Facial esthetics in adolescents and its relationship to "ideal" ratios and angles

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Introduction: Many guidelines, norms, and ideal ratios and angles for attractive faces have been proposed in the literature. The aim of this study was to test the hypothesis that facial attractiveness in adolescents is related to ideal angles and ratios, as indicated in the literature. **Methods:** Seventy-six laypeople viewed sets of photographs of 64 adolescents and rated them on a visual analog scale (VAS) from 0 to 100. The facial esthetic value of each subject was calculated as a mean VAS score. Three observers recorded the positions of 61 landmarks, and 45 were found to have acceptable reproducibility. Based on these 45 landmarks, 27 ideal ratios on frontal photographs and 26 ideal angles on lateral photographs were identified in the literature. These ratios and angles were calculated on each photograph, and their deviation from the ideal targets in the literature were determined. Each deviation was related to the VAS score. **Results:** Two ratios and 3 angles had a significant negative correlation with the VAS scores, indicating that beautiful faces have less deviation from the ideal target than less beautiful faces. Together, these variables explained 28.7% of the variance. **Conclusions:** Few "ideal" ratios and angles have a significant relationship with facial esthetics in adolescents. (Am J Orthod Dentofacial Orthop 2008;133:188.e1-188.e8)

Soft-tissue facial analyses can be made on lateral cephalograms and photographs, by anthropometry (measurements directly on the face), or with 3-dimensional imaging techniques. Many guidelines, norms, and ideal ratios and angles dealing with attractive faces, have been proposed in the literature, mainly based on 2-dimensional measurements. Few investigators, however, have shown a scientific basis for their criteria; in general, the choice of the criteria themselves and their assumed optimal values are arbitrary. Most "ideal" norms are given for adults and especially for women. They are often based on beautiful or idealized faces, or on author's preferences,[1-15] whereas others are based on average faces.[16-21] Average values have been considered "ideal," assuming that average faces are attractive,[22] and that average facial proportions could provide a basis for quantitative assessment of facial esthetics.[23] Norms for facial proportions and angles for adolescents are rare in the literature. Farkas and Munro[16] stated that average differences in facial proportions between both sexes from 6 to 18 years are relatively small. Halazonetis[24] found only minor differences in the average facial shapes of boys and girls between 7 and 17 years of age. Although some facial proportions and angles might be different for adults and children,[25] and for males and females,[14] most orthodontists use the "ideal" norms for all patients, irrespective of their age or sex.

Our aim in this study was to test the hypothesis that facial attractiveness in adolescents is related to "ideal" ratios and angles, as indicated in literature.

MATERIAL AND METHODS

Sets of 3 pretreatment photographs (frontal, three quarter smiling, and lateral) of adolescents were collected from the files of the Department of Orthodontics and Oral Biology, Radboud University Nijmegen Medical Centre, the Netherlands, from 1990 to 2000. The inclusion criteria were age between 10 and 16 years at start of treatment, white background, not wearing glasses, no dental or facial trauma, and no congenital defects. From this group, sets of photographs of 64 adolescents were selected, using randomization in strata according to Angle class and sex. The Angle classes were defined as follows: Class I, neutroclusion and neutral relationship of the jaws; Class II

Division 1, distoclusion and distal relationship of the jaws with proclined maxillary incisors; Class II Division 2, distoclusion and distal relationship of the jaws with retroclined maxillary incisors; and Class III, mesioclusion and mesial relationship of the jaws. The stratification aimed for about 8 boys and 8 girls for each of the 4 Angle classes to obtain a wide range of dental and skeletal variations.

A panel of 76 lay adults with relatively high socioeconomic backgrounds evaluated the sets of photographs on a visual analogue scale (VAS) from 0 (very unattractive) to 100 (very attractive). The sets of photographs were placed in random order in a slide show, and each set was shown for 15 seconds on a wall screen. Scores were given in relation to a reference set of photographs with a known score, as described by Kiekens et al.[26] The scores of 2 panel members were excluded because of missing data. Statistical analyses of the VAS scores were performed on the ratings of the panel of the remaining 74 persons.

