Three-dimensional facial morphometry of attractive adolescent boys and girls

Chiarella Sforza*, Alberto Laino**, Raoul D'Alessio***, Gaia Grandi****, Francesca Catti****, Virgilio Ferruccio Ferrario*****

*Professor, Functional Anatomy Research Center, Department of Human Morphology, University of Milan, Milano, Italy
**Associate Professor, Dental, Oral, and Maxillo-Facial Sciences, Section of Orthodontics, University Federico II, Naples, Italy
***Private Practice, Rome, Italy
****Postdoc, Functional Anatomy Research Center, Department of Human Morphology, University of Milano, Milan, Italy
*****Professor and Department Chair, Functional Anatomy Research Center, Department of Human Morphology, University of Milan, Milano, Italy

Correspondence to:
prof. Chiarella Sforza
Dipartimento di Morfologia Umana, via Mangiagalli 31, 20133 Milan, Italy
Telephone: +39.02.503.155.07
Fax: +39.02.503.153.87
E-mail: chiarella.sforza@unimi.it

Objectives. To identify reference standards and possible esthetic features of facial size and form of Italian adolescent boys and girls.

Methods and Subjects. A three-dimensional electromagnetic digitizer was used to collect the coordinates of 50 facial landmarks (forehead, eyes, nose, cheeks, mouth, jaw, ears) in 231 healthy, reference adolescents (10-17 years old) and in 93 "attractive" adolescents selected by a commercial casting; soft tissue facial angles, distances and volumes were computed.

Results. Attractive adolescents had wider and shorter faces than reference subjects of the same age and sex, with relatively larger upper and middle facial thirds, and a reduced mandible relative to the maxilla. Lips were larger and more prominent, and the nasolabial angle was reduced, but in older boys the effect was reversed. The prominence of the soft-tissue profile, and of the maxilla relative to the mandible, were larger in attractive boys, but smaller in attractive girls than in their reference peers. Attractive adolescents had a relatively less prominent chin relative to the lower lip, with increased values of the mentolabial angle. In the horizontal plane, attractive "young" adolescents had a more obtuse mandibular convexity angle, while the opposite pattern was observed in the "old" adolescent subjects, with a relatively more prominent chin. Attractive adolescents had smaller noses than reference subjects of the same age and sex.

Conclusion. Esthetic reference values have been identified which could be used to determine optimal timing and goals in orthodontic treatment.

Introduction

In the contemporary Western society, esthetics is becoming a matter of concern at all ages and in all social strata. Among all parts of the body, primary attention is given to the face[1-4]. Facial appearance is fundamental for communication and interaction with the environment[3,5,6], and it carries information that allows the identification of a single person[7,8]. Bones, muscles, cutaneous and subcutaneous layers all contribute to a unique morphology in the single individual[9]; this morphology, even continuously changing during growth, development and aging[10], always maintains its peculiar characteristics[11].

The definition of esthetic standards brings together scientists, clinicians, artists, who tried to codify which facial dimensions, angles and ratios make a person look more attractive. Indeed, no universal canons seem to exist, and esthetic characteristics are often peculiar to each cultural background[2,6,12-15]. Therefore, the quest for the sacred Grail of facial attractiveness is still open. From a psychological point of view, average facial features, symmetry, youthfulness, neoteny (baby like appearance) all need to be taken into consideration, especially for women[1,2,16,17]. In contrast, facial attractiveness in adult men mingle perceptions of masculinity, health, developmental stability and social dominance[1,18,19]. Currently, the perception of attractiveness is extremely influenced by media: television, cinema, advertisements, fashion industries, all enter in our life bringing facial "standards" that should convey perceptions of beauty, healthiness, fitness, mixed with feelings of social achievement, intelligence, richness, and happiness: a beautiful face becomes the key to the success[3,20,21]. The clinical specialists working in the facial area are therefore asked by patients to provide medical and surgical modifications of non-attractive dentofacial physiognomies[14,17,22]. As a result, orthodontists, maxillofacial and plastic surgeons should have a deep understanding of those quantifiable, objective facial characteristics that are considered by the public as "attractive"[2,17,23,24].

Obiettivi. Identificare eventuali canoni estetici nella forma e dimensioni della faccia degli adolescenti italiani. Metodi e Materiali. Un digitalizzatore elettromagnetico tridimensionale ha permesso di raccogliere le coordinate di 50 punti di repere facciali (fronte, occhi, naso, guance, bocca, mandibola, orecchie) in 231 adolescenti normali (10-17 anni) e in 93 provenienti da un casting pubblicitario ("attraenti"); sono stati calcolati angoli, distanze, e volumi facciali. Risultati. Gli adolescenti attraenti hanno la faccia più larga e corta dei loro coetanei, con un maggiore sviluppo di mascellare e fronte, ed una mandibola in proporzione più piccola. Le labbra sono di maggiori dimensioni negli adolescenti attraenti, e più sporgenti, con un angolo nasolabiale ridotto. Il naso degli adolescenti attraenti è di dimensioni minori di quello dei coetanei. Nei maschi attraenti, il profilo è più sporgente, con una maggiore prominenza mascellare; nelle femmine si osserva l'opposto. La prominenza del mento aumenta negli adolescenti più vecchi. Conclusione. La definizione di parametri estetici di riferimento può fornire indicazioni per individuare modalità e finalità di trattamento ortodontico ottimali.

Key words: face; adolescents; attractiveness; soft tissues.

In a previous investigation, we analyzed attractive and reference, normal children with deciduous and early mixed dentition, and found that attractive children maintained several facial characteristics of baby like appearance: a large face, with relatively large maxilla and forehead, and reduced vertical dimensions. Lips were more voluminous, mouth was bigger, and the soft-tissue facial profile was more convex in attractive children, with a more prominent maxilla relative to the mandible, than in the reference coetaneous[24,25].

In the current investigation, the three-dimensional facial characteristics of adolescent boys and girls considered "attractive" were measured with a non-invasive computerized instrument, and several measurements obtained. Data were compared to those collected in healthy children of the same age, sex and ethnicity, selected using criteria of dentofacial normality[6,12,14]. The possible presence of measurable esthetic characteristics was assessed.

Materials and subjects

Subjects

Three hundred and 24 white Caucasian, Northern Italian adolescent boys and girls aged 10-17 years were analyzed.

