ANALYSIS OF THE RELATIONSHIP BETWEEN FACE PROPORTIONS AND ESTHETICS ASSESSMENT

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Abstract

Introduction. The goal of the orthodontic treatment is, among others, improvement of patient's face esthetics. Taking into consideration rational and objective standards is a requirement for achieving the good final result.

Aim. The goal of the study was to investigate the relationship between facial proportions and subjective esthetics assessment in the group of young Polish adults.

Material and methods. Standardized facial *en face* photographs of 73 dentistry students of the Medical University of Lublin were analyzed. The sample consisted of 40 females and 33 males aged 21-24 years old. Skin cephalometric points were found in the face photographs using Ortomed Evo software. Respective lengths were measured and 26 facial proportions were calculated. Simultaneously, attractiveness of the faces in the photographs was assessed by 15 third party people, using a ranking method.

Results. A significant positive correlation betwe*en face* esthetics and value of the frontal vertical proportion: Trichion-Nasion/Nasion-Stomion (ratio of forehead height to nose length together with upper maxillary part) was found. Statistical significance was also discovered in relation between face attractiveness and intercanthal distance, described by proportion Excanthus Right-Endocanthus Right/Endocanthus Right-Endocanthus Left. Great deviations from standard values decreased face attractiveness and small deviations were favorable. In the female respondents a significant positive correlation between esthetics assessment and nose proportion Alare Right-Alare Left/Nasion-Subnasale was found. In males the significance of proportion ExR-EnR/EnR-EnL referring to intercanthal distance was repeated.

Conclusions. The study exhibited correlation between face proportion and esthetics assessment. The strongest impact on attractiveness was found in intercanthal distance, and in the female group also in nose proportions.

Keywords: facial proportions, esthetics, cephalometrics.

Introduction

An attractive face is an important aspect of interpersonal communication, it has a positive influence on a person's development in all the areas of the civilized society, and also facilitates success [1-3], that is why a contemporary person seeks to maximal improvement of beauty.

The aim of the orthodontic treatment is, among others, improvement of patient's face esthetics [4-6]. An orthodontic and surgical-orthodontic treatment, including

both functional and esthetic aspects, are necessary for obtaining good final result which is satisfying for a patient and a doctor. Therefore, it seems purposeful to study and consider rational and objective standards.

Search for answers to the question, what guides people in assessing face attractiveness, inspired the researchers to look for the relationship between facial proportions and beauty. Face proportions' measurements in the photographs were made by Knight and Keith [7], by marking caphalometric skin points in the printed profiles' photographs and by calculating appropriate ratio of the front lower face height to the total face height together with A-N-B angle. The obtained results were referred to esthetics ranking. In 2006 Edler proved that on the basis of measurements of facial proportions in the photographs, it is possible to objectively assess esthetics [8].

Studies concerning the relationship between face proportions and esthetics assessment have been conducted in various populations [9-12], however, there are not any research in reference to the Polish population. Face esthetics is a willingly undertaken subject of scientific research due to the fact that representatives of various medical specialties, who change patients' facial appearance, e.g. jaw surgeons, orthodontists, plastic surgeons, dermatologists, need scientific grounds for their clinical practice [13]. In the modern society, requiring perfect appearance, an improvement of beauty may significantly improve the patient's life quality [14].

Aim

The aim of the work was search for possible relationships between selected measurements of face proportions and subjective face esthetics assessment made by a third party observer. What was especially looked for, were such dependencies that could be useful in preserving positive esthetic effects during the orthodontic and/or surgical treatment around the facial area.

Material and methods

Material consisted of face photographs of 73 dentistry students of the Medical University of Lublin, including 40 females and 33 males aged from 21 to 24 years old. The mean age in the group of women was equal to 23.15, while in the group of men – 22.93. All the respondents were Caucasians.

The patients qualified for the study: did not have any congenital abnormality, did not wear dental braces, could not have any visible mole in the facial area which could significantly influence esthetics perception, did not wear heavy makeup, did not report the history of facial skeleton injuries nor plastic or reconstructive surgeries in an interview.

The photographed people were asked to take off their glasses and to do their hair in a way they do not impede further research (face and ears had to be visible in the photo). The photographs were taken in front of the plain, bright background in the same light conditions, with the Olympus Digital Camera (Olympus Imaging Corp.) in the portrait mode with automatically set diaphragm and exposure time. The respondents were sitting while the photograph was being taken. The distance

between the camera and the photographed face was 2.5 m, and the camera was put on the level of the person's pupils. The photographs were taken in the respondents' natural head position (NHP). The collected research material in the form of photographs was archived in the program Ortomed Evo, Gesimag (Henry Schein, Infomed Software Sanitario), which is helpful in collecting and analyzing orthodontic documentation.