From the scores of all panel members, the final facial esthetic score for a subject was determined as the mean of all VAS scores given for him or her. This method has shown to yield reproducible results.[26]

All frontal and lateral photographs were digitized at 500 × 751 pixels. Sixty-one landmarks, frequently found in the literature, pertaining to ideal ratios and angles, were identified on a screen by 3 independent observers using Sigma Scan (Jandel Scientific, San Rafael, Calif). On the frontal photographs, 39 landmarks and, on the lateral photographs, 22 landmarks were selected (Figs 1 and 2). Because the accuracy of the determination of soft-tissue landmarks is variable,[4] a data quality control of the landmark measurements was performed, including the elimination of outliers. To that end, the measurement variance of a specific point on a photograph was calculated as the mean squared distance of the mean point between the 3 observations. The measurement error of each landmark was defined as the square root of the median measurement variance of the landmark over all 64 photographic sets. After assessment of the measurement error of the landmarks, outliers were defined as individual points with a measurement error larger than 3 times the measurement error in the landmark. In total, 1.3% (150) of all measurements (64 patients × 61 landmarks × 3 observers = 11.712) appeared to be outliers. They were excluded from further analysis. After the elimination of the outliers, the measurements of the 61 landmarks showed median errors ranging from 1.2 to 32.5 pixels, indicating that the quality of the landmarks was diverse. As an inclusion criterion for a landmark,
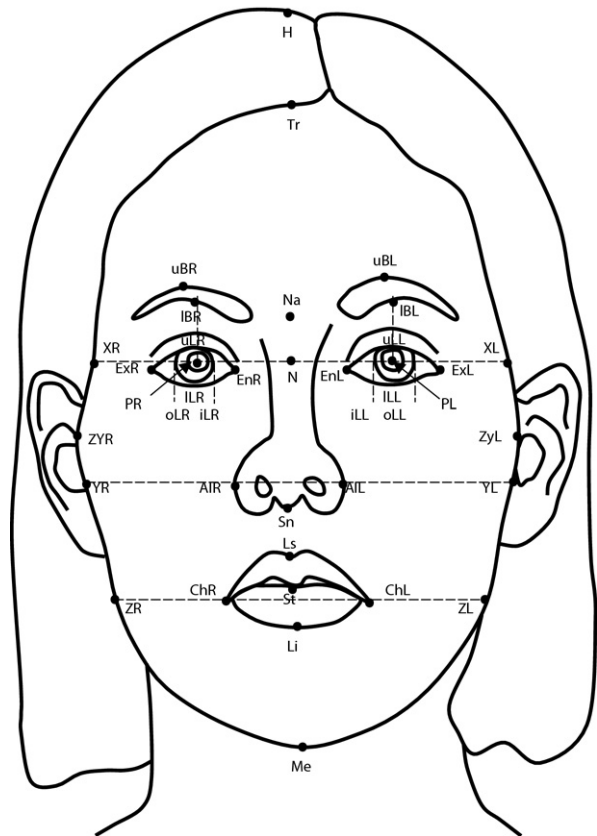

