# Craniofacial and body growth: a cross-sectional anthropometric pilot study on children during prepubertal period

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*ABSTRACT. **Aim** This was to compare craniofacial and body growth during prepubertal period using direct medical anthropometry for body and craniofacial measurements. **Methods** The sample consisted of 100 patients (48 males, 52 females), aged between 7 and 12 years. Thirty craniofacial and body measurements of height, width, length and circumference were made on each subject. **Statistical analysis** Comparisons were made of averages, percentages and standard deviations, for three growth patterns during prepubertal period: cranial, facial and body growth pattern. Linear correlation coefficients (r) were calculated to evaluate the intensity of the interdependence between variables, using BMDP Dynamic software. **Results** Skull and face measurements increased less than body dimensions, but those for the face increased more than for skull, which was valid both for males and females. Differences between males and females were determined for standing height, mandibular height (T-Go) and lower facial height (Sto-Gn). **Conclusions** No body parameter was found to be a good indicator of craniofacial growth during this period. The jaw was found to be the facial area that showed the higher development.*

*KEYWORDS: Craniofacial growth, Body growth, Prepubertal period.*

## Introduction

Body growth is steady during the prepubertal period and is simple to assess [Burgio et al., 1997; Cisternino et al., 1997; Behrman et al., 2002]. However, craniofacial growth is not so easy to determine, because it is strongly influenced by environmental factors [Van Limborg, 1970, 1972; Caprioglio, 2000]. Many authors compared body and craniofacial growth, but they have not always obtained similar results.

Nanda [1955] analyzed individual facial skeletal dimensions using incremental percentage body curves which are similar to those for stature, despite the fact that the skull shows a neural growth pattern. Like Nanda, Burstone [1963] and Johnston et al. [1965], compared skeletal maturation, craniofacial development and chronological age. They found out that some skeletal facial parameters are correlated to sexual maturation. These findings confirmed those of Rose [1960] who noted that stature and body weight are the best indicators of craniofacial growth.

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Bambha [1961] emphasised that facial growth is similar to skeletal, while that of cranial bones is similar to neural growth pattern. Pike [1968] concluded that growth rhythms of the maxilla, when compared with mandibular growth rhythms, do not show a fixed correlation to stature growth, as there is an influence of cranial base and nasal septum. Moreover, Hunter [1966] showed that the maximum facial growth coincides with the maximum stature growth in most of the patients they examined.

Shah et al. [1980] concluded that the orbito-ethmoidal area is subjected to neural growth pattern, unlike maxillary and mandibular areas. These follow skeletal growth patterns, tightly correlated to weight and stature. Baume et al. [1983] showed a strong correlation between body and craniofacial growth.

Other authors have divergent opinions and they do not agree that there is an association between body and craniofacial growth. Thus, Singh et al. [1967] did not find substantial relationships between body and vertical facial measurements, as also suggested by Woodside and Linder-Aronson [1979]. The latter authors concluded that there is a small and not significant correlation between facial growth and other body dimensions. Bishara et al. [1981] did not find any associations between mandibular dimensions and puberal stature growth peak. Moore et al. [1990] showed a high correlation between stature growth and skeletal maturation, while facial dimensions presented a weak relation with stature growth, except for the posterior facial height. Van der Beek et al. [1996] showed that only the mandibular branch is an excellent indicator of body growth because it is firmly tied to height.

By analysing the literature it appears that the maximum growth in stature corresponds to the maximum growth of facial structures, particularly as regards the mandible. It is less clear how that happens during the prepubertal period. Accordingly, the aim of the research reported herein was to evaluate the growth during prepubertal period and to compare it with different craniofacial and body parameters using direct medical anthropometry.

## Material and methods

Cross-sectional studies were carried out on 100 Caucasian patients, 48 males and 52 females, between 7 and 12 years old. All subjects were born and grew up in Italy and were under treatment at the Orthodontic Department at "Tor Vergata General Hospital". The children were selected when they attended consecutively for treatment, based on anamnesis and clinical examination, which took place in the presence of at least one parent. Subjects were excluded if they presented any signs of sexual maturation. All patients examined were in excellent health with no contraindications of pathologies and/or craniofacial deformities.

Twenty-eight (28) craniofacial and body measurements, using the methods of Farkas [1994, 1996], using the systems advocated by Snyder et al. [1975] and Cisternino and Livieri [1997] were made. Measurements were taken on each subject for height, width, length and head circumference (Table 1). Parameters for the assessments were as follows.