En face photographs of resp ondents were archived in Ortomed Evo. With the use of computer measuring tool, in the photos, there measured in millimeters the segments required to indicate face proportions. The photographs were not calibrated – the segments were not measured in real lengths.

During the process, *en face* cephalometric skin points were used: Tr, Na, EnR, EnL, ExR, ExL, PR, PL, XR, XL, Sn, AlR, AlL, Ls, St, Li, ChR, ChL, Gn, whose characteristics and localization is shown in Table 1. Those points were described by Kiekens *et al.* [9] as encumbered with low risk of researcher's error and valuable for face proportions assessment.

Table 1. Characteristics of *en face* facial skin points

Point	Localization of facial skin point
Tr	Trichion – point on the sagittal plane of face median line, on the forehead, border of hairline
N	Nasion – point on the sagittal plane of face median line reconstructed on the root of the nose in the point of intersection of horizontal line connecting the pupils
EnR	Endocantion Right – inner commissure of the right eye fissure
EnL	Endocantion Left – inner commissure of the left eye fissure
ExR	Exocantion Right – outer commissure of the right eye fissure
ExL	Exocantion Left – outer commissure of the left eye fissure
PR	The middle point of the right pupil
PL	The middle point of the left pupil
XR	Reconstructed point on the right temple on the line intersecting the pupils
XL	Reconstructed point on the left temple on the line intersecting the pupils
Sn	Subnasale – transition point from skin nose bridge to the upper lip
AlR	Alare Right – the most lateral point on the right wing of the nose
AlL	Alare Left – the most lateral point on the left wing of the nose
Ls	Labrale superius – the point on the upper lip denoting transition of skin into vermillion border
St	Stomion – the point on the upper and lower lip contact on the sagittal plane of face median line
Li	Labrale inferius – the point on the lower lip denoting transition of vermillion border into skin
ChR	Cheilion Right – right corner of the mouth
ChL	Cheilion Left – left corner of the mouth
Gn	Gnathion – the point located the lowest and the most frontal in the bony chin

On the basis of the marked points, the linear measurements were made and mutual proportions between the appropriately matched indicators were analyzed.

Simultaneously, an assessment of an attractiveness of the photographed students' faces with a ranking method proposed by Knight and Keith [7] was made. The assessment was made by 15 people (8 women and 7 men) aged 28-35 years. All of them had higher education level and average socioeconomic status. Each person was supposed to assess two groups of black and white photographs printed in A4 format,

A. women's *en face*,

B. men's *en face*.

It was suggested to separately rank each group of photos in the order from the most to the least attractive. The scores were given, where 1 point meant the best assessment, therefore, the most attractive face. The photographs considered as less attractive were scored more points, increasing with decrease of the evaluated face's attractiveness. Then, the assessments (rankings) were divided by the number of people who were assessed and that is how the general assessment indicator OS was calculated with values ranged (0-1). The ranking method for an attractiveness assessment was used by Abu Arqoub and Al-Khateeb [15], Tulloch *et al.* [16], and was positively opinioned by Philips *et al.* [17] and Torsello *et al.* [18].

The subjective results of an attractiveness assessment were analyzed taking into account relations with studies of *en face* proportions.

A statistical analysis of the research results was made using Statistica 10.0 PL.

Analysis of the relationship between face esthetics assessment (for all the respondents and divided into genders) and measured proportions indicators AS was made using Spearman's rank correlation coefficient (R) and t-test of this coefficient in the population. The statistically significant results were.

Results

For each face proportion A value (A means face proportion value for a given respondent), the absolute value of its deviation from the ideal T value was set (Table 2), that is |A-T| value, which was next standardized by calculating AS=(|A-T|-M|A-T|)/SD|A-T| value. Therefore, the higher AS of the studied indicators, the higher their deviations from the ideal value. The assessments (ranks) were divided by the number of the assessed, obtaining OS assessments with values ranged (0-1). Then, mean values of the assessments for each of the assessed persons were calculated, *en face*. The higher OS values, the worse attractiveness assessment. Table 2 includes ideal T values of the studied indicators as well as mean values and standard deviation of A indicators, and deviations of the observed values from the ideal ones A-T.