Fig 1. Landmarks on the frontal photograph (landmarks in *italics* were rejected: *H, estimated middle of the hair top*; *Tr, trichion*; *uBR, upper border of the eyebrow on the right side*; *uBL, upper border of the eyebrow on the left side*; IBR, lower border of the eyebrow on the right side; IBL, lower border of the eyebrow on the left side; *Na, skin nasion*; N, skin nasion at bipupil line (constructed point); ExR, exocanthion on the right side; ExL, exocanthion on the left side; EnR, endocanthion on the right side; EnL, endocanthion on the left side; uLR, upper limbus on the right side; uLL, upper limbus on the left side; ILR, lower limbus on the right side; ILL, lower limbus on the left side; *oLR, outer limbus on the right side*; *oLL, outer limbus on the left side*; *iLR, inner limbus on the right side*; *iLL, inner limbus on the left side*; PR, middle of the pupil on the right side; PL, middle of the pupil on the left side; AIR, alare on the right side; AIL, alare on the left side; Sn, subnasale; St, stomion; ChR, cheilion on the right side; ChL, cheilion on the left side; Ls, labrale superior; Li, labrale inferior; Me, menton; *ZyR, zygion on the right side*; *ZyL, zygion on the left side*; XR-XL, face width at bipupil line (XR and XL = constructed points); YR-YL, face width at alare (YR and YL = constructed points); ZR-ZL, face width at stomion (ZR and ZL = constructed points).
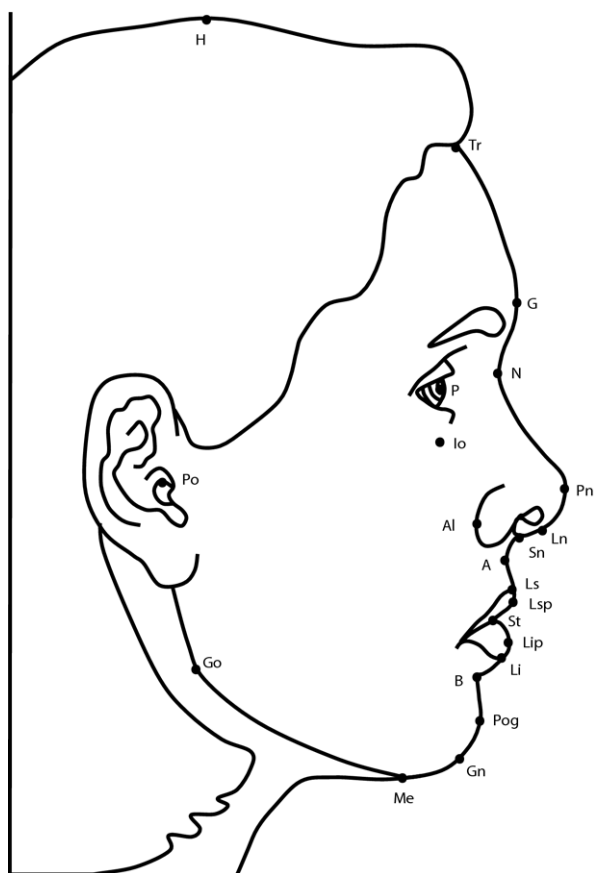
Fig 2. Landmarks on the lateral photograph (landmarks in *italics* were rejected): *H, hair top*; *Tr, trichion*; G, glabella; N, nasion; P, pupil; *Io, infraorbitale*; Pn, pronasale; Al, alare; *Ln, lowest nose point*; Sn, subnasale; A, soft-tissue Point A; Ls, labrale superior; Li, labrale inferior; St, stomion; Lsp, most protruded point of upper lip; Lip, most protruded point of lower lip; B, soft-tissue Point B; Pog, pogonion; Gn, gnathion; *Me, menton*; *Go, gonion*.

a median measurement error equal to or less than 5 pixels was taken. All landmarks with low reproducibility were excluded, except 2 landmarks on the frontal and 2 landmarks on the lateral photographs. These landmarks were included because they are often used in the literature and could not be replaced by more accurate landmarks. On the frontal photographs, these landmarks were XL and Tr with median measurement errors of 5.7 and 9.9 pixels, respectively; on the lateral photographs, these landmarks were G and Gn with median measurement errors of 12.6 and 15.1, respectively. In total, 45 landmarks with acceptable reproducibility, 29 on the frontal and 16 on the lateral photographs, were included in the analysis (Figs 1 and 2).

"Ideal" ratios and angles

"Ideal" ratios on the frontal photographs and "ideal" angles on the lateral photographs, dealing with the accepted landmarks, were selected from the literature.[1-21] In some ratios and 1 angle, the nonreproducible landmarks were replaced by more accurate landmarks. By this procedure, Na was replaced by N, ZyR and ZyL by XR and XL, and Me by Gn.