A first group, "reference" adolescents, was made of 141 boys and 90 girls. All subjects were healthy, they had normal dentofacial dimensions and proportions; no subjects with a previous history of craniofacial trauma or with congenital anomalies were included. These adolescents were attending several schools in Milan and surroundings, and part of their data had already been published[10].

A second group, "beautiful" or "attractive" adolescents, comprised 46 boys and 47 girls selected by a commercial casting agency. The same selection criteria used in the previous investigation performed on young children[24,25] were used: the agency

Résumé. Pour identifier des normes de référence esthétiques possibles de dimension et forme faciale de garçons et de filles adolescents italiens. Méthodes et objets. Un convertisseur analogique/numérique électromagnétique tridimensionnel a été utilisé pour rassembler les coordonnées de 50 loints faciales (front, yeux, nez, joues, bouche, mâchoire, oreilles) dans 231 adolescents en bonne santé, de référence (10-17 ans de) et dans 93 adolescents "attirants" choisis par un group commercial; ont a calculé des angles faciaux, les distances et les volumes de tissus mous. Résultats. Les adolescents attirants ont eu des visages plus larges et plus courts que des sujets de référence du mêmes âge et sexe, avec des troisièmes faciaux supérieurs et moyens relativement plus grands, et une mâchoire inférieure réduite relativement au maxillaire supérieur.

Les lèvres étaient plus grandes et plus en avant, et l'angle nasolabial a été réduit, mais dans des garçons plus âgés l'effet a été renversé. La prominence du profil des tissu doux, et du maxillaire supérieur relativement à la mâchoire inférieure, étaient plus grande dans les garçons attirants, mais plus petite dans les filles attirantes que dans leur référence. Les adolescents attirants ont eu un menton relativement moins en avant relativement à la lèvre inférieure, avec des plus grandes valeurs de l'angle mentolabial. Dans le plan horizontal, les "jeunes" adolescents attirants ont eu un angle mandibulaire plus obtu de convexité, alors qu'on observait le modèle opposé dans les "vieux" sujets adolescents, avec un menton relativement plus en avant. Les adolescents attirants ont eu de plus petits nez que des sujets de référence du mêmes âge et sexe. Conclusion. On a identifié des valeurs de référence esthétiques qui pourraient être employées pour déterminer la temps et les buts optimaux dans le traitement orthodontique.

Traduit par Maria Giacinta Paolone

was asked to provide adolescents of both sexes with a "beautiful", "attractive" face, within a well defined age range and ethnicity. These boys and girls normally act in cinema and television, are used for advertising, and the fashion industry; overall, their faces could be considered "trendy", and should convey "positive" feelings[4].

All the analyzed adolescents, and their parents/legal guardians gave their informed consent to the experiment. All procedures were non-invasive, did not provoke damages, risks or discomfort to the subjects, and were preventively approved by the local ethic committee.

Collection of facial landmarks

All the procedures were non-invasive, not potentially harmful, did not provoke pain and did not use any instrument or energy currently considered to be potentially dangerous to the present or future health of the subjects or of her/his offspring.

The data collection procedure took place in two separate steps, and it was followed by off-line calculations[26]. At first, for each subject, a single experienced operator located a set of 50 soft-tissue landmarks by inspection and/or palpation[10], and marked them on the cutaneous surface using a liquid eye-liner. The eye-liner can be easily washed from the face with soap and water. During landmark marking, the subjects sat relaxed in a position suitable for a correct identification of facial features. For each subject, this phase lasted less than 5 minutes. The previous marking of the landmarks allowed a subsequent faster data collection procedure, and provided to the operator all the time necessary for a correct identification, even of those landmarks that must be palpated for their individuation (for instance, gonion).

In the second step, the three-dimensional (x, y, z) coordinates of the facial landmarks were obtained with a computerized electromagnetic digitizer (3Draw, Polhemus Inc., Colchester, VT) that supplies real metric data

Objetivos. Fueron tomados en consideración un grupo de adolescentes Italianos "hombres y mujeres" , para identificar estándares posibles del tamaño y forma facial en referencia a las características estéticas. Métodos y temas. Fue utilizado un digitador electromagnético tridimensional para acumular las coordenadas de 50 puntos faciales (frente, ojos, nariz, mejillas, boca, quijada, oídos) en 231 adolescentes sanos, entre (10-17 años) y en 93 adolescentes "atractivos" seleccionados para un comercial; de esta forma fueron computarizados los ángulos faciales, las distancias y los volúmenes del tejido blandos. Resultados. Los adolescentes atractivos tuvieron caras más anchas y más cortas en referencia a los sujetos de la misma edad y sexo, con el tercio facial superior y medios relativamente más grandes. Además presentaron una mandíbula mas pequeña con respecto al maxilar. Los labios eran más grandes y más prominentes, y el ángulo nasolabial era mas reducido; mientras que en los adolescentes mas viejos el efecto fue inverso. La prominencia del perfil de los tejidos blandos y del maxilla con respecto a la mandíbula, fue más grande en los adolescentes atractivos; y más pequeño en las adolescentes atractivas con referencia al mismo. Los adolescentes atractivos tenían una barbilla relativamente menos prominente concerniente al labio inferior con valores aumentados del ángulo mentolabial. En el plano horizontal, los adolescentes "jóvenes" atractivos tenían un ángulo de la convexidad mandíbular más obtuso, mientras que en los adolescentes mas "viejos" se observo todo lo contrario, ose a una barbilla relativamente más prominente. Los adolescentes atractivos tenían narices más pequeñas que los sujetos de referencia de la misma edad y sexo. Conclusión. Fueron identificados los valores de referencia estéticos que se podrían ser utilizar para determinar los objetivos y metas óptimas para el tratamiento ortodóntico.

