entertainers were acquired from Internet Web pages and stored in a computer as JPG files using Adobe Photoshop 7.0 (Adobe Systems, Inc., San Jose, CA, USA) if the photograph met the following criteria:

- (1) Photograph shows the described landmarks as noted in Fig. 1, and both sides of the face appear as symmetric as possible. To limit the rotation around the cervical axis, the soft tissue landmark “glabella” should be positioned at the mid 5% with respect to the facial width.
- (2) The soft tissue “trignon” and “gonion” points are completely visible. There are no silhouettes or irregular photographic shadows. Asymmetric illumination should not be a hindrance in defining the facial fiducials correctly.
- (3) Lips are closed smoothly.
- (4) The resolution of the photographs are more than 30 pixels/cm in Adobe photoshop 7.0 (Adobe Systems, Inc.).

Photographs were acquired for 15 famous Korean female entertainers and 15 famous Korean male entertainers highly ranked in a variety of Korean Internet search engines and photographic ranking sites. The entertainers chosen were leading entertainers based on the Korean style of “Hallyu” [16].

The photographs were divided into two groups based on gender. Semiautomatic measurements were used for the survey. From each photograph, after 28 frontal soft tissue

landmarks had been marked, 10 defined proportions or 4 angles (Table 2) from each photographs were measured and analyzed by V-ceph (CyberMed, Inc., Seoul, Korea) for photographic facial analysis (Fig. 1, Table 1).

Using “user-defined analysis” and modifying V-ceph software, each analyzed polygonal chart was exported to Microsoft Excel (San Francisco, CA) data automatically. The analysis and calculations were repeated three times for each photograph, and the mean values were determined for each measurement to two decimal places. Data from each group were analyzed to determine the mean p and F values as well as the standard deviation for each measurement. For data files and statistical analysis, SAS 8.1 (SAS Institute, Inc., Cary, NC, USA) was used. Between-group mean value differences were calculated using the t test, with the significance level set at a p value of 0.05. To test the level of error involved in the method, photographs from each group were randomly selected, and the measurements were repeated by another plastic surgeon.

Results

The data from each group are presented in Table 3. To test the differences in marking of the landmarks between measurers, photographs from each group were randomly selected, and measurements were repeated by another plastic surgeon. The error in marking of the fiducials was not statistically significant ($Pr > F = 0.3157$; $t = 0.51$ $Pr > |t| = 0.7413$; $p = 0.05$).

The frontal analysis (Table 3) found significant differences between the groups for P-lower face (P3), P-eye height (P6), P-lip (P9), P-mandible (P10), R-mandible angle (A15), L-mandible angle (A16), R-latgo angle (A17), and L-latgo angle (A18).

The P3 value ($[\text{sn} \sim \text{gn}]/[\text{R-zy} \sim \text{L-zy}]$), representing the evaluation of the relative lower face length, was larger in the men (46.59%) than in the women (43.81%). This suggests that Korean men have a relatively longer lower face than Korean women. The P6 value ($[\text{ps} \sim \text{pi}]/[\text{tr} \sim \text{gn}]$), representing the evaluation of the relative palpebral fissure height, was larger in the women (7.50% vs. 6.21%), whereas the P9 value ($[\text{R-ch} \sim \text{L-ch}]/[\text{R-zy} \sim \text{L-zy}]$), representing the evaluation of the relative mouth size, was larger in the men (36.25% vs. 34.30%). The P10 value ($[\text{R-ang} \sim \text{L-ang}]/[\text{R-zy} \sim \text{L-zy}]$), representing the measurement of the relative horizontal mandible width, was larger in the men (87.26% vs. 81.59%), whereas the P11 ($\angle \text{R-zy}$, R-ang, gn), P12 ($\angle \text{gn}$, L-ang, L-zy), P13 ($\angle \text{R-zy}$, R-latgo, gn), and P14 ($\angle \text{gn}$, L-latgo, L-zy) values evaluating the mandibular contour were larger in the women: P11 (138.13° vs. 134.81°), P12 (137.63° vs. 134.39°), P13 (137.40° vs. 131.96°), and P14 (136.07° vs. 131.97°). These