Because "ideal" ratios and angles for adolescents were seldom available in the literature, proposed ideals for young adults were used. If separate ideals were given for both sexes, their mean value was used to test the hypothesis that "ideal" ratios and angles as proposed in the literature can be used for all adolescents, aged 10 to 16 years, irrespective of age or sex. In total, 27 ratios on the frontal photographs and 26 angles on the lateral photographs were selected (Figs 3 and 4). Descriptions of the ratios and angles, with the "ideal" targets and their authors, are given in Tables I and II.

For each set of photographs, the accepted measurements were used to calculate the ratios and angles as presented in Table I and II. The z-score of the deviation of an individual variable (v) from its "ideal" target (t) was calculated as $z = [\text{individual } (v - t) - \text{mean } (v - t)]/\text{SD}$ (with *SD* as the standard deviation of the individual variable).

For further analysis, the z-scores were dichotomized (Dz = dichotomized z-scores) as follows:

$$\text{Dz} = 0 \text{ if } -0.5 \leq z \leq +0.5 \text{ and}$$

$$\text{Dz} = 1 \text{ if } z < -0.5 \text{ or } z > +0.5$$

This dichotomization was performed to reduce the effect of outlying individual variables and to classify these variables in only 2 groups. Within a range of 1 SD of the z-score ($-0.5 \leq z \leq +0.5$), the variable was supposed to be close to the "ideal" target; outside this area ($z < -0.5$ or $z > +0.5$), the variable was supposed to be different from the "ideal" target. All individual Dz scores for each variable were used as input for subsequent correlation analysis with the VAS scores on facial esthetics. A negative correlation means that the VAS scores in the deviant group (Dz = 1) were lower than the VAS scores in the other group (Dz = 0). A positive correlation points in the other direction. Subsequently, multivariate regression was performed to ascertain the combined effect of the significant dichotomized z-values of the angle and ratio measurements on the dependent variable of the VAS score.
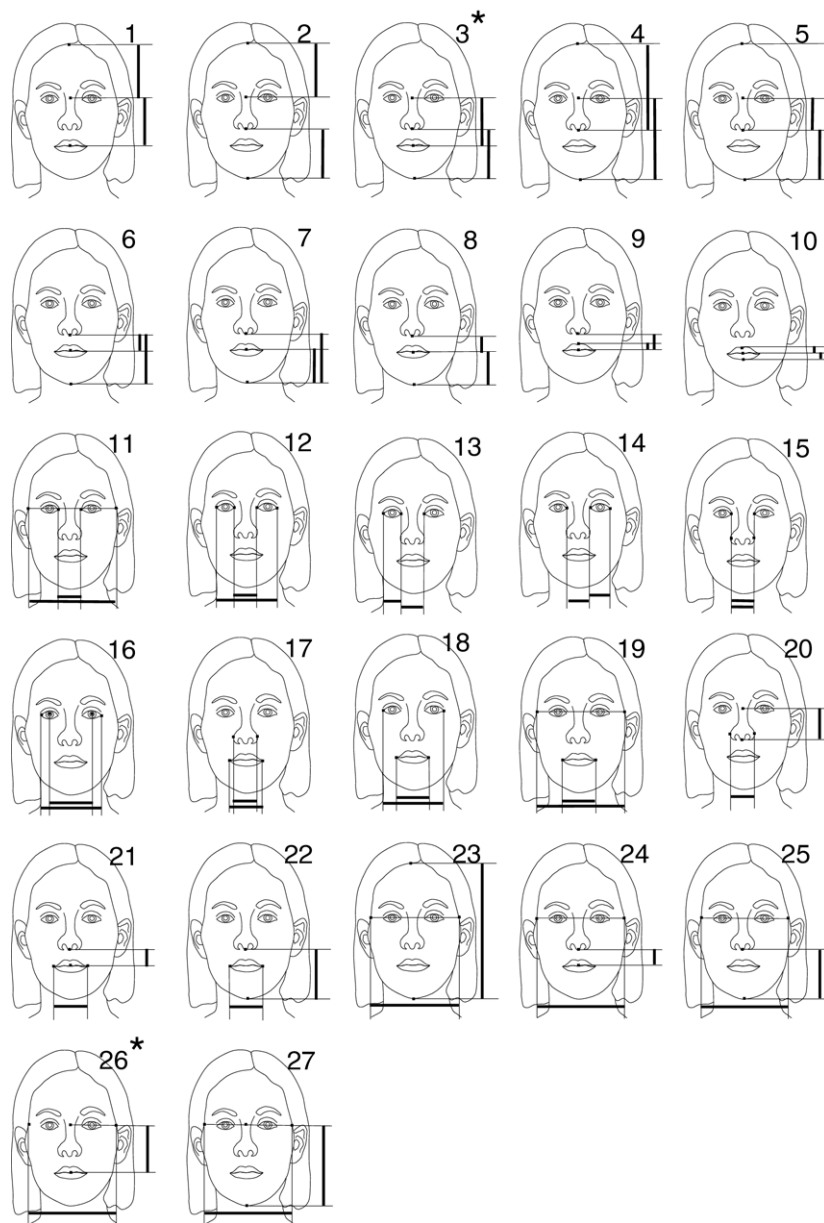
Fig 3. Twenty-seven "ideal" ratios on a frontal photograph, based on the accepted landmarks in the literature. *Significant at $P < .05$.

