Association of facial sagittal and vertical characteristics with facial aesthetics in the Northern Finland Birth Cohort 1966

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Summary

Objective: To explore the association of facial sagittal and vertical dimensions in relation to aesthetic assessment of three panel groups.

Materials and Methods: The study population comprised adult individuals from the Northern Finland Birth Cohort 1966 (NFBC1966). A clinical oral examination was performed including digital facial photographs. The study population was divided into subjects with lowest and highest values in soft tissue measurements in lower anterior facial height percentage (LAFH%) (60 subjects) and antero-posterior jaw relationship (soft tissue ANB angle) (60 subjects) and a control group (30 subjects). Frontal and profile facial photographs were presented to three panel groups: 5 orthodontists, 5 dentists and 5 laypersons, who evaluated the photographs using the Visual Analogue Scale (VAS).

Results: This study showed significant differences in VAS mean scores between the panel groups. Curve estimation revealed a significant quadratic association between aesthetic VAS evaluation and ANB angle for all panel groups. The association between ANB angle and perceived facial attractiveness was highest among orthodontists (R^2=0.276, *P*=0.001 for males; R^2=0.285, *P*=0.001 for females). However, no statistically significant association was found between facial attractiveness and lower anterior facial height percentage.

Conclusion: Facial sagittal dimensions appeared to influence facial aesthetics more than vertical dimensions in middle-aged adults. In their perception of facial aesthetics, orthodontists were more influenced by antero-posterior jaw relationships compared to dentists and laypersons. The overall perception of facial attractiveness related to facial dimensions appeared to differ between the panel groups in female and male faces.

Introduction

A balanced and harmonious facial appearance is one of the main goals of orthodontic treatment, along with optimal occlusal relationships (1, 2). Previous studies have demonstrated that aesthetic concern is the major reason for patients to seek orthodontic treatment (3–5). In addition, treatment of severe malocclusions has been shown to improve aesthetic satisfaction and oral health-related quality of life (6).

Since orthodontic treatment may change facial soft tissue appearance, the study of facial aesthetics is an important part of comprehensive treatment planning and evaluation of treatment outcomes. However, the evaluation of facial aesthetics is not simple due to the subjective nature of the perception of facial attractiveness (2). Assessment of facial aesthetics by orthodontists is not necessarily in accordance with patients' perceptions (7). In addition, orthodontic treatment requires co-operation between the patient and the clinician. Therefore, it is important for orthodontists to understand how the general public experiences facial aesthetics.

There is a large body of published literature discussing whether orthodontists and laypersons differ in their perceptions of facial aesthetics. It has been shown that preferences of facial attractiveness are in agreement between clinicians and patients (8) as well as between orthodontists or orthodontic residents and laypersons (2, 9, 10). On the other hand, some earlier studies have found differences between orthodontists and laypersons (7, 11, 12) as well as between dentists and laypersons (13) in their perception of profile aesthetics.

Earlier studies have attempted to answer whether there is an association between sagittal and vertical dimensions of facial soft tissue characteristics and perception of facial attractiveness. Some cephalometric (14, 15) and facial silhouette (16) investigations have evaluated facial aesthetics of sagittal (antero-posterior) discrepancies, while other studies have concentrated on the attractiveness of vertical dimensions based on silhouette (17) and facial (8) images. Several studies have also evaluated the facial aesthetics of combined sagittal and vertical dimensions (2, 13, 18, 19). It has been shown that both lower facial height and mandibular prominence have an influence on facial attractiveness (14, 17, 20). However, Knight & Keith (19) found only minor influence of soft tissue ANB angle and facial vertical dimension on facial attractiveness. Normal lower facial height (17, 20) and normal antero-posterior position of the mandible (14, 16) have been rated as the most attractive facial characteristics. By contrast, both extreme vertical and sagittal dimensions have been scored as the least attractive appearance (2).