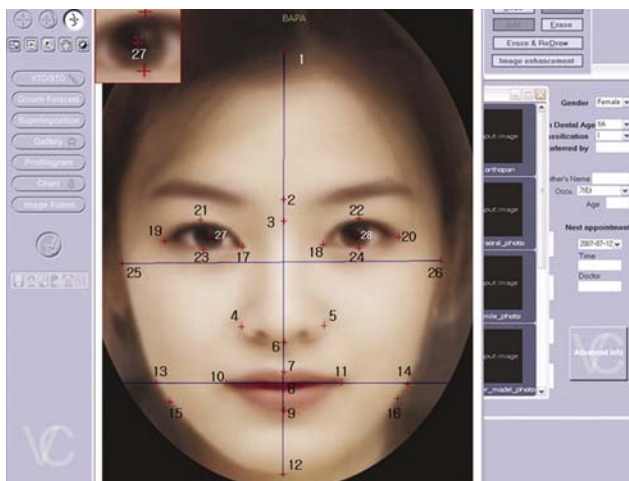


Fig. 1 Landmarks and lines used in this study. See Table 1 for a detailed definition for each landmark. Facial fiducials of the average Korean attractive composite face were marked and analyzed by the V-ceph computer program for balanced angular and proportional analysis (BAPA)

Table 1 Landmarks for balanced angular and proportional analysis (BAPA)

No.	Landmarks	Definitions
<i>In frontal view</i>		
1	Trignon (tr)	Lowest point of hairline in center of face
2	Glabella (g) ^a	Most midpoint between center of eyebrows, the transecting point of the vertical line (tr-gn)
3	Nasion (n)	Midpoint of transverse line of highest points of palpabrae superius (ps)
4, 5	Ala (al)	Most lateral portion of ala curvature,
6	Subnasale (sn)	Central junction of the columella and the upper cutaneous lip
7	Labiale superius (ls)	Midpoint of the upper vermilion line
8	Stomion (sto)	Midpoint of junction between upper and lower lip
9	Labiale inferius (li)	Midpoint of the lower vermilion line,
10, 11	Cheilon (ch)	Most lateral point of lips, left and right
12	Gnathion (gn)	Most central and inferior point of chin
13, 14	Mandibular angle (ang) ^a	Meeting point of mandibular contour with the extension line linking the left and right cheilons
15, 16	Lateral gonion (latgo) ^a	Tangential point around contour of mandible, made by drawing line parallel to the ipsilateral reference line (gn-zy)
17, 18	Entocanthion (en)	Most medial point of eye fissures, left and right
19, 20	Exocanthion (ex)	Most lateral point of palpebral fissure, left and right
21, 22	Palpebrae superius (ps)	Highest point in the midportion of the free margin of each upper eyelid, left and right
23, 24	Palpebrae inferius (pi)	Lowest point in the midportion of the free margin of each lower eyelid, left and right
25, 26	Zygion (zy)	Most lateral zygomatic point of frontal face, left and right
27, 28	Center of pupil (p)	Centers of pupils, left and right

^a Different from the neoclassical facial canons; authors refined and renewed the definition of the landmark

Table 2 Definitions of proportional or angular measures in the frontal analysis for balanced angular and proportional analysis (BAPA)

P/A	Names of proportion	Definition	Measurement
<i>General index</i>			
P1	P-facial	Face height/face width	$([tr \sim gn]/[R-zy \sim L-zy]) \times 100$
P2	P-upper face	Upper face height/face width	$([n \sim sto]/[R-zy \sim L-zy]) \times 100$
P3	P-lower face	Lower face height/face width	$([sn \sim gn]/[R-zy \sim L-zy]) \times 100$
<i>Brow and forehead index</i>			
P4	P-forehead height	Forehead height/face height	$([tr \sim g]/[tr \sim gn]) \times 100$
<i>Eyes index</i>			
P5	P-interpupil	Interpupil width/face width	$([R-p \sim L-p]/[R-zy \sim L-zy]) \times 100$
P6 ^a	P-R-eye height	R-eye fissure height/face height	$([R-ps \sim R-pi]/[tr \sim gn]) \times 100$
P7 ^a	P-R-eye width	R-eye fissure width/face width	$([R-ex \sim R-en]/[R-zy \sim L-zy]) \times 100$
<i>Nose index</i>			
P8	P-nasal	Interala width/face width	$([R-al \sim L-al]/[R-zy \sim L-zy]) \times 100$
<i>Mouth index</i>			
P9	P-lips	Lip width/face width	$([R-ch \sim L-ch]/[R-zy \sim L-zy]) \times 100$
<i>Mandible index</i>			
P10	P-mandible	Interangle width/face width	$([R-ang \sim L-ang]/[R-zy \sim L-zy]) \times 100$
<i>Mandible angular measures</i>			
A15	R-mandible angle	Acute angle (R-zy, R-ang, gn)	
A16	L-mandible angle	Acute angle (gn, L-ang, L-zy)	
A17	R-latgo angle	Acute angle (R-zy, R-latgo, gn)	
A18	L-latgo angle	Acute angle (gn, L-latgo, L-zy)	