RESULTS

The mean VAS scores for the photographs were 55.3 ± 8.9 for the boys and 52.6 ± 9.5 for the girls. The range of all VAS scores was 31.0 to 70.8.

The correlation coefficients between the dichotomized z-scores and the VAS scores with their P values are given in Tables I and II. Of the 27 investigated ratios, only 2 were significantly correlated with the VAS scores, and both had the desired negative sign: ratio 3 ($r = -0.32$, $P = .01$) and ratio 26 ($r = -0.29$, $P = .02$) (Table I, Fig 3). When these 2 variables were combined, the correlation coefficient increased to $r = 0.41$ ($P < .001$) with an explained variance of 16.8% (prognostic value). Three of the 26 investigated angles were significantly correlated with the VAS scores, and all 3 had the desired negative sign: angle 3 ($r = -0.29$, $P = .02$), angle 22 ($r = -0.28$, $P = .02$), and angle 24 ($r =$
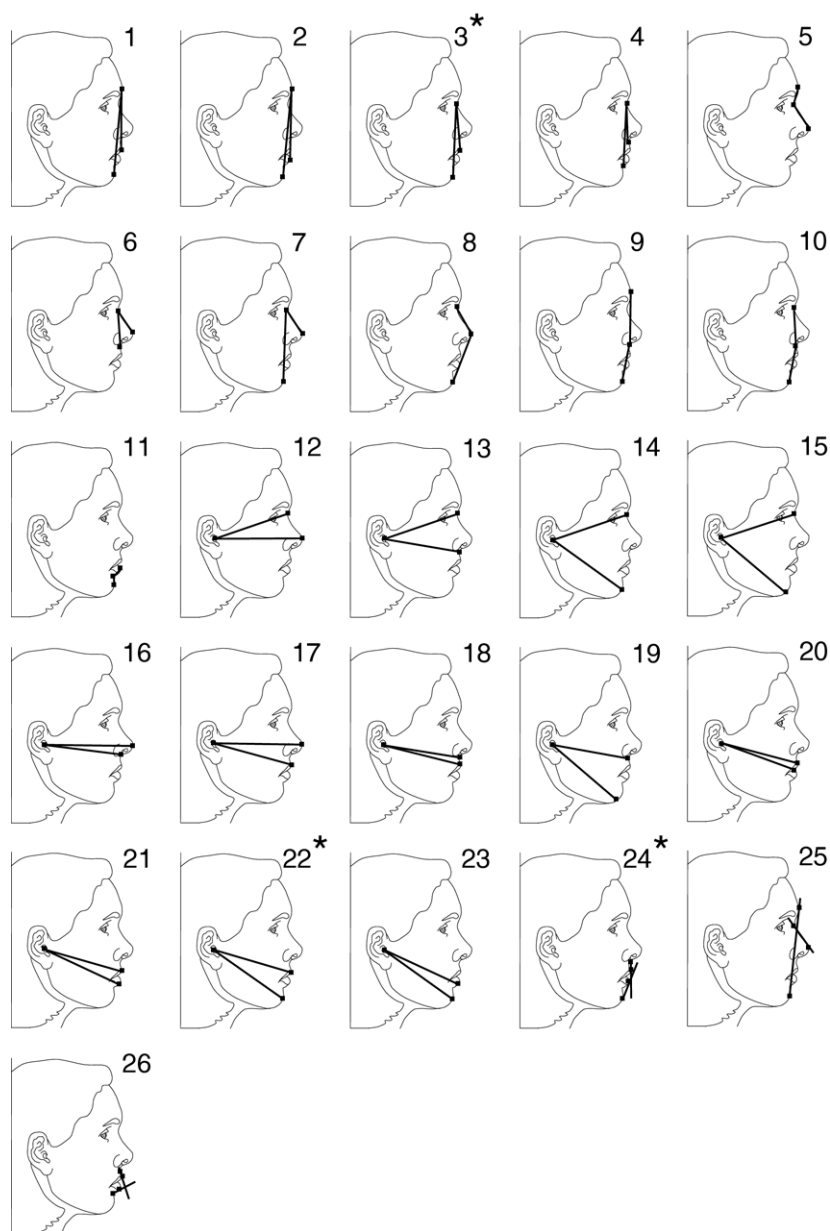
Fig 4. Twenty-six "ideal" angles on a lateral photograph, based on the accepted landmarks in the literature. *Significant at $P < .05$.