The aims of this study were (i) to explore the association between facial sagittal and vertical dimensions when analysed in soft tissues in relation to aesthetic assessment of three panel groups in a large birth cohort of middle-aged individuals, and (ii) to investigate whether there is agreement between orthodontists, dentists and laypersons in their perceptions of facial aesthetics.

Materials and methods

Study population

The study population in this investigation was part of the Northern Finland Birth Cohort 1966 (NFBC1966). The NFBC1966 is an epidemiological and longitudinal research program aimed at promoting the health and well-being of the population in Northern Finland (21). The total NFBC1966 cohort consists of 12,058 subjects who were born in 1966 in the two northernmost provinces of Finland. These individuals represent 96.3% of all births in Oulu and Lapland in 1966. A total of 3,150 individuals lived in the Oulu region (range 100 kilometres) and were invited to attend a clinical oral and dental health examination that took place in 2012. The initial study population of the present study consisted of 1,964 individuals (912 men and 1,052 women) who took part in the clinical examination which was performed at the Institute of Dentistry, University of Oulu. The subjects were included in the study if they had full records from the clinical examination and facial photographs of diagnostic quality. Subjects with craniofacial syndromes or severe facial deformities were excluded. Participation was voluntary and the study was approved by the Ethical Committee of the Northern Ostrobothnia Hospital District (74/2011). The subjects gave written consent for the study.

Clinical facial photographs

All subjects underwent a standardized clinical examination including standardized clinical facial photographs. A profile and a frontal 2D photograph with basic facial expression was taken of each subject in a standardized manner. All photographs were taken without eyeglasses. The type of the camera and camera settings used were Canon 600D, Canon-EF-S 60 mm F/2.8 MACRO USM, general illumination. The position where subjects had to

stand was marked on the floor and the distance between the subject and the camera tripod was 190 cm. Camera settings were based on F/5.6 and ISO/200 (jpeg-format).

Soft tissue measurements

Profile photographs were transferred to ViewBox software (dHAL Software, Kifissia, Athens, Greece) and lower facial height percentage (LAFH%) and sagittal jaw relationships (soft tissue ANB angle) were measured in order to determine facial dimensions. Soft tissue cephalometric points A-point, nasion and B-point were digitized and ANB angle was measured. The LAFH percentage was determined as a ratio of the distances between soft tissue points subnasale–menton and nasion–menton. All measurements were calculated automatically in ViewBox software after the soft tissue landmark digitization performed by the same examiner.

Sample selection

The final study population in the present study consisted of two main study groups and a control group based on vertical and sagittal facial dimensions (Table 1.). The subgroups comprised LAFH min group (30 subjects), LAFH max group (30 subjects), ANB min group (30 subjects) and ANB max group (30 subjects). The ranges for the LAFH groups were 48.1–54.3% (LAFH min) and 64.5–70.8% (LAFH max), and for the ANB groups, 0.1–2° (ANB min) and 12.3–14.7° (ANB max). For the control group, subjects were first sorted with LAFH%. A median value was located and 100 subjects nearest to the centre point of the study population were chosen. The same sorting was performed for ANB. After sorting, both lists were compared with each other, and 30 subjects who presented at most median values, were chosen as control group members (LAFH 59.1–59.7%; ANB 6.7–7.4°). Regarding the LAFH groups, LAFH min group included the first 30 subjects with the lowest LAFH values

while LAFH max group consisted of the first 30 subjects with the highest LAFH values. ANB min and max groups were selected analogously to the LAFH groups. Since three subjects were included both in extreme cases of anterior lower facial height and soft tissue ANB angle, the total size of the final study population was 147 subjects (69 men and 78 women).