Table 2. Ideal T values and basic descriptive statistics (mean value and standard deviation) for the studied A indicators and A-T values

No.	Proportion (A)	Ideal T value	Face proportion mean value in the studied group M(A)	Standard deviation SD (A)	Mean M (A-T)	Standard deviation SD (A-T)
1	Tr-N/N-St	1.000	1.069	0.103	0.069	0.103
2	Tr-N/Sn-Me	1.000	1.116	0.156	0.116	0.156
3	N-St/Sn-Me	1.000	1.038	0.084	0.038	0.084
4	Tr-Sn/N-Me	1.000	1.066	0.079	0.066	0.079
5	N-Sn/Sn-Me	0.754	0.719	0.087	-0.035	0.087
6	Sn-St/Sn-Me	0.333	0.317	0.028	-0.016	0.028
7	St-M/Sn-Me	0.667	0.687	0.040	0.020	0.040
8	Sn-St/St-Me	0.500	0.463	0.056	-0.037	0.056
9	Ls-St/Sn-St	0.360	0.245	0.079	-0.115	0.079
10	Ls-St/St-Li	0.880	0.526	0.183	-0.354	0.183
11	EnR-EnL/XR-XL	0.200	0.233	0.020	0.033	0.020
12	EnR-EnL/ExR-ExL	0.333	0.338	0.022	0.005	0.022
13	ExR-EnR/EnR-EnL	1.000	0.982	0.121	-0.018	0.121
14	EnR-EnL/AlR-AlL	1.000	0.890	0.098	-0.110	0.098
15	PR-PL/ExR-ExL	0.700	0.658	0.062	-0.042	0.062
16	AlR-AlL/ChR-ChL	0.625	0.716	0.062	0.091	0.062
17	ChR-ChL/ExR-ExL	0.600	0.536	0.041	-0.064	0.041
18	ChR-ChL/XR-XL	0.400	0.369	0.028	-0.031	0.028
19	AlR-AlL/N-Sn	0.625	0.774	0.079	0.149	0.079
29	Sn-St/ChR-ChL	0.400	0.414	0.061	0.014	0.061
21	Sn-Me/ChR-ChL	1.330	1.301	0.134	-0.029	0.134
22	XR-XL/Tr-Me	0.783	0.737	0.035	-0.046	0.035
23	Sn-St/XR-XL	0.225	0.152	0.019	-0.073	0.019
24	Sn-Me/XR-XL	0.530	0.479	0.038	-0.051	0.038
25	N-St/XR-XL	0.535	0.499	0.042	-0.036	0.042
26	N-Me/XR-XL	0.860	0.822	0.042	-0.038	0.042

R – rank correlation coefficient, p – level of significance

In order to study the relationship between the face proportion value and the obtained attractiveness assessment, Spearman's rank correlation coefficient was calculated (Table 3).

Analyzing relationship of the set proportions with the obtained esthetics assessment, a significant positive correlation was found between *en face* assessment and two AS indicators, (1)Tr-N/N-St and (13)ExR-EnR/EnR-EnL. It means that great proportions'

Table 3. Spearman's rank correlation coefficient between AS values of the proportions and *en face* esthetics assessment (significant correlations are marked with an asterisk * and with bold font)

No.	Proportion values (AS)	R	p
1	Tr-N/N-St	**0.245**	**0.037***
2	Tr-N/Sn-Me	0.065	0.586
3	N-St/Sn-Me	-0.085	0.476
4	Tr-Sn/N-Me	0.012	0.920
5	N-Sn/Sn-Me	-0.041	0.732
6	Sn-St/Sn-Me	-0.027	0.818
7	St-Me/Sn-Me	-0.120	0.312
8	Sn-St/St-Me	0.002	0.988
9	Ls-St/Sn-St	0.058	0.625
10	Ls-St/St-Li	0.017	0.886
11	EnR-EnL/XR-XL	-0.045	0.707
12	EnR-EnL/ExR-ExL	0.020	0.864
13	ExR-EnR/EnR-EnL	**0.257**	**0.028***
14	EnR-EnL/AlR-AlL	0.193	0.102
15	PR-PL/ExR-ExL	0.077	0.517
16	AlR-AlL/ChR-ChL	0.217	0.065
17	ChR-ChL/ExR-ExL	0.121	0.307
18	ChR-ChL/XR-XL	0.117	0.326
19	AlR-AlL/N-Sn	0.152	0.200
20	Sn-St/ChR-ChL	0.139	0.242
21	Sn-Me/ChR-ChL	0.051	0.670
22	XR-XL/Tr-Me	-0.054	0.653
23	Sn-St/XR-XL	0.075	0.526
24	Sn-Me/XR-XL	0.053	0.657
25	N-St/XR-XL	0.098	0.409
26	N-Me/XR-XL	0.039	0.746

R – rank correlation coefficient, p – level of significance

deviations from the ideal (optimal) value negatively affect face esthetics, while small deviations foster positive attractiveness assessment. AS(1)Tr-N/N-St means ratio of the length of the section from hairline to the Nasion point (the height of forehead) to the section from Nasion to Stomion (nasal section together with upper part of the jaw section); according to Ricketts, the ideal value is equal to 1 [19]. AS(13)ExR-EnR/EnR-EnL value means ratio of the width of the right eye to length of the section connecting inner corners of the eyes. According to McNamara *et al*. [20], and Proffit *et al*. [21], the ideal value of the to intercanthal distance is equal to 1.