−0.25, $P = .04$) (Table II, Fig 4). When these 3 variables were combined in the multivariate regression analysis, the correlation coefficient increased to r = 0.43 ($P < .001$) with an explained variance of 18.5%. When the 2 significantly correlated ratios and the 3 significantly correlated angles were combined, the explained variance of this combination of the 5 variables was 28.7% ($P = .004$).

DISCUSSION

The ratios and the angles in this study were calculated directly between the landmarks. No reference axes, projections, perpendiculars, or tangent lines were used. These restrictions were followed to prevent projection errors and to make the measurement technique simpler and more applicable in clinical practice. Because of these restrictions and the fact that some

Table I. Description, target, author, and sample described in the literature, correlation coefficient (CC) between the dichotomized z-scores (Dz) of the deviation of the ratio from the target, and the VAS scores with *P* values for the 27 investigated ratios on frontal photographs

					Dz/VAS	
Variable	*Description*	*Target*	*Author*	*Target base*	*CC*	*P*
Ratio 1	Tr-N/N-St	1	Ricketts[1,2]	10 selected adult female fashion	0.13	.30
Ratio 2	Tr-N/Sn-Me	1	Ricketts[1,2]	models, age unknown	−0.10	.42
Ratio 3*	N-St/Sn-Me	1	Al-Al line replaced by Sn		−0.32	.01*
Ratio 4	Tr-Sn/N-Me	1			−0.04	.77
Ratio 5	N-Sn/Sn-Me	0.754	Powell and Humphreys[3] McNamara et al[4] Na replaced by N	Idealized males and females	−0.16	.20
Ratio 6	Sn-St/Sn-Me	0.333	Powell and Humphreys[3] Proffit et al[5]	Idealized males and females	0.04	.78
Ratio 7	St-Me/Sn-Me	0.667	Farkas and Munro[16]	654 males, 658 females, 6-18 y Mean 10-16 y	0.04	.78
Ratio 8	Sn-St/St-Me	0.5	Arnett and Bergman[6,7]	Authors' normative value for facial beauty	0.04	.78
Ratio 9	Ls-St/Sn-St	0.36	Farkas et al[17]	50 men, 39 women, age 18-25 y	0.06	.64
Ratio 10	Ls-St/St-Li	0.88			−0.02	.88
Ratio 11	EnR-EnL/XR-XL	0.2	El-Mangoury et al[8]	Authors' guidelines for good facial esthetics	−0.10	.44
Ratio 12	EnR-EnL/ExR-ExL	0.333	Powell and Humphreys[3]	Idealized males and females	−0.02	.85
Ratio 13	ExR-EnR/EnR-EnL	1	McNamara et al[4] Proffit et al[5]		0.03	.79
Ratio 14	EnL-ExL/EnR-EnL	1	El-Mangoury et al[8]		0.02	.86
Ratio 15	EnR-EnL/AlR-AlL	1	McNamara et al[4] Proffit et al[5]		−0.20	.11