Aesthetic evaluation

Profile and frontal (basic facial expression) photographs of each subject (N=147) in the study groups and control group were numbered and placed in random order into Microsoft PowerPoint. The number of the subject was marked in the upper left corner in the PowerPoint slide and there was a frontal and a profile image of the same subject in each slide. The size of the photos was fixed at 16.8 x 11.2 cm. The photograph series was presented to three panel groups: 5 orthodontists (2 men, 3 women; mean age = 53.8 years; range = 35–62 years), 5 dentists (5 women; mean age = 56.2 years; range = 47–68 years) and 5 laypersons (3 men, 2 women; mean age = 41.4 years, range 30–53 years). The orthodontists and general dentists were staff working at the research unit of Oral Health Sciences, University of Oulu. The laypersons were non-clinical staff with no medical education working at the Faculty of Medicine, University of Oulu. Each photograph of the same subject (frontal and profile) was shown for 10 seconds. After every 10^{th} photo there was a 10-second break. Before judging the series of photographs, the panel groups were instructed to pay attention only to facial appearance. The raters were asked to evaluate facial appearance independently. Each panel group member evaluated facial appearance using Visual Analogue Scale (VAS) with 0 and 10 representing the least and most attractive visual appearance, respectively. The rating sheet included an example of a marked 100-mm VAS line and 159 numbered 100-mm VAS lines for ratings. The raters marked their answers

physically on the visual scale using a vertical line and the results were measured with 1 mm accuracy using a ruler.

Statistical analysis

All statistical analyses were carried out using SPSS version 25.0 (SPSS, IBM©, Armonk, NY, USA). Since VAS values were normally distributed, parametric methods were chosen to analyse the data. In order to test method error, 12 randomly selected photos were re-evaluated at the end of the judging by each rater. Paired samples t-test was used to test intra-rater reliability of the aesthetic evaluation. Paired samples t-test was selected to investigate the differences in aesthetic evaluation between the panel groups (orthodontists vs. clinicians, orthodontists vs. laypersons and clinicians vs. laypersons). Differences between the perception of the panels evaluators according to LAFH min, LAFH max and control groups as well as ANB min, ANB max and control groups were evaluated using ANOVA with Tukey's post hoc test. Pearson correlation coefficient was used to test the association in aesthetic VAS scores between different panel groups. Associations between anterior lower facial height (LAFH) and soft tissue ANB angle in relation to aesthetic assessment (VAS) of the three panel groups in female and male subjects were studied with quadratic regression models. Statistical significance was determined at $p < 0.05$.

Results

Reliability analysis

No statistically significant differences were found in intra-class ratings ($P_{orthodontists}$ = 0.557, Difference = 0.06; $P_{Dentists}$ = 0.894, Difference = -0.02; $P_{Laypersons}$ = 0.821, Difference = -0.03). These values justified the subsequent analyses of the data. Pearson correlation coefficients for associations in aesthetic VAS-scores between different panel groups varied between 0.733 and 0.839 (P<0.001 for all), indicating that all panel groups gave the highest and lowest VAS scores to the same subjects.

Differences in perceived attractiveness between the panel groups

Differences in aesthetic evaluation between the panel groups were studied with paired samples t-test. On average, laypersons gave lower aesthetic VAS scores than orthodontists and dentists in the LAFH groups (Table 2.). Orthodontists gave significantly higher VAS scores than laypersons (P = 0.038) in the ANB min group (Table 2.).

Comparisons between the study groups and the control group

The LAFH max group differed significantly from the control group in all panel groups' evaluations (P = 0.011 among orthodontists, P = 0.008 among dentists, and P = 0.015 among laypersons) while the LAFH min group did not (ANOVA with Tukey's post hoc test). Regarding ANB groups, the ANB max group differed significantly from the control group in all panel groups' evaluations (P < 0.001 among orthodontists and dentists, P = 0.036 among laypersons), while the ANB min group differed from the control group among orthodontists (P = 0.003) and dentists (P < 0.001) but not among laypersons (P = 0.070).