There was also made Spearman's rank correlation analysis with division into the respondents' sex. The results are shown in Tables 4 and 5.

Table 4. Spearman's rank correlation coefficient between AS values and assessments in the female group (significant correlations are marked with an asterisk * and with bold font)

No.	Proportion values (AS)	R	p
1	Tr-N/N-St	0.048	0.768
2	Tr-N/Sn-Me	-0.170	0.295
3	N-St/Sn-Me	-0.267	0.096
4	Tr-Sn/N-Me	-0.241	0.133
5	N-Sn/Sn-Me	-0.070	0.667
6	Sn-St/Sn-Me	0.026	0.874
7	St-Me/Sn-Me	-0.247	0.125
8	Sn-St/St-Me	0.087	0.595
9	Ls-St/Sn-St	0.184	0.256
10	Ls-St/St-Li	0.061	0.708
11	EnR-EnL/XR-XL	-0.018	0.914
12	EnR-EnL/ExR-ExL	0.098	0.548
13	ExR-EnR/EnR-EnL	0.276	0.084
14	EnR-EnL/AlR-AlL	0.283	0.077
15	PR-PL/ExR-ExL	-0.038	0.814
16	AlR-AlL/ChR-ChL	0.288	0.072
17	ChR-ChL/ExR-ExL	0.151	0.354
18	ChR-ChL/XR-XL	0.174	0.283
19	AlR-AlL/N-Sn	**0.423**	**0.007***
20	Sn-St/ChR-ChL	0.299	0.061
21	Sn-Me/ChR-ChL	-0.024	0.883
22	XR-XL/Tr-Me	-0.231	0.151
23	Sn-St/XR-XL	-0.006	0.971
24	Sn-Me/XR-XL	-0.086	0.597
25	N-St/XR-XL	0.008	0.960
26	N-Me/XR-XL	-0.088	0.591

R – rank correlation coefficient, p – level of significance

In the studied group of women, a significant positive correlation between *en face* esthetics assessment and AS(19) AlR-AlL/N-Sn indicator (ratio of the width of the nose base to the nose length) was found. It means that a big influence on the attractiveness of female face had shape of the nose; great proportions' deviations from the ideal value negatively affected face esthetics, while small deviations fostered positive esthetics

assessment. Spearman's rank correlation analysis, showing relationship between the studied face proportions and esthetics assessment, was also made separately for males, and the results are shown in Table 5.

Table 5. Spearman's rank correlation coefficient between AS values and assessments in the male group (significant correlations are marked with an asterisk * and with bold font)

No.	Proportion values (AS)	R	p
1	Tr-N/N-St	0.048	0.768
2	Tr-N/Sn-Me	-0.170	0.295
3	N-St/Sn-Me	-0.267	0.096
4	Tr-Sn/N-Me	-0.241	0.133
5	N-Sn/Sn-Me	-0.070	0.667
6	Sn-St/Sn-Me	0.026	0.874
7	St-Me/Sn-Me	-0.247	0.125
8	Sn-St/St-Me	0.087	0.595
9	Ls-St/Sn-St	0.184	0.256
10	Ls-St/St-Li	0.061	0.708
11	EnR-EnL/XR-XL	-0.018	0.914
12	EnR-EnL/ExR-ExL	0.098	0.548
13	ExR-EnR/EnR-EnL	0.276	0.084
14	EnR-EnL/AlR-AlL	0.283	0.077
15	PR-PL/ExR-ExL	-0.038	0.814
16	AlR-AlL/ChR-ChL	0.288	0.072
17	ChR-ChL/ExR-ExL	0.151	0.354
18	ChR-ChL/XR-XL	0.174	0.283
19	AlR-AlL/N-Sn	**0.423**	**0.007***
20	Sn-St/ChR-ChL	0.299	0.061
21	Sn-Me/ChR-ChL	-0.024	0.883
22	XR-XL/Tr-Me	-0.231	0.151
23	Sn-St/XR-XL	-0.006	0.971
24	Sn-Me/XR-XL	-0.086	0.597
25	N-St/XR-XL	0.008	0.960
26	N-Me/XR-XL	-0.088	0.591

R – rank correlation coefficient, p – level of significance

In *en face* assessment a significant positive correlation was demonstrated by AS(13) ExR-EnR/EnR-EnL proportion, which describes the width of the right eye in ratio to intercanthal distance.