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Fig. 1 Digitized facial landmarks: tr, trichion; g, glabella; n, nasion; prn, pronasale; c', columella; sn, subnasale; ls, labiale superius; sto, stomion; li, labiale inferius; sl, sublabiale; pg, pogonion; me, menton; ex, exocanthion; en, endocanthion; os, orbitale superius; or, orbitale; ft, frontotemporale; zy, zygion; chk, cheek; t, tragion; pra, preaurale; sa, superaurale; pa, posturale; sba, subaurale; al, alare; ac, nasal alar crest; itn, inferior point of the nostril axis; stn, superior point of the nostril axis; cph, crista philtri; ch, cheilion; go, gonion; pra, preaurale; sa, superaurale; pa, postaurale; sba, subaurale.

independent from external reference systems. The digitizer has a resolution of 0.005 mm/mm of range, and an accuracy of 0.08 mm, with the receivers located within 76 cm of the transmitter. During data collection, the subjects sit in a natural head position in a chair with a backrest, where a cephalostat fixes the subject's head. Vertically and horizontally movable systems accommodation for different sitting heights and head dimensions. To obtain the natural head position, the subjects were asked to look at the reflected image of their eyes in a mirror positioned at eye level at approximately 2 m of distance. They were asked to close their eyes, to keep their teeth in contact, and to not move for the duration of the data collection[26].

Using the instrument stylus, a single operator gently touched the facial landmarks in a standardized sequence. Data collection takes approximately 1 minute. Before discharging the subject, the computer performed a fast reconstruction of facial morphology using the three-dimensional coordinates of the collected landmarks, and a check between the video image and the face of the subject was made to assess the correct sequence of landmarks, and any motion artifact. The procedure was repeated immediately in 1% of acquisitions.

The reproducibility of landmark identification, marker positioning and the reproducibility of the data collection procedure have been reported[26], with random errors of 1.20 mm (adult men) and 0.95 mm (adult women), corresponding to 1.04-1.05% of the relevant nasion-mid tragion distance. Files of the three-dimensional coordinates were obtained, and original computer programs were used for all the subsequent off-line calculations.

Data analysis

Fifty facial soft tissue landmarks were collected on each subject (Fig. 1):

- midline landmarks: tr, trichion; g, glabella; n, nasion; prn, pronasale; c', columella; sn, subnasale; ls, labiale superius; sto, stomion; li, labiale inferius; sl, sublabiale; pg, pogonion; me, menton;
- paired landmarks (right and left side noted r and l): exr, exl, exocanthion; enr, enl, endocanthion; osr, osl, orbitale superius; orr, orl, orbitale; ftr, ftl: frontotemporale; chkr, chkl, cheek; zyr, zyl, zygion; tr, tl, tragion; alr, al-l, alare; acr, acl, nasal alar crest; itnr, itnl, inferior point of the nostril axis; stnr, stnl, superior point of the nostril axis; cphr, cphl, crista philtri; chr, chl, cheilion; gor, gol, gonion; prar, pral,
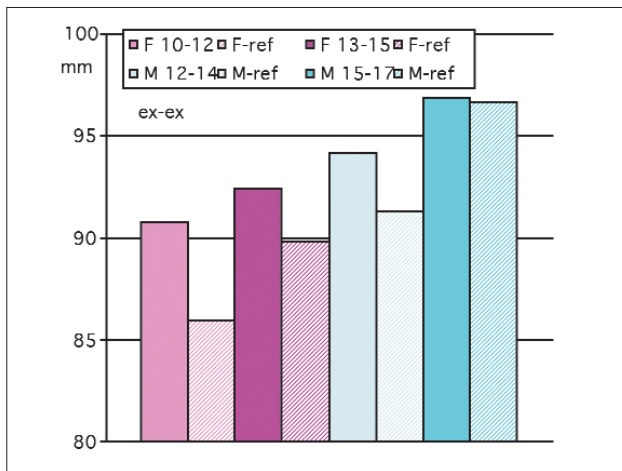
Fig. 2 Upper facial width (ex-ex) in the analyzed adolescent subjects. Mean values for male (light blue) and female (pink) attractive (solid colors) and reference (hatched colors) adolescents in the two age groups. Darker shades correspond to older adolescents.
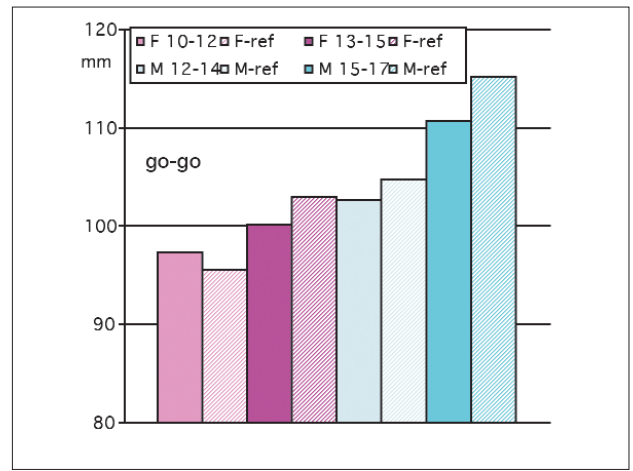

Fig. 3 Lower facial width (go-go) in the analyzed adolescent subjects. Mean values for male (light blue) and female (pink) attractive (solid colors) and reference (hatched colors) adolescents in the two age groups. Darker shades correspond to older adolescents.

preaurale; sar, sal, superaurale; par, pal, postaurale; sbar, sbal, subaurale.

The three-dimensional coordinates of the 50 landmarks were used to estimate a set of linear distances, angles, facial volumes and areas as detailed elsewhere[10,13,24-28]. Euclidean geometry was used for all calculations; the volumes of facial structures were estimated from the sum of several tetrahedra, with the 50 landmarks serving as nodes (vertices of the tetrahedra). In particular, the following were computed:

- distances (unit, mm): facial height (n-pg); upper facial width (ex-ex); lower facial width (go-go); middle facial depth (sn-t); mandibular corpus length (pg-go); mouth width (ch-ch); vermilion height (ls-li); upper lip to E-line distance, ls-(prn-pg); lower lip to E-line distance, li-(prn-pg);

- angles (unit, degrees): facial convexity including the nose (n-prn-pg); lower face convexity (go-pg-go); maxillary prominence, soft tissue analog of skeletal ANB angle (sl-n-sn); nasolabial (prn-sn-ls); mentolabial (li-sl-pg); interlabial (sn-ls^sl-pg);

- areas (unit, cm^2): area of the vermilion of the upper and lower lips (between landmarks chr, ls, chl, sto; and chr, li, chl, sto);

- volumes (unit: mm^3): total facial volume (volumes of all facial structures from the external cutaneous surface up to a quasi-frontal plane passing through trichion, tragi and gonia), subdivided into facial upper third volume (forehead), facial middle third volume (maxilla), facial lower third volume (mandible); nasal volume.