Association between ANB angle and perceived attractiveness

The mean ANB values were 1.36 (SD=0.54) among the ANB min group, 12.92 (SD=0.62) among the ANB max group, and 7.06 (SD=0.21) among the control group. Curve estimation revealed a quadratic association between aesthetic VAS evaluation and ANB angle for all panel groups. The association between ANB and perceived facial attractiveness appeared to be highest among orthodontists (R^2=0.276, *P*=0.001 for males; R^2=0.285, *P*=0.001 for females) (Figure 1a). For dentists, the association was R^2=0.188 (*P*=0.014) among males and R^2=0.231 (*P*=0.004) among females (Figure 1b). For laypersons, the association between VAS evaluation and ANB angle was R^2=0.075 (*P*=0.201) among males and R^2=0.269 (*P*=0.001) among females (Figure 1c). These results indicate that among orthodontists, 28% and 29% of the variability in VAS scores can be explained by ANB angle in males and females, respectively.

Association between LAFH and perceived attractiveness

Mean value for LAFH was 53.25 (SD=1.27) among the LAFH min group, 65.33 (SD=1.23) among the LAFH max group, and 59.41 (SD=0.20) among the control group. Based on the results of curve estimation, the best fitting model for association between aesthetic VAS and LAFH was the quadratic model for all panel groups. Associations between LAFH and perceived attractiveness among orthodontists (R^2=0.146, *P*=0.054 for males; R^2=0.058, *P*=0.244 for females) and laypersons (R^2=0.044, *P*=0.436 for males; R^2=0.064, *P*=0.211 for females) were non-significant (Figures 2a and 2c). For dentists, a weak association was found among males (R^2=0.172, *P*=0.031) while among females the association between LAFH and perceived facial attractiveness was non-significant (R^2=0.032, *P*=0.471) (Figure 2b).

Discussion

This study investigated the association between facial sagittal and vertical dimensions in relation to aesthetic assessment of three panel groups in a large Finnish birth cohort of middle-aged individuals. In the present study, aesthetic evaluation of facial attractiveness by panel members was based on VAS scores. Earlier panel studies have also used VAS scores in aesthetic assessment of facial characteristics (2, 17). Due to the subjective nature of perception of facial aesthetics, a possible disadvantage of using VAS is distraction between the raters. The same positioning of lines in VAS does not necessarily describe the same feeling for different evaluators (22).

Furthermore, raters' age (13, 23–25), gender (11, 23, 24) and education (23, 26) have an influence on perceived facial attractiveness. It appears that females and younger individuals tend to be stricter judges of facial aesthetics than males and older adults (27, 28). In the present study, distribution of genders was unequal and thus the influence of rater's gender and education on perceived facial aesthetics could not be separated and examined. The mean ages of the judges varied between 41 and 56 years of age, which was similar to the study population consisting of middle-aged subjects born in 1966. The results of the present investigation need to be interpreted under the spectrum of the above-mentioned factors.

Our results demonstrated differences in aesthetic assessment between the panel groups. An earlier profile image study also detected significant differences between dentists and laypersons in the perception of profile attractiveness (13). In the present study, compared to orthodontists and dentists, laypersons judged especially subjects with extreme values of lower anterior facial height as less attractive. Conversely, orthodontists evaluated subjects

with a concave facial profile (low ANB angle) as more attractive than dentists and laypersons. In a previous investigation, there was a statistically significant difference in the perceived level of attractiveness between orthodontists and laypersons based on facial convexity angle (29).

In this study, soft tissue ANB angle was significantly related to facial attractiveness in all panel groups in both genders. The association was insignificant only among male faces judged by laypersons. The current results indicate that antero-posterior discrepancy or facial convexity, as measured by soft tissue ANB angle, is associated with facial aesthetics. Antero-posterior dimension of the face has earlier been considered as the most important factor in evaluation of facial aesthetics (30). It has also been shown that facial attractiveness is influenced by soft tissue profile outline form and improvement in profile outline is related to increased perception of facial aesthetics (3). On the other hand, a previous facial photograph investigation found only minimal correlation between soft tissue ANB angle and facial attractiveness (19). However, the subjects in the earlier study were young adults (19) while the present study was based on middle-aged adults. It has been shown that the craniofacial complex undergoes several changes during adulthood regarding skeletal and soft tissue characteristics (31). Earlier studies have detected changes in facial convexity in adulthood both in skeletal (32) and soft tissue profiles (33). A significant increase has been found in ANB angle between 25 and 46 years of age based on cephalograms (32). In addition, the angle of soft tissue convexity (GL'-SLS-Pog') has been observed to decrease between 25 and 45 years of age in both genders (33).