P/A proportion or angle

^a P6 and P7 can be measured from left or right eye. It is an arbitrary decision

Table 3 Statistical results for balanced angular and proportional analysis (BAPA) of frontal photographs of famous Korean entertainers

Measures	Sex	RAMP (%)/ RAMA (°)	SD (%)	Pr > F	t value	Pr > t
P1	M	131.13	4.66	0.1707	−1.99	0.0561
	F	134.04	3.20			
P2	M	51.94	2.69	0.2833	−1.53	0.1361
	F	53.73	3.61			
P3	M	46.59	3.42	0.5095	2.43	0.0219 ^b
	F	43.81	2.85			
P4	M	31.17	2.06	0.2391	−1.36	0.1832
	F	32.41	2.85			
P5	M	44.80	2.07	0.1428	0.43	0.6693
	F	44.38	3.09			
P6	M	6.21	0.86	0.7595	−4.26	0.0002 ^b
	F	7.50	0.79			
P7	M	22.61	2.01	0.6777	−2.03	0.0522
	F	25.62	1.54			
P8	M	28.20	2.54	0.6523	2.93	0.0593
	F	26.03	3.35			
P9	M	36.25	2.64	0.4225	2.24	0.0335 ^b
	F	34.30	2.12			
P10	M	87.26	4.70	0.7214	3.46	0.0018 ^b
	F	81.59	4.27			
A15 ^a	M	134.81°	3.47°	0.4944	−2.38	0.0242 ^b
	F	138.13°	4.14°			
A16 ^a	M	134.39°	3.65°	0.6739	−2.28	0.0301 ^b
	F	137.63°	4.09°			
A17 ^a	M	131.96°	4.24°	0.5423	−6.86	<0.0001 ^b
	F	137.40°	3.59°			
A18 ^a	M	131.97°	4.24°	0.7340	−6.96	<0.0001 ^b
	F	136.07°	3.86°			

RAMP recommended aesthetic mean proportion, RAMA recommended aesthetic mean angle, P1 P-facial, P2 P-upper face, P3 P-lower face, P4 P-forehead, P5 P-interpupil, P6 P-eye height, P7 P-eye width, P8 P-nasal, P9 P-lip, P10 P-mandible, A15 R-mandible angle, A16 L-mandible angle A17 R-latgo angle, A18 L-latgo angle

^a Belongs to RAMA

^b Shows statistically significant between-group differences ($p < 0.05$)

measurements suggest that famous Korean women have a more slender and oval shape to their mandibular contour than famous Korean men.

Discussion

Investigators suggest that the ideal facial analysis should include the following essential elements. First, the ideal method of facial analysis should consider the demographic

factors of the subjects. The perception of an attractive or beautiful face varies according to time, ethnicity, race, gender, and personal preferences [17–22].

Second, the ideal method for facial analysis must be a comprehensive analysis dealing with a generalized balance or harmony of the whole human face, not with pieces or specific parts of the face [23]. As Le [24] reported, the classic or neoclassical canons of beauty are not really applicable to Asian women. Therefore, absolute arithmetic lengths between facial fiducials should not be used for facial analysis because each human face is different in the size of the skull base and its own unique balance or harmony.

Third, although controversy exists regarding the significance of averageness and attractiveness [4], facial analysis should be performed based on scales of attractiveness rather than averageness.

In general, three methods for facial analysis are available: cephalometric, anthropometric, and photogrammetric. Cephalometry is a valuable technique generally used for surgical planning and evaluation of pre- and post-operative outcomes. However, its validity, sensitivity, and significance are a matter of ongoing dispute. Cephalometric normative data, for example, are not representative of facial attractiveness and cannot be applied universally to different racial and ethnic groups.