*Stature (SH).* Subject stands erect with head oriented in the Frankfort Plane, arms hanging at sides. The vertical distance from the standing surface to vertex (top of the head) is measured.

*Frontal grip reach (FGR).* Subject stands erect with feet together, back to wall, grasping the handle of the grip device in right hand. The subject's right shoulder is held against the wall as the subject extends right arm to maximum horizontal grip reach. The horizontal distance from the wall to the most distal point on the handle of the grip device is measured.

*Lateral grip reach (LGR).* Subject stands erect with feet together, left shoulder against wall, grasping the handle of the grip device in right hand, and abducts extended right arm to maximum horizontal grip reach. The horizontal distance is measured from the wall to the most distal point on the handle of the grip device.

*Shoulder breadth (SB).* Subject stands erect, upper arms at sides, and elbows flexed 90°. The horizontal breadth across the shoulders at a fixed pressure value is measured.

*Biacromial breadth (BB).* Subject stands erect, arms hanging at sides. The horizontal distance between the most lateral edges of the right and left acromion landmarks is measured.

*Shoulder-elbow height (SEL).* Subject stands erect, upper arms hanging at sides and elbows flexed 90°. The

| | Height | Breadth | Lenght | Circumference |
|---|---|---|---|---|
| **Stature measurements** | SH | LGR | FGR | |
| **Shoulder, arm and hand** | SEL | SB<br>BB | EHL | WC<br>MFC |
| **Torso, pelvis and leg** | CHA<br>IH | CBA<br>BB | | |
| **Craniofacial measurements** | VN<br>NGn<br>NSto<br>StoGn<br>TGo | EuEu<br>ExEx<br>ZyZy<br>GoGo<br>AlAl<br>ChCh | OpFr<br>TSn<br>TPg<br>GoPg | HC<br>NC |

**TABLE 1 -** *Categories of body and craniofacial anthropometric measurements made in a comparative study in an Italian prepubertal population.*

distance is measured from the superior surface of the right shoulder to the inferior surface of the forearm just below the elbow parallel to the long axis of the upper arm.

*Elbow-hand length (EHL).* Subject stands erect, upper arms hanging at sides and elbows flexed 90° with hands and fingers extended. The distance is measured from the posterior surface of the right upper arm, just above the elbow, to the tip of the middle finger parallel to the long axis of the forearm.

*Wrist circumference (WC).* Subject stands erect, arms hanging at sides. The minimum circumference of the right wrist above the distal (ulna) styloid process is measured.

*Maximum fist circumference (MFC).* Subject extends right hand contracted to form a fist, thumb lying across fingers. The maximum circumference of the fist is measured by passing the tape over the thumb and across the knuckles.

*Chest height at axilla (CHA).* Subject stands erect, with feet together, weight evenly distributed, arms initially raised then lowered when instrument is in place. The vertical distance from the standing surface to the right axilla is measured.

*Chest breadth at axilla (CBA).* Subject stands erect with feet together, weight evenly distributed, arms initially raised then lowered when instrument is in place. The horizontal breadth of the chest at the level of the axilla is measured.

*Iliospinale height (IH).* Subject stands erect with feet together, weight evenly distributed. The vertical distance from the standing surface to the right anterior superior iliac spine of the pelvis is measured.

*Bispinous breadth (BisB).* Subject stands erect with feet together, weight evenly distributed. The distance between the right and left anterior superior iliac spines of the pelvis is measured.

*Neck circumference (NC).* Subject stands erect with head oriented in the Frankfort Plane. Circumference of the neck, perpendicular to the long axis of the neck at the midpoint, is measured.

*Head circumference (HC).* Subject stands erect, arms hanging at sides. The circumference of the head is measured at the level of the plane passing above glabella (most anterior protrusion of forehead) and through opisthocranion (most posterior protrusion from glabella on the back of the head), perpendicular to the mid-sagittal plane.

*Head height (VN).* Subject sits erect with head oriented in the Frankfort Plane, with jaws closed. The height of the head, perpendicular to the Frankfort Plane from vertex to nasion is measured.

*Head breadth (EuEu).* Subject sits erect with head oriented in the Frankfort Plane, arms hanging at sides. The maximum breadth of the head between right and left eurion is measured.

*Head lenght (OpFr).* Subject stands erect with head oriented in the Frankfort Plane. The distance from the glabella (most anterior protrusion of the forehead) to opisthocranion (most posterior point from glabella on the back of the head) is measured.