Earlier investigations have shown differences between female and male faces regarding facial features related to attractiveness (17, 19, 34, 35). This was confirmed by the results

of this study. In female subjects, a slightly convex profile was considered most attractive among orthodontists and dentists. This finding is in agreement with a previous study reporting that professionals preferred a slightly convex profile for females (34). On the other hand, contradictory findings have also been published with no significant differences found among orthodontists in perception of facial aesthetics between retrognathic and prognathic profiles (35).

Lower anterior facial height did not relate significantly to facial attractiveness in this study. Only a weak association was found in male subjects among dentists. Earlier reports have shown that increased LAFH is associated with less attractive faces for females (17, 19). However, this is not in agreement with our findings. The present results are in accordance with the study of Chew et al. (36) which was based on cephalograms and showed that lower facial height did not significantly influence profile aesthetics as evaluated by clinicians and laypersons. According to a facial silhouette study, lower facial height has an influence on frontal facial attractiveness perception of laypersons (17). In spite of the literature demonstrating that both lower facial height and antero-posterior position of the mandible have an influence on facial attractiveness (2, 14, 17, 20) we were not able to present similar findings.

A most likely explanation for the non-significant relationship between facial attractiveness and lower anterior facial height may be our study design. The LAFH ranges for the LAFH min group were not very low and correspondingly, the ranges for the LAFH max group were not very high in terms of soft tissue facial aesthetics. However, the selected values were the most extreme values in this normal adult population. Another potential confounder in the present study might be related to the nature of the study population. It has been shown that

change in subcutaneous adipose tissue is a general feature associated with aging facial tissue (37). Therefore, due to excess facial fat deposition, facial photographs and soft tissues do not necessarily correlate with skeletal features in middle-aged adults. Undoubtedly, a limitation of this study was that soft tissue thickness was not determined. The ANB min subgroup contained very mild Class III skeletal discrepancy while the ANB max subgroup contained very severe cases.

In this study, 28% and 29% of the variability in VAS scores among orthodontists could be explained by the ANB angle in male and female faces, respectively, while the proportions were smaller among dentists and laypersons. This result indicates that in the perception of facial attractiveness, the significance of soft tissue ANB angle is greater among orthodontists as compared to dentists and laypersons. This is an expected finding as orthodontists are more familiar with facial profile morphology. It has earlier been proposed that orthodontists could be more sensitive to certain aspects of the profile compared to laypersons (38). By contrast, laypersons might pay more attention to the overall characteristics of the face (7). Laypersons are also more likely to concentrate on chin shape, nose and hair colour (11). Because of their training, orthodontists might be sensitive to discrepancy in facial attractiveness (39). In the present study, only 6–15% of the variability in VAS scores among orthodontists could be explained by vertical dimensions. The present findings are in line with a previous study as it has been shown that orthodontists are more sensitive to horizontal than vertical changes in facial profile (18). The present study showed significant differences between orthodontists, dentists and laypersons in the perception of facial attractiveness, as related to facial convexity. Clinically, this highlights the importance of the patient's opinion on facial aesthetics when making decisions on treatment objectives.

Conclusions

- Among middle-aged adults, facial sagittal dimensions appeared to have more influence on facial aesthetics than vertical characteristics.
- The overall perception of facial attractiveness related to facial characteristics differed between the panel groups in female and male faces.
- Soft tissue ANB angle was more significant in explaining facial aesthetics among orthodontists than among dentists or laypersons.

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Conflict of interest

The authors report no conflicts of interest.