Discussion

Relationship between face dimensions together with its proportions, and its esthetic perception is present in the scientific discussion of the specialists from various fields of medicine. In the researches methodological difficulties in creating a group of people assessing beauty, in selection of a studied group, and in a technique of face esthetics assessment were encountered. The method of face measurements made in the photographs was accepted and used by many researchers [7,22-26]. However, special attention was put on the quality of the photographs. According to the mentioned authors, the photographs should meet the standards required by orthodontists and jaw surgeons in preparing medical documentation. The subject of interest of many researchers has become the relationship between the subjective assessment of face esthetics and the results of cephalometric analysis of lateral photographs of head. Opinions concerning usefulness of profile analysis and *en face* projection are divided, however a majority of authors prefer search for interrelations between *en face* measured proportions and face esthetics [27,28].

In the research on correlations of face proportions with *en face* attractiveness assessment without division into respondent's sex, out of the 26 calculated face proportions, the high dependence was found in the area of two analysed indicators marked in Table 3, sections 1 and 13. A significant positive correlation was proved between *en face* esthetics assessment and ratio of the height of the forehead to the height of the nose together with upper lip. The more unbalanced this ratio, the worse attractiveness assessment of the face. Analyzing relationship of vertical face proportions with esthetics assessment separately in both sexes, statistical significance in the female group was found in the case of indicator (3) ratio of the length of the nose and upper lip length to the length of jaw section, as well as indicator (4) expressing ratio of the length of the forehead and nose to the length of nose and jaw section (Table 4, positions 3 and 4). Deviations from the correct values of those proportions negatively affected face attractiveness. Vertical face proportions were considered as significant for esthetics in numerous studies. For instance, assessment of digitally modified photos of profiles in the work of Abu Arqoub and Al-Khateeb [15] showed that the most preferable male profile characterized with correct height of jaw section in ratio to the total face height, while, taking into account attractiveness, the best-assessed female profile had shorten jaw section. However, in the studies assessing profile preferences, Johnston *et al.* [29] proved that correct vertical face proportions were perceived as the most attractive, while persons with enlarged vertical face dimensions were, taking into account esthetics, assessed negatively.

Statistically significant influence on *en face* attractiveness assessment, irrelevant of the sex, had also ratio of the width of the eye to the intercanthal distance (Table 3, position 13). Ideally, those sections should be equal, and each imbalance had an impact on the decrease of respondent's attractiveness. This result shows great significance of the vicinity of eyes and maintaining its appropriate proportions for the facial beauty. According to psychological studies by Hasseubrauck [30], people tend to pay attention

to the eyes while assessing another person's attractiveness. Also experiments made by Faure *et al*. [31], who digitally reduced and enlarged the intercanthal distance in the photograph and then gave the modified photographs to be assessed considering attractiveness, proved that abnormal change of the intercanthal distance negatively affects face esthetics. However, Husein *et al*. [23], when making research on the Indian women from the North America, found out that wider distance between the eyes and bigger eyes positively affected facial attractiveness. Hickman *et al*. [32], when studying gaze fixation on the static pictures of face, did not prove focusing attention on the vicinity of eyes, although in the conducted by the same author questionnaire the observers responded that when they meet someone for the first time, they particularly pay attention to the eyes of the interlocutor. The authors also observed that attractive women most of all considered their eyes as a main feature of beauty.

In the analysis of esthetics with division into genders, a statistically significant correlation was observed in the group of women in the case of the ratio of the width of the nose measured on the level of nose wings to the length of the nose (Table 4, position 19). The more a proportion was distant from the ideal value 0.625, the worse assessment of the face esthetics. It is in accordance with an observation of other researchers, who proved that nose is the most frequently negatively evaluated face element in the self-assessment of attractiveness, whereas ethnic groups with characteristic nose proportions, for instance with wide nostrils, often resort to plastic surgeries in order to change those features [23].

Conclusions

1. A relationship between face proportions and subjective esthetics assessment was proved.
2. In the studied group the facial esthetics assessment was influenced by the inter-canthal distance and vertical face proportion Trichion-Nasion/Nasion-Stomion.
3. The perception of female face esthetics was negatively affected by deviations from the correct nose construction.

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