Many studies have addressed the drawbacks of cephalometric analysis. As suggested by Lines et al. [18], cephalometric analysis does not help to reflect the soft tissue structures accurately according to changes in bony structures. Reports also show that the distribution or changes in the soft tissue structures planned by cephalometric analysis are very discordant with those of hard tissue structures. With regard to anthropometric analysis of the human face [9, 10, 12, 13], if a surgeon tried to use these reference measures for each individual patient, he or she would have to measure each face individually with rulers and protractors, a very cumbersome procedure in the clinical setting.

The photogrammetric method of analyzing the human face is another alternative. Using digital cameras, many scholars have used this method of evaluation. Although Farkas [25] have demonstrated important differences between anthropometric and photogrammetric data, many investigators, including Nechala [26], Neger [27], Larrabee [28], Auger and Turley [5], for example, have shown that photogrammetric facial analysis is a very useful approach for practical purposes.

Many studies have discussed the alternative methods for ideal facial analysis. Laser scanners [29, 30], computed tomography [31], the golden ratio or the facial mask [32–34], and three-dimensional head tracking by particle filters [35] are examples of newly developed approaches to facial

analyses. However, the data obtained cannot be applied to different ethnic populations and races [36] or the methods used are very complicated.

Photogrammetric facial analysis has several drawbacks. The shortcomings are due to the difficulties of standardizing conditions for taking and measuring photographs and for defining the correct reference planes or lines. For photogrammetry, if the true horizontal line is correctly defined, the orbitale or subnasion must be marked with special metal labels before photographs are taken, with preservation of the natural head position. However, this is not always consistent in clinical circumstances. It also is reported that errors and distortions of photogrammetric facial analysis are frequent with linear measurements, but angular and proportional measures are not influenced as much by photographic enlargement [25, 37, 38].

Whereas the fiducials and other measures used in this study originated from methods of classic anthropometrical or photogrammetric analysis, BAPA introduces different landmarks and new measurements. New fiducials for photogrammetry are presented such as the angular point (ang) and the lateral gonial point (latgo). These new fiducials were introduced because the mandibular contour is recognized and characterized not only by bony structure but also by the soft tissue bulk of the mandible. The transecting point of the mandibular contour with the horizontal line connecting the two points of the cheilion is referred to as “ang.” The point “latgo” is the tangential point of the mandible with the line running parallel to that connecting the points “zy” and “gn.” The mandibular contour in the frontal view is perceived as one plane that consists of different planes and depths. These new fiducials are very important for rating attractiveness.

For the frontal analysis, the findings show significant differences between genders for P3 (P-lower face), P6 (P-eye height), P9 (P-lip), P10 (P-mandible), P11 (R-mandible angle), P12 (L-mandible angle), P13 (R-latgo angle), and P14 (L-latgo angle). In general, each fiducial point of tr–gn–sn–gn divides the facial vertical height into three equal parts [12, 37]. Although the vertical facial ratios were not measured, they can be measured by an indirect method because $P3/P1$ represents $([sn \sim gn/zy \sim zy]/[tr \sim gn/zy \sim zy])$, and consequently, $([sn \sim gn]/[tr \sim gn])$ arithmetically, which is the ratio of the lower face. Accordingly, the relative proportion of the lower face is 32.7% (43.81/134.04) for female Korean entertainers and 33% (44.3/134.2) from Western measures, as noted in our previous study. This is consistent with the result of an anthropometric study investigating winners of Korean beauty contests [13].

In this way, the current study can be compared with other previous studies of Caucasian or Korean faces.

Comparing our results with the anthropometric study by Farkas [37], we can speculate indirectly on the attractive female face in terms of racial characteristics and differences. According to the study by Farkas [37], the bizygomatic distance ($zy \sim zy$) of the most attractive Caucasian females was 128.3 mm, and the total facial height ($tr \sim gn$) was 171.9 mm. Consequently, $P1$ ($[tr \sim gn]/[zy \sim zy]$) would be 133.98% arithmetically. In his study, $P2$ was 53.7% in attractive females and 53.4% in the most attractive females; $P3$ was 48.79%; $P6$ was 6.86%; $P7$ was 24.16%; and $P9$ was 39.5% arithmetically.