*Biocular distance (ExEx).* Subject sits erect with head oriented in the Frankfort Plane. The maximum horizontal breadth of the eyes between the right and left exocantion is measured.

*Bizygomatic breadth (ZyZy).* Subject sits erect with head oriented in the Frankfort Plane. The maximum horizontal breadth of the face is measured between the zygomatic points.

*Bigonial breadth (GoGo).* Subject sits erect with head oriented in the Frankfort Plane. The maximum horizontal breadth of the mandible is measured, between the right and left gonion.

*Face height (NGn).* Subject sits erect with head oriented in the Frankfort Plane, with jaws closed. The vertical distance of the face from nasion to gnation is measured.

*Upper face height (NSto).* Subject sits erect with head oriented in the Frankfort Plane, with jaws closed. A measurement is taken of the vertical distance of the upper face from nasion to stomion.

*Lower face height (StoGn).* Subject sits erect with head oriented in the Frankfort Plane, with jaws closed. The vertical distance of the lower face from stomion to gnathion is measured.

*Posterior face height (TGo).* Subject sits erect with head oriented in the Frankfort Plane, with jaws closed. The vertical distance is measured of the posterior face from tragus to gonion.

*Upper face lenght (TSn).* Subject sits erect with head oriented in the Frankfort Plane, with jaws closed. The distance is measured of the upper length face from tragus to subnasale.

*Lower face lenght (TPg).* Subject sits erect with head oriented in the Frankfort Plane, with jaws closed. The distance of the lower length face from tragus to pogonion is measured.

*Mandibular body lenght (GoPg).* Subject sits erect with head oriented in the Frankfort Plane, with jaws closed. A measurement is made of the distance of the mandibular body from gonion to pogonion.

All measurements were made with two Vernier calipers, reading 0-500 mm and 0-200 mm, for all linear anthropometric measurements. A wall stadiometer was used to measure stature and a circumference gauge to measure circumferential sizes. The previous papers by Farkas [1994, 1996], Farkas and Posnick [1992] and

Farkas and Deutsch [1996] were used as a basis for the testing of the reliability and reproducibility of the measurements.

As regards the measurements of errors and the reproducibility of the measurements we took into consideration previous papers written by other authors. Himes [1989] says that the mean of independent replicate measurements is more reliable than a single determination. Jamison and Ward [1993] say that statistically craniofacial measurements bigger than 6 cm present precision and reliability. Accordingly, all anthropometric measurements, made by the same operator (GS), were repeated twice or more and the mean value of the measurements was used. The measurement error coefficient was found with IC (r = 0.93-0.97; P = 000.1). All values were found to be close to 1.00 and within acceptable limits.

*Statistical analysis.* Descriptive analysis was carried out on all variables assessed. This consisted of calculating means, standard deviations and percentages and individualising anomalous and erroneous data. Means of the variables taken into consideration were compared. Then linear correlation coefficients (p) were calculated to assess the intensity of the interdependence between variables. Statistical analysis was carried out with BMDP Dynamic software (release 7, 1993, Cork - Ireland).

## Results

The averages of all variables are reported for males and females separately in Tables 2 and 3. Means and percentages of the development for each body and