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Figures and Tables

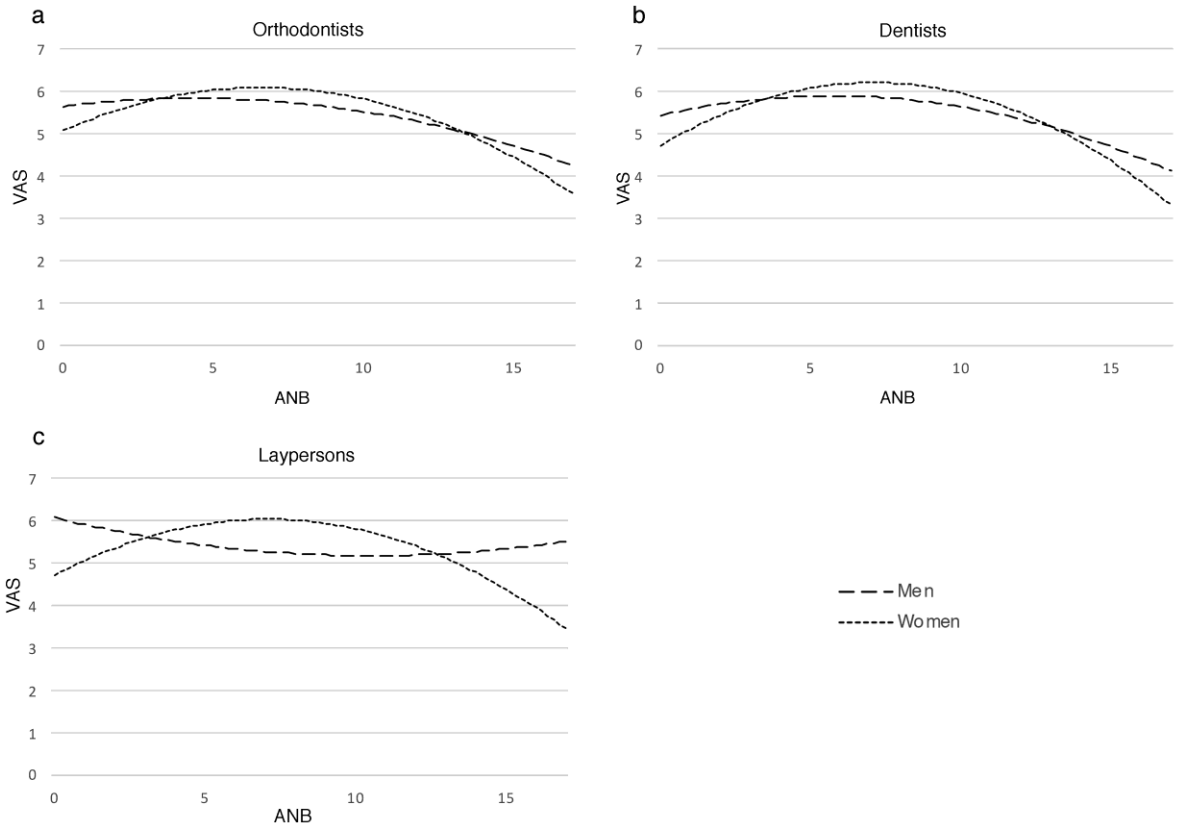

Figure 1. Quadratic regression models for association between VAS scores and ANB angle at different panel groups: (a) Orthodontists, (b) Dentists, (c) Laypersons.