Using BAPA, in the current study, we were able to find not only interesting differences in frontal faces among races but also differences between average faces and attractive faces. Rhodes et al. [22] and Gruendl [39] reported on the average or attractive composite faces using a computerized morphing system. These composites were analyzed using BAPA (Fig. 2). German attractive faces and Caucasian or Eurasian average faces do not match with Korean attractive faces.

The BAPA approach has several advantages. First, BAPA does not provide absolute measures but does provide attractive scales and tools for facial analysis that depend on the individual face as a unique and organized structure. It can be applied to different ethnic and racial groups because the recommended aesthetic mean angles (RAMA) and the recommended aesthetic mean proportions (RAMP), the ideal angles and proportions suggested by BAPA, can and must be adjusted according to racial backgrounds as well as current general preference. The BAPA approach may be useful for prevention of perceptual error or unrealistic ideas regarding the possibility for facial outcomes.

Veale [40] emphasized the importance of the body dimorphic disorder with regard to aesthetic plastic surgery. In the clinical setting, individual patient expectations may not be compatible with the plastic surgeon’s assessment. In addition, the surgeon may be biased by his or her own preferences. The BAPA approach can help with objective visualization of data in terms of harmony and balance. In addition, BAPA can be used to verify and examine a surgeon’s aesthetic decision and to gain the patient’s confidence that the most appropriate surgical procedure for improving facial soft tissue structures has been chosen.

The BAPA data can be arranged quantitatively and used for the assessment of surgical outcomes. Moreover, because a digital camera is used commonly, BAPA can be based solely on photographs. This makes Internet Web consultation for aesthetic facial consultation available and reliable.

Limitations associated with this method include the following. First, the RAMP and RAMP data are