Ratio 16	PR-PL/ExR-ExL	0.7	Koury and Epker[18]	Data from Farkas mean females, age 18-25 y	0.06	.64
Ratio 17	AlR-AlL/ChR-ChL	0.625	ZyR-ZyL replaced by		0.12	.36
Ratio 18	ChR-ChL/ExR-ExL	0.6	XR-XL		−0.10	.44
Ratio 19	ChR-ChL/XR-XL	0.4	Na replaced by N		0.03	.84
Ratio 20	AlR-AlL/N-Sn	0.625			0.22	.08
Ratio 21	Sn-St/ChR-ChL	0.4			0.08	.55
Ratio 22	Sn-Me/ChR-ChL	1.33	Koury and Epker[18]	Data from Farkas mean males and females, age 18-25 y	−0.02	.88
Ratio 23	XR-XL/Tr-Me	0.783	Jacobson[9]	Authors' opinion of balanced	−0.01	.96
Ratio 24	Sn-St/XR-XL	0.225	ZyR-ZyL replaced by	facial esthetics mean male/	0.01	.95
Ratio 25	Sn-Me/XR-XL	0.53	XR-XL	female mesoprosopic	−0.21	.09
Ratio 26*	N-St/XR-XL	0.535	Na replaced by N		−0.29	.02*
Ratio 27	N-Me/XR-XL	0.86			0.12	.33

*Significant at *P* < .05.

landmarks with a low reproducibility were excluded, some ratios and angles with their proposed targets described in literature were not tested.

Although a search for reliable landmarks was performed, we realize that the error in a given measurement does not depend only on the reproducibility of the landmarks involved. A vertical measurement error in a certain landmark has a greater impact on the measurement of a vertical distance than on a horizontal distance between this landmark and another landmark. The absolute distance between landmarks is also important. The smaller the distance between 2 landmarks, the more impact an erroneous landmark has on the mea-surement. It is also true that if the same landmark is involved in the 2 magnitudes of a ratio, an erroneous measurement of this landmark will have a high impact on the measurement of this ratio (because the 2 magnitudes of the ratio can change in a different direction).

Since it was considered important that not only beautiful faces were tested, we used a random selection of untreated adolescents who visited our clinic, representing a broad range of faces with different characteristics.

Professionals show great confidence in the so-called "ideal" ratios and angles, and use them as guidelines in their treatment plans. However, on the relationship of

Table II. Description, target, author, and sample described in the literature, correlation coefficient (CC) between the dichotomized z-scores (Dz) of the deviation of the angle, and the VAS scores with *P* values for the 26 investigated angles on lateral photographs