Statistical calculations

"Reference" and "attractive" boys and girls were divided into two age groups for each sex. For girls, 24 attractive and 39 reference girls were aged 10 to 12 years ("young" adolescent girls); 23 attractive and 51 reference girls were aged 13 to 15 years ("old" adolescent girls). For boys, 22 attractive and 87 reference boys were aged 12 to 14 years ("young" adolescent boys); 24 attractive and 54 reference boys were aged 15 to 17 years ("old" adolescent boys). Different age groups were used for the two sexes because of the different timing of pubertal growth spurt[10]. Descriptive statistics (mean and standard deviation) were computed for each group, angular data were assessed using their rectangular components (sine and cosi-

ne). Comparisons between the two groups of adolescents (reference, attractive) were performed within each sex and age group using independent Student's tests with two-tailed distributions, and a significance level set at 5% (p < 0.05).

Results

Upper facial width (ex-ex) resulted larger in boys than in girls in both "young" and "old" adolescent age groups, and increased with age (Fig. 2). In all groups, attractive adolescents had a wider upper face than reference adolescents of the same age and sex; the differences were statistically significant in both female groups, and in the "young" adolescent males (p < 0.02, Student's t for independent
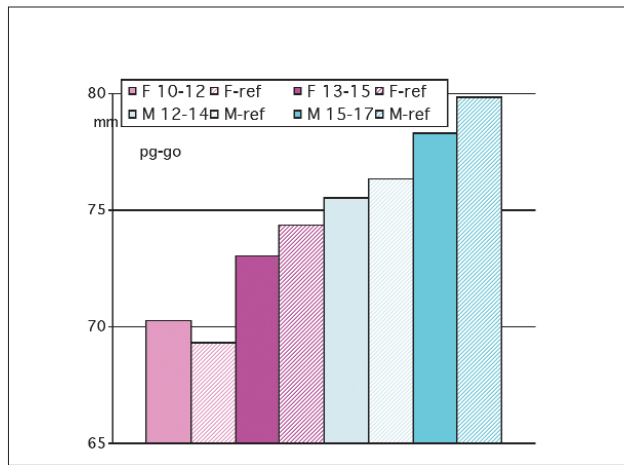

Fig. 4 Mandibular corpus length (pg-go) in the analyzed adolescent subjects. Mean values for male (light blue) and female (pink) attractive (solid colors) and reference (hatched colors) adolescents in the two age groups. Darker shades correspond to older adolescents.
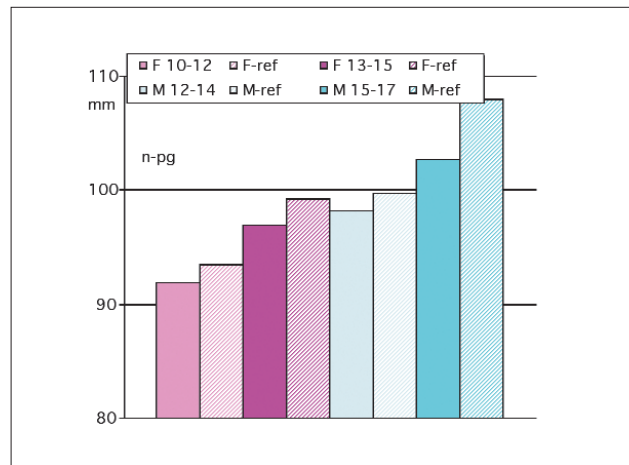

Fig. 5 Facial height (n-pg) in the analyzed adolescent subjects. Mean values for male (light blue) and female (pink) attractive (solid colors) and reference (hatched colors) adolescents in the two age groups. Darker shades correspond to older adolescents.
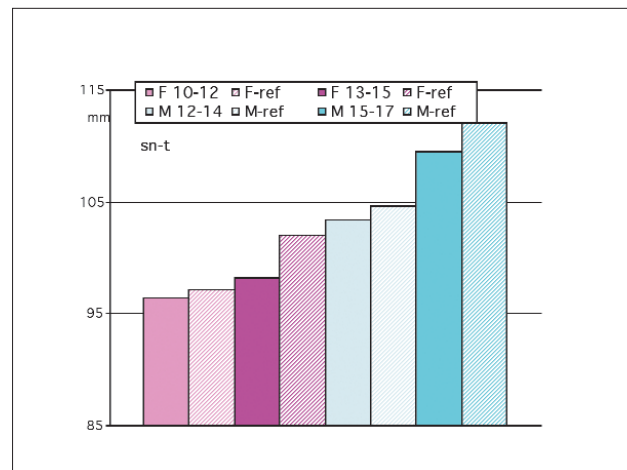

Fig. 6 Middle facial depth (sn-t) in the analyzed adolescent subjects. Mean values for male (light blue) and female (pink) attractive (solid colors) and reference (hatched colors) adolescents in the two age groups. Darker shades correspond to older adolescents.
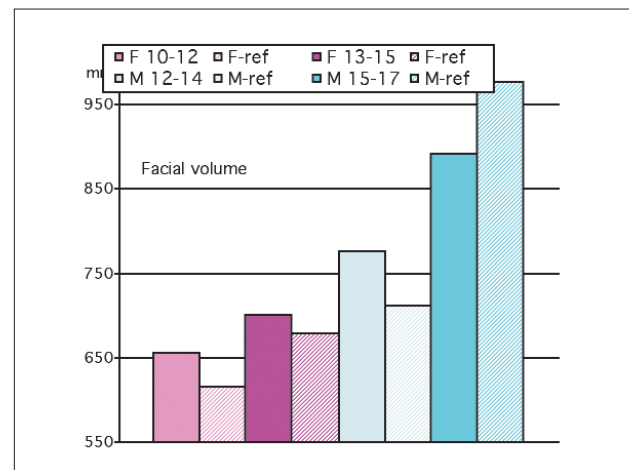

Fig. 7 Facial volume in the analyzed adolescent subjects. Mean values for male (light blue) and female (pink) attractive (solid colors) and reference (hatched colors) adolescents in the two age groups. Darker shades correspond to older adolescents.

samples). Similar effects of sex and age were observed for lower facial width (go-go) and mandibular corpus length (pg-go), with males larger than females, and older adolescents larger than younger adolescents (Figs 3, 4). Overall, reference adolescents had larger faces and longer mandibles than attractive adolescents, with the exception of the "young" girls, but in no occasion the trends were substantiated by statistical significance ($p > 0.05$).