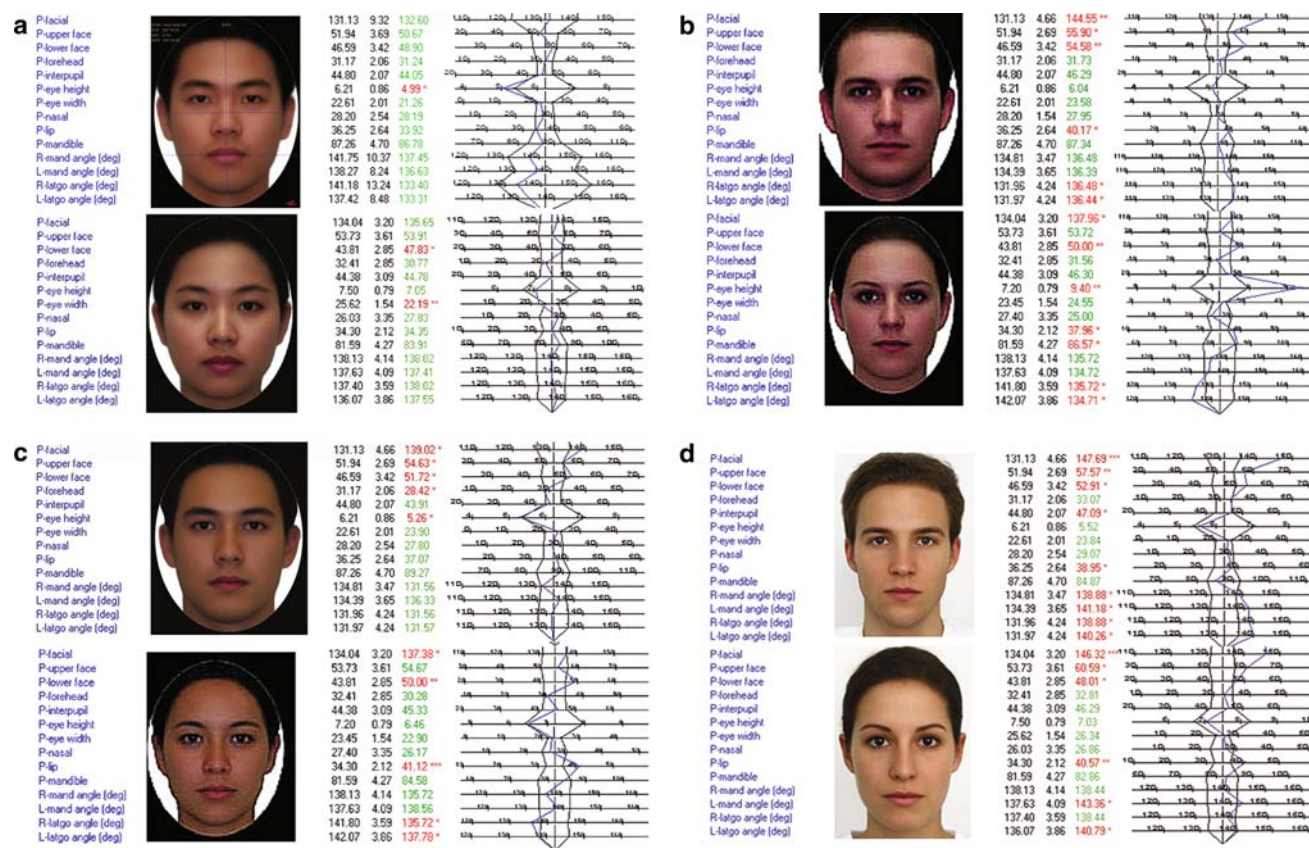


Fig. 2 a Balanced angular and proportional analysis (BAPA) result for the average Asian man and woman (reprint of facial pictures permitted by courtesy of Rhodes et al. [22]). **b** BAPA result for the average Caucasian man and woman (reprint of facial pictures permitted by courtesy of Rhodes et al. [22]). **c** BAPA result for the

average Eurasian man and woman (reprint of facial pictures permitted by courtesy of Rhodes et al. [22]). **d** BAPA result for the attractive Eurasian man and woman (reprint of facial pictures permitted by courtesy of Gruendl [39])

representative of only 30 famous entertainers. The size of the reference samples, however, is not important for BAPA because the meaning of the attractiveness is not rated by the size of samples.

Second, although the subjects were determined to be very famous entertainers and ranked high at Internet Web sites with various search engines, the general population did not decide on their degree of attractiveness. Because the relatively young use the Internet and because preferences vary according to age, a selection bias may have occurred. Because the RAMA and RAMP presented are not perfect data, additional research and expanded clinical application are needed. The RAMA or RAMP as target reference data must be regarded as temporary and changeable values and must be modified for different racial, ethnic, and preferential backgrounds. For example, superattractive average values (RAMA and RAMP) can be obtained from the top five entertainers and applied to attractive composite faces (Fig. 3). Namely, additional comprehensive and psychological research regarding the

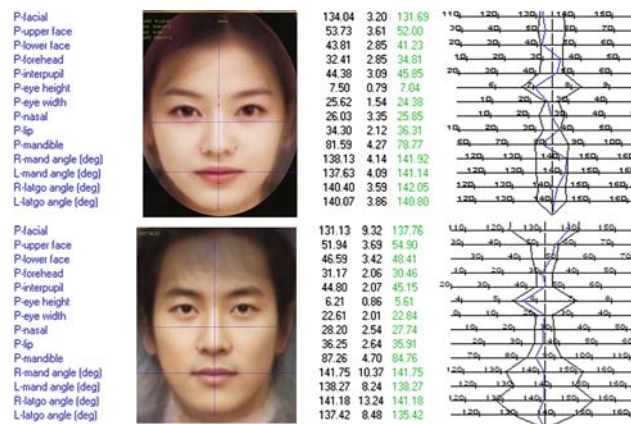


Fig. 3 Balanced angular and proportional analysis (BAPA) result for composite faces of the superattractive Korean man and woman. The composite faces are made by the facial morphing method [41] for 10 female and 16 male entertainers

preference among different racial and ethnic groups as well as different genders will help to verify the BAPA method.

Conclusion

- (1) From the standpoint of facial balance or harmony, famous Korean female entertainers differ from famous male entertainers. The women have a more obtuse nasolabial contour, a shorter lower face, larger eyes, smaller lips, and a more slender and oval shape of the mandibular soft tissue contour.
- (2) The accuracy or significance of the method for analysis can be validated by an indirect comparison with previous anthropometric studies.
- (3) The BAPA approach has several advantages. It measures the relative facial balance and harmony for each patient, and it can be applied to different genders and to different racial and ethnic groups regardless of generation and time. Because BAPA helps to define facial preference, the objective visualization and quantification of the patient's face may improve the patient–doctor relationship and trust.
- (4) The BAPA approach is a new practical and simple method for photogrammetric facial analysis that uses proportional and angular measurements. Using the authors' method, we are trying to develop more advanced and automated web-based computer program analyzing human faces at <http://beautyportal.co.kr>.

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