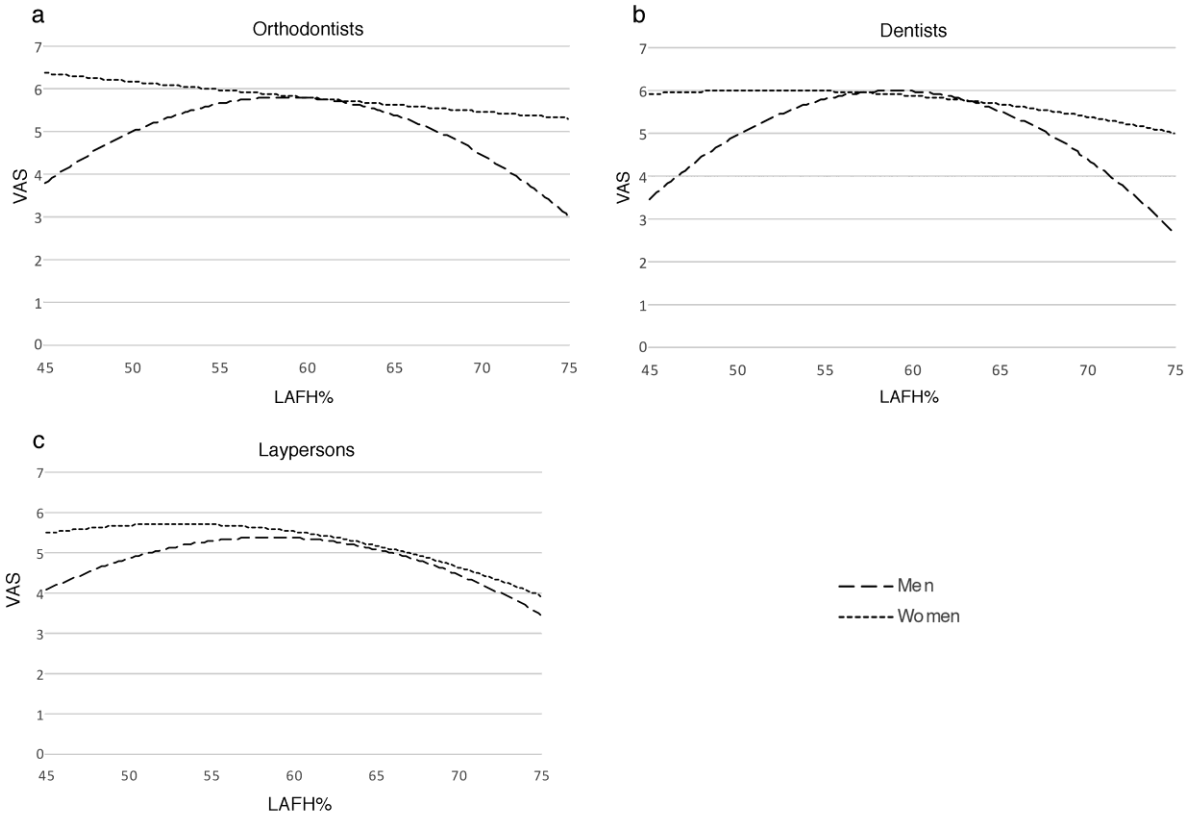

Figure 2. Quadratic regression models for association between VAS scores and LAFH% at different panel groups: (a) Orthodontists, (b) Dentists, (c) Laypersons.

Table 1. The study population.

Study groups	N	Gender	Range
Low LAFH	30	8 men, 22 women	48.1-54.3%
High LAFH	30	17 men, 13 women	64.5-70.8%
Low ANB angle	30	5 men, 25 women	0.1-2°
High ANB angle	30	24 men, 6 women	12.3-14.7°
Control group	30	15 men, 15 women	59.1-59.7%; 6.7-7.4°

LAFH = lower anterior facial height.

Table 2. Aesthetic evaluation VAS mean scores at different groups (n=30 at each group) by evaluators occupation.

	LAFH min	LAFH max	ANB min	ANB max	Controls
Orthodontists	5.86	5.45	5.49	5.10	5.99
Dentists	5.83	5.49	5.27	5.15	6.11
Laypersons	5.24	5.03	5.26	5.21	5.70
p^1	0.612	0.616	0.057	0.614	0.177
p^2	0.010	0.001	0.038	0.210	0.007
p^3	0.009	<0.001	0.967	0.667	<0.001

p^1, orthodontists vs. dentists; p^2, orthodontists vs. laypersons; p^3, dentists vs. laypersons.