In both sexes and in both age groups, facial height (n-pg) and middle facial depth (sn-t) were smaller in the attractive adolescent than in their reference peers (Figs 5, 6); the differences were statistically significant in the "old" male adolescents (n-pg, $p = 0.003$) and in the "old" female adolescents (sn-t, $p = 0.003$). Age and sex influenced both measurements, with longer and deeper faces in males than in females, and in "old" than in "young" adolescents.

The modifications in facial dimensions resulted in variations in facial volumes: total facial volume was larger in attractive girls in both age groups, and in attractive "young" adolescent males than in the reference subjects, with significant differences in the "young" adolescents ($p = 0.021$ in girls, $p = 0.009$ in boys). In contrast, "old" adolescent attractive boys had a significantly smaller face then their reference peers ($p = 0.009$). Age-related increments in facial volume were more evident in boys than in girls; sexual dimorphism was present in both age groups (Fig. 7).

A different arrangement of facial thirds was observed in the attractive subjects when compared to the reference ones, with relative larger upper and middle thirds. Indeed, the forehead (facial upper third) occupied a larger part of the face in both attractive boys and girls, and at both ages (Fig. 8). The effect was particularly evident in the "old" adolescent girls and in the "young" adolescent boys ($p < 0.001$). Overall, the ratio decreased with age (older adolescents had a relatively smaller forehead than younger adolescents), and, in each age group, it was larger in girls than in boys. In attractive adolescents, the mandible was reduced relatively to the maxilla, with mandibular/ maxillary volume ratios all less than 94% (Fig. 9). The differences were statistically significant in the girls, and in the "young" adolescent males ($p < 0.05$). In reference girls, the ratio increased with age, with a relative larger grow in the facial lower third than in the middle facial third.

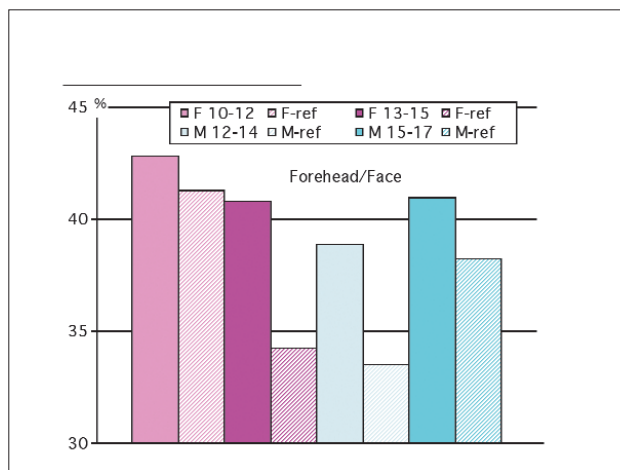In the middle facial third, nasal volume increased with age, and it

Fig. 8 Forehead volume as a percentage of facial volume in the analyzed adolescent subjects. Mean values for male (light blue) and female (pink) attractive (solid colors) and reference (hatched colors) adolescents in the two age groups. Darker shades correspond to older adolescents.

Fig. 9 Mandibular volume as a percentage of maxillary volume in the analyzed adolescent subjects. Mean values for male (light blue) and female (pink) attractive (solid colors) and reference (hatched colors) adolescents in the two age groups. Darker shades correspond to older adolescents.

was larger in boys than in girls (Fig. 10). Attractive adolescents had smaller noses than reference subjects of the same age and sex, with significant differences in the "old" adolescents (p < 0.002). The area of the vermilion of the total (upper plus lower) lip was larger in the attractive than in the reference adolescents (Fig. 11), with a larger contribution of the upper lip (Fig. 12). In the attractive adolescents, vermilion height (ls-li) was a larger percentage of mouth width (ch-ch) than in the reference subjects (Fig. 13); at both ages, it was larger in attractive girls than in attractive boys. In the attractive adolescents, both lips were nearer to the esthetic E-line (prn-pg) than in the reference adolescents (Fig. 14); the observed trend was not substantiated by statistically significant differences. In both sexes, the distances increased as a function of age; in the lower lip, values were somewhat smaller (that is, the lip was more prominent) in girls than in boys. Attractive boys had more acute soft
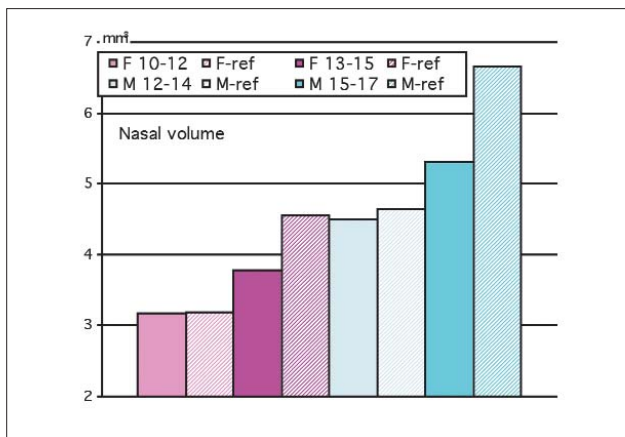

Fig. 10 External nasal volume in the analyzed adolescent subjects. Mean values for male (light blue) and female (pink) attractive (solid colors) and reference (hatched colors) adolescents in the two age groups. Darker shades correspond to older adolescents.
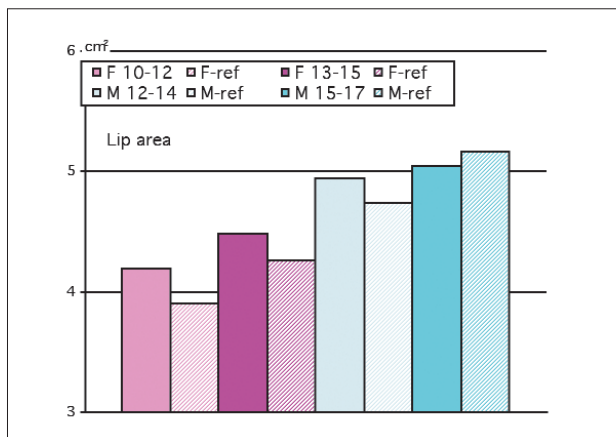

Fig. 11 Area of the vermilion of the total lip in the analyzed adolescent subjects. Mean values for male (light blue) and female (pink) attractive (solid colors) and reference (hatched colors) adolescents in the two age groups. Darker shades correspond to older adolescents.