Variables	Description	Target	Author	Target base	Dz/VAS CC	P
Angle 1	Lsp-G-Pog	6.3°	Nguyen and Turley[10]	43 male, 25 female fashion models (1980-1995), estimated age 18-35 y	−0.02	.85
Angle 2	Lip-G-Pog	3.3°	Auger and Turley[11]		−0.10	.44
Angle 3*	Lsp-N-Pog	5.9°	Peck and Peck[12]	52 esthetically pleasing faces (49 females, 3 males), mean age 21.2 y	0.29	.02*
Angle 4	A-N-B	7.1°	Cox and van der Linden[13]	Best facial harmony 18 men, 18 women (from a group of 87 men, 87 women), age 18-20 y	0.01	.91
Angle 5	G-N-Pn	140.3°	Fernández-Riveiro et al[19]	50 men, 162 women, age 18-20 y	−0.16	.21
Angle 6	Pn-N-Sn	22.5°	Lines et al[14]	Preferred composite male/female silhouettes of profiles	0.15	.24
Angle 7	Pn-N-Pog	27.5°			−0.13	.30
Angle 8	N-Pn-Pog	129.5°	Cox and van der Linden[13]	Best facial harmony 18 men, 18 women (from a group of 87 men, 87 women), age 18-20 y	−0.04	.76
Angle 9	G-Sn-Pog	170°	Nguyen and Turley[10] Auger and Turley[11]	43 male, 25 female fashion models (1980-1995), estimated age 18-35 y	0.02	.87
Angle 10	N-Sn-Pog	163°	Cox and van der Linden[13]	Best facial harmony 18 men, 18 women (from a group of 87 men, 87 women), age 18-20 y	−0.12	.34
Angle 11	Lip-B-Pog	125.5°	Lines et al[14]	Preferred composite male/female silhouettes of profiles	−0.06	.62
Angle 12	N-Po-Pn	23.6°	Peck and Peck[12]	52 esthetically pleasing faces (49 women, 3 men) mean age 21.2 y	−0.19	.13
Angle 13	N-Po-Sn	28.5°	Fernández-Riveiro et al[19]	50 men, 162 women, age 18-20 y	−0.14	.29
Angle 14	N-Po-Pog	54.4°	Peck and Peck[12]	52 esthetically pleasing faces (49 women, 3 men) mean age 21.2 y	−0.04	.74
Angle 15	N-Po-Gn	57°	Hautvast[20]	1110 children (11-14 y) at 13 y	−0.02	.89
Angle 16	Pn-Po-Sn	7°			0.09	.46
Angle 17	Pn-Po-Ls	14.5°	Nanda et al[15]	25 male, 25 female esthetically pleasing balanced profiles, age 21-36 y	0.08	.55
Angle 18	Sn-Po-Ls	7°	Hautvast[20]	1110 children (11-14 y) at 13 y	0.19	.14
Angle 19	Sn-Po-Gn	36.5°	Fernández-Riveiro et al[19] Me replaced by Gn	50 men, 162 women, age 18-20 y	−0.16	.19
Angle 20	Ls-Po-St	2.8°	Nanda et al[15]	25 male, 25 female esthetically pleasing balanced profiles, age 21-36 y	−0.03	.81
Angle 21	Ls-Po-Li	7.1°			−0.01	.96
Angle 22*	Ls-Po-Pog	17.1°	Peck and Peck[12]	52 esthetically pleasing faces (49 females, 3 males), mean age 21.2 y	−0.28	.02*
Angle 23	Li-Po-Pog	12.5°	Nanda et al[15]	25 male, 25 female esthetically pleasing balanced profiles	−0.14	.27
Angle 24*	Sn-Lsp-/Pog-Lip	157.3°	Ferrario et al[21]	70 boys, 71 girls, age 11-13 y mesocephalic	−0.25	.04*
Angle 25	G-Pog/N-Pn	35°	Koury and Epker[18]	Data from Farkas mean females, age 18-25 y	−0.04	.77
Angle 26	B-Lip/Lsp-A	125°	Nguyen and Turley[10] Auger and Turley[11]	43 male, 25 female fashion models (1980-1995), estimated age 18-35 y	−0.01	.91

*Significant at P < .05.

facial features with facial esthetics in adolescents, little evidence is available. The use of various landmarks and the mixture of ages and sexes might be why so little evidence was found for so-called "ideal" ratios and angles.

The dichotomized z-scores of only 2 ratios and 3 angles showed a negative and significant correlation with VAS scores, indicating that subjects with values close to the "ideal" target were judged to be more attractive than the others. The sum score of these 5 dichotomized z-scores resulted in an explained variance of 28.7%. This is not high but far higher than the explained variance of 16% in a previous investigation on the relationship between golden proportions and facial esthetics.[27]

CONCLUSIONS

From the "ideal" proportions and angles found in the literature, few have a significant relationship with facial esthetics in adolescents. Combining these significant ratios and angles yields an explained variance of 28.7%.

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