Fig. 12 Percentage areas of the vermilion of the upper and lower lips in the analyzed adolescent subjects.

Fig. 13 Mouth vermilion height (ls-li) as a percentage of mouth width (ch-ch) in the analyzed adolescent subjects. Mean values for male (light blue) and female (pink) attractive (solid colors) and reference (hatched colors) adolescents in the two age groups. Darker shades correspond to older adolescents.
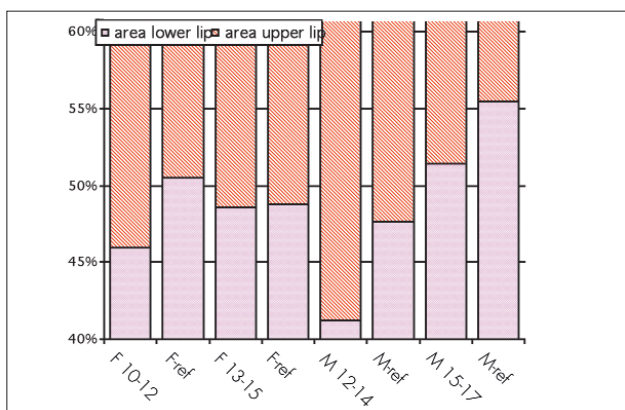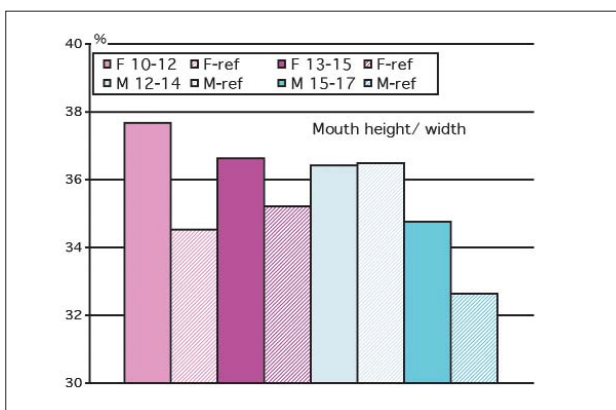
tissue profiles than reference boys, with smaller angles of facial convexity including the nose (n-prn-pg, Fig. 15), a difference significant in the 13-to-15 year old age group (p = 0.014). Accordingly, they had a larger maxillary prominence relative to the mandible, with a smaller soft tissue analog of skeletal ANB angle (sl-n-sn, Fig. 16). In girls, the reverse pattern was found, with less acute facial profiles (p = 0.049 in 10-to-12 year old girls), and reduced maxillary prominence (p = 0.008 in 14-to-16 year old girls) in the attractive than in the reference subjects.

In the middle and lower parts of the face, reduced nasolabial (prn-sn-ls, Fig. 17) and interlabial (sn-ls; sl-pg, Fig. 18) angles characterized attractive adolescents, who presented with relatively more prominent lips, with the exception of the 15-to-17 year old boys. In the attractive boys, and in the attractive 14-to-16 year old girls, the chin was relatively less

prominent relative to the lower lip, with increased values of the mentolabial angle (li-sl-pg, Fig. 19). In the "young" adolescent attractive boys and girls, the horizontal plane convexity of the lower facial third (go-pg-go) was somewhat larger than in their reference peers (Fig. 20), while the opposite pattern was observed in the "old" adolescent subjects, with a relatively more prominent chin.

Discussion

Analysis of the three-dimensional arrangement of facial soft tissues should be made with a complete morphological and functional evaluation, aimed at a global assessment of all elements classically forming beauty: precision, symmetry, coordination and functional structure[9]. The first elements to be considered are those describing the morphological structure, that forms the base for function. Attractive per-

sons (like cinema and television actors and actresses, fashion and advertising models) are often believed to possess peculiar esthetic relationships, but these do not seem to be a necessary condition for attractiveness[17,28-30].

Indeed, not only do not cultural background and secular trends influence influence the perception of beauty[6,12-15,20], but also a well-defined sexual dimorphism seems to emerge[1,2,4,19,31]. In adult Caucasian women, current opinions seem to prefer a prominent facial middle third, with full lips; a relatively large face with a reduced mandible and increased forehead; reduced vertical development[1,2,4,6,12,13,31,32]. Overall, attractive women seem to maintain several facial characteristics of baby like appearance. In contrast, in adult men attractiveness seems to be positively influenced by facial markers of high testosterone levels, with a relative increment of the facial lower third[1,2,4,18,19,31]. Further factors that may influence
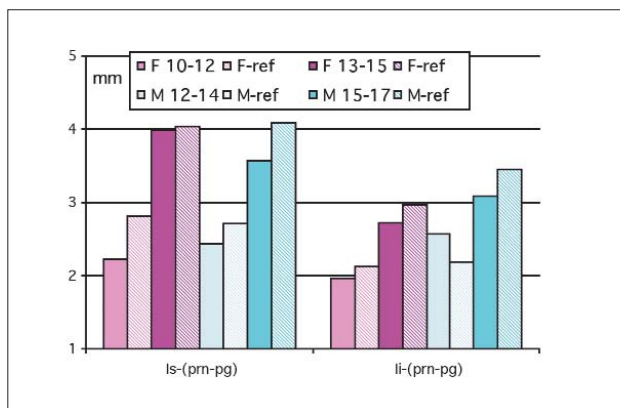

Fig. 14 Upper lip to E-line distance, ls-(prn-pg), and lower lip to E-line distance, li-(prn-pg) in the analyzed adolescent subjects. Mean values for male (light blue) and female (pink) attractive (solid colors) and reference (hatched colors) adolescents in the two age groups. Darker shades correspond to older adolescents.
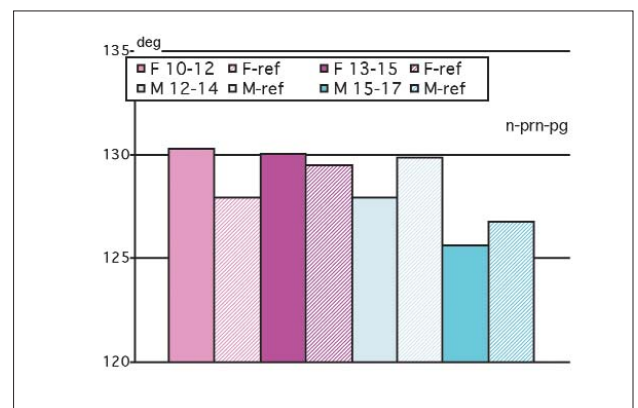

Fig. 15 Facial convexity including the nose (n-prn-pg) in the analyzed adolescent subjects. Mean values for male (light blue) and female (pink) attractive (solid colors) and reference (hatched colors) adolescents in the two age groups. Darker shades correspond to older adolescents.

the perception of beauty are growth and development: attractiveness is becoming a matter of concern also in growing individuals. Currently, children and adolescents are widely employed at the cinema and television, play an important part in the fashion industry, and are a key element for advertising. Children with a non-attractive face are likely to be considered less intelligent, and to be isolated and underscored than children with an attractive face[3,21,23]. A beautiful face is believed the key to the success, with parents and children looking for modifications of non-attractive dentofacial physiognomies[14,22].

Previous studies on facial attractiveness in children and adolescents mostly focused on dentolabial characteristics, where subjects with malocclusion, irregular dental arches and thin lips were considered less attractive than children with normal occlusion, well-arranged dental arches, and medium or thick lips[22,23]. The global soft-tissue facial esthetic characteristics in three
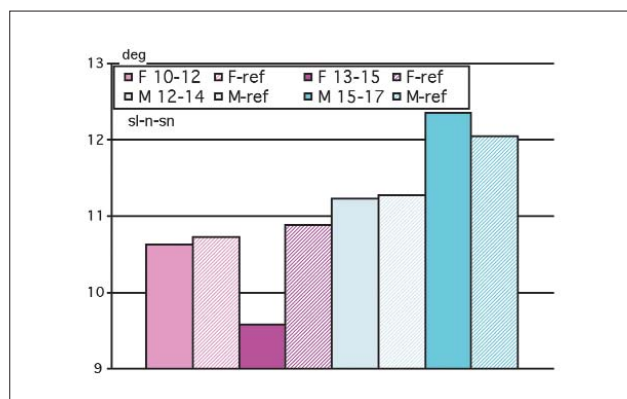

Fig. 16 Maxillary prominence angle (sl-n-sn) in the analyzed adolescent subjects. Mean values for male (light blue) and female (pink) attractive (solid colors) and reference (hatched colors) adolescents in the two age groups. Darker shades correspond to older adolescents.
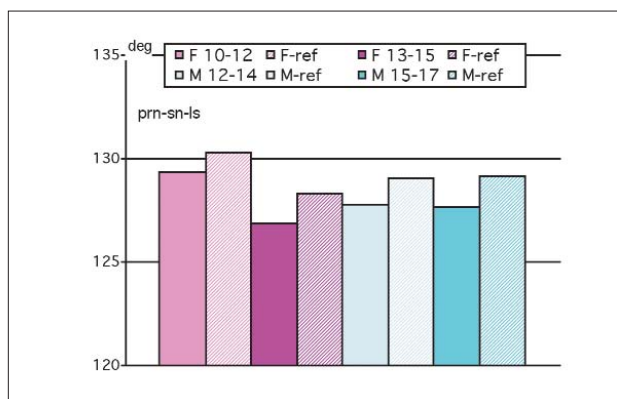

Fig. 17 Nasolabial angle (prn-sn-ls) in the analyzed adolescent subjects. Mean values for male (light blue) and female (pink) attractive (solid colors) and reference (hatched colors) adolescents in the two age groups. Darker shades correspond to older adolescents.

Fig. 18 Interlabial angle (sn-ls; sl-pg) in the analyzed adolescent subjects. Mean values for male (light blue) and female (pink) attractive (solid colors) and reference (hatched colors) adolescents in the two age groups. Darker shades correspond to older adolescents.

Fig. 19 Mentolabial angle (li-sl-pg) in the analyzed adolescent subjects. Mean values for male (light blue) and female (pink) attractive (solid colors) and reference (hatched colors) adolescents in the two age groups. Darker shades correspond to older adolescents.
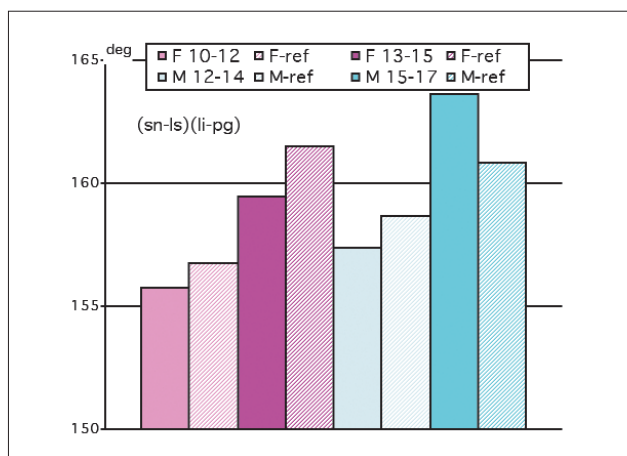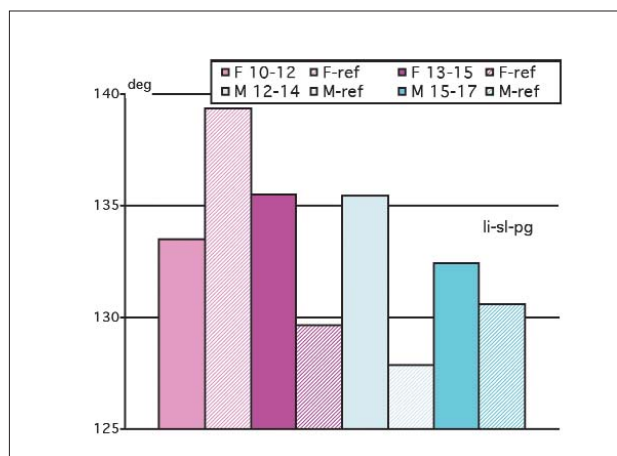
dimensions were scarcely assessed: Ferrario et al.[33] analyzed the relationship between attractiveness and facial dimensions in 8-to-9 year old children, Sforza et al.[24] measured attractive and normal children aged 4 to 9 years. Overall, attractive young children shared several of the facial characteristics found in attractive women[12,13,32]: relatively large forehead and more prominent maxilla, reduced vertical dimensions, voluminous lips and more prominent soft-tissue facial profile[24].

In the current investigation, some of the previous esthetic characteristics were maintained, but also some sex- and age-related differences emerged. In accord with previous findings[24], attractive subjects had wider and shorter faces than reference subjects of the same age and sex, with relatively larger upper and middle facial thirds, and a re-

duced mandible relative to the maxilla. Lips were larger and more prominent, as previously found by Matoula and Pancherz[6] for 14-to-24 years old attractive women; the nasolabial angle was reduced in girls and younger boys, but in older boys the effect was reversed. Vermillion height was a larger percentage of mouth width than in the reference subjects, thus confirming the findings reported by Scott et al.[23]. The prominence of the soft-tissue profile, and of the maxilla relative to the mandible, were larger in attractive boys, but smaller in attractive girls than in their reference peers. An increased facial convexity was also reported by Kiekens et al.[22] as the principal anterior-posterior characteristics for 10-to-16 years old adolescents considered attractive by laypeople, and by Matoula and Pancherz[6]. Attractive adolescents had a relatively less prominent chin relative

to the lower lip, with increased values of the mentolabial angle, whereas the attractive children analyzed by Sforza et al.[24] had the opposite pattern. In the horizontal plane, attractive children and "young" adolescents had a more obtuse mandibular convexity angle, while the opposite pattern was observed in the "old" adolescent subjects, with a relatively more prominent chin. This feature is in good accord with the reports by Fink et al.[34] and by Schaefer et al.[19]: high prenatal testosterone levels, and high circulating testosterone produce a more prominent lower face, which is positively linked to male attractiveness[1]. Attractive adolescents had smaller noses than reference subjects of the same age and sex, in accord with previous findings in adult women[13], but in contrast with the patterns observed in attractive children[24]. Even if the reduced nasal volume in attractive women may be an effect of surgical interventions, the current finding seems to depend from actual esthetic preferences.

Among the limitations of the current study there is the analysis of only two age groups for each sex. Indeed, the current attractive adolescents were selected by a casting agency among those already involved into cinema, television, and advertising industry; additionally, they should move to the laboratory for measurement, and this limited the selection to persons living in Milan and surroundings, thus reducing their number. Possibly, this limited the number of significant differences, and for several measurements only trends
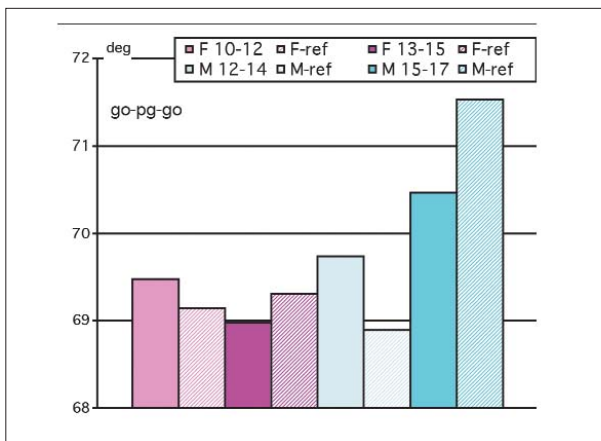

Fig. 20 Lower face convexity in the horizontal plane (go-pg-go) in the analyzed adolescent subjects. Mean values for male (light blue) and female (pink) attractive (solid colors) and reference (hatched colors) adolescents in the two age groups. Darker shades correspond to older adolescents.

not substantiated by statistically significant values were found.

Selection was made using the same procedure followed for attractive children[24] and women[12,13,32,35]: boys and girls were independently selected by professionals in a casting agency who were unaware of the actual scope of the investigation; they were asked to provide "attractive" subjects of both sexes within a well defined age range and ethnicity. These faces were to be considered "positive" and "acceptable" for mass medias[4]. This procedure avoided the specialized opinions of dental and surgical professionals, that are often relatively more critical in their assessment of facial esthetics than non-professionals[3,4,14,20,36,37], even if different findings about plastic surgeons have recently been reported[23]. Additionally, esthetics should be evaluated by the laypersons, who actual seek (and finally judge) orthodontic or maxillofacial treatment[22,37]. The existence of some genetic background to the esthetic perception of attractiveness has been reported[1], as demonstrated in infants as young as 3 months of age[17], but the effect is likely to be modulated by several social factors[4,6,12,19,36].

Male and female attractive adolescents were subdivided into different age groups, girls being 2-3 years young than boys. This difference should take the sex-related discrepancies in the timing of pubertal growth spurt into account[10], thus allowing the assessment of more homogenous biological ages. Nevertheless, the extension of the study to other age groups could allow a deeper understanding of the actual biological processes.

A further limitation resides in the selected measurements: the analysis of soft tissue facial dimensions and angles should be implemented with the assessment of symmetry[17,20,35], and of facial shape (independently from dimensions[19,27,34]). Also, a wider set of angles and distances should be analyzed, with the inclusion of all facial structures, including eyes and ears[1,2].

In conclusion, when compared to reference subjects of the same age and sex, attractive adolescents had:

- wider and shorter faces with relatively larger upper and middle facial thirds, and a reduced mandible relative to the maxilla;
- larger and more prominent lips, with a reduced nasolabial angle;
- in boys, more prominent soft-tissue profile, and maxilla relative to the mandible;
- smaller noses.

Clinical implications

Facial esthetics is one of the principal concerns of orthodontists and maxillofacial surgeons[2,11,12,17,38]. The creation of a harmonic occlusion, within a well functioning stomatognathic apparatus[14], must always consider the effect of teeth position on facial soft tissues[28]. The clinician should therefore be provided with esthetic guidelines referred to subjects of the same age, sex and ethnic group of their patients; the guidelines should also be updated, considering the evolution of the esthetic canons within a given society[12,37]. These guidelines may offer useful indications for the best kind, timing and goals of orthodontic treatment, with the best cost/ benefit ratio.

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