| Males (mm) | 7-8 yrs (9) | | 9-10 yrs (22) | | 11-12 yrs (17) | |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD |
| SH | 1300 | 35.7 | 1404 | 53 | 1532 | 82 |
| LGR | 610 | 42.8 | 681 | 39 | 753 | 49.2 |
| FGR | 442 | 42 | 481 | 30.6 | 563 | 86 |
| SEL | 274 | 10 | 300 | 15.2 | 326 | 21.8 |
| SB | 302 | 16.5 | 335 | 25.1 | 354 | 23.5 |
| EHL | 348 | 21.3 | 375 | 19.4 | 404 | 37.4 |
| WC | 138 | 6.8 | 148 | 8.5 | 153 | 7.7 |
| BB | 261 | 19.5 | 290 | 19.1 | 306 | 28.7 |
| MFC | 211 | 7.2 | 227 | 10.8 | 242 | 17 |
| CHA | 969 | 29.7 | 1048 | 46.3 | 1157 | 77 |
| CBA | 213 | 13.8 | 234 | 30.2 | 240 | 24 |
| IH | 750 | 22 | 816 | 43.8 | 896 | 47.9 |
| BisB | 197 | 12.9 | 217 | 19.3 | 231 | 18 |
| VN | 104 | 4.2 | 107 | 2.8 | 108 | 4.5 |
| EuEu | 138 | 3.5 | 143 | 6.9 | 145 | 4.3 |
| OpFr | 185 | 4 | 184 | 5.4 | 190 | 7.2 |
| HC | 526 | 5.4 | 534 | 13.7 | 548 | 14.8 |
| NC | 270 | 14.3 | 290 | 20.3 | 310 | 21.6 |
| NGn | 96 | 1.7 | 102 | 3.8 | 105 | 3.1 |
| NSto | 65 | 1.9 | 68 | 4.4 | 70 | 3.4 |
| StoGn | 36 | 2.7 | 37 | 3 | 40 | 2.1 |
| ExEx | 94 | 3.1 | 98 | 4.8 | 100 | 3 |
| ZyZy | 97 | 4.5 | 102 | 4.7 | 105 | 4.1 |
| GoGo | 88 | 4.9 | 93 | 5.7 | 96 | 5.7 |
| TSn | 109 | 4.6 | 114 | 5.5 | 118 | 5.2 |
| TPg | 121 | 5.4 | 127 | 6.1 | 129 | 8.2 |
| GoPg | 83 | 3.3 | 86 | 6.1 | 91.5 | 6.3 |
| TGo | 54 | 3.4 | 56 | 3.9 | 60.5 | 4.9 |

**TABLE 2 -** *Body and craniofacial anthropometric measurements. Statistical averages and SD for males.*

| Females (mm) | 7-8 yrs (16) | | 9-10 yrs (19) | | 11-12 yrs (17) | |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD |
| SH | 1318 | 70 | 1386 | 69.3 | 1496 | 76.3 |
| LGR | 634 | 36.4 | 673 | 48.1 | 742 | 61.3 |
| FGR | 451 | 26.3 | 475 | 34.5 | 527 | 40.7 |
| SEL | 276 | 20.8 | 292 | 17.7 | 324 | 28 |
| SB | 307 | 26 | 318 | 27 | 352 | 29.5 |
| EHL | 345 | 19 | 367 | 21.9 | 387 | 38 |
| WC | 141 | 9.5 | 142 | 8 | 153 | 7.5 |
| BB | 260 | 21.3 | 274 | 18.4 | 294 | 20.9 |
| MFC | 206 | 12.6 | 217 | 15 | 232 | 15.2 |
| CHA | 993 | 57.9 | 1054 | 67.4 | 1140 | 77.8 |
| CBA | 212 | 15.8 | 224 | 25.1 | 249 | 17.7 |
| IH | 774 | 44.5 | 818 | 55.4 | 888 | 55.8 |
| BisB | 197 | 19.3 | 217 | 19.3 | 228 | 20.4 |
| VN | 104 | 3.2 | 108 | 2.7 | 112 | 3.5 |
| EuEu | 141 | 7.5 | 141 | 5.8 | 143 | 4.7 |
| OpFr | 180 | 6.5 | 182 | 6.6 | 184 | 7.2 |
| HC | 520 | 14 | 525 | 13.3 | 535 | 14.9 |
| NC | 271 | 13 | 271 | 17.6 | 293 | 21 |
| NGn | 96.4 | 5 | 102 | 3.5 | 104 | 3.8 |
| NSto | 64.6 | 3.9 | 67 | 2.3 | 68 | 5.1 |
| StoGn | 36.7 | 2 | 39 | 2.8 | 38 | 3.2 |
| ExEx | 95.8 | 4.6 | 95 | 3.6 | 99.5 | 5.6 |
| ZyZy | 99.6 | 6.7 | 99.5 | 5.2 | 104 | 4.8 |
| GoGo | 89.6 | 4.8 | 88 | 7 | 94.6 | 5.3 |
| TSn | 108 | 3.6 | 110 | 5.1 | 115.6 | 5.3 |
| TPg | 120 | 4.9 | 123 | 4.5 | 128 | 6.7 |
| GoPg | 85.2 | 5.5 | 87 | 4.5 | 90.4 | 8.9 |
| TGo | 52.8 | 7 | 55 | 5.4 | 56 | 4.8 |

**TABLE 3 -** *Body and craniofacial anthropometric measurements. Statistical averages and SD for females.*

| | Males 7-12 years | Females 7-12 years | Males 7-12 years | Females 7-12 years |
|---|---|---|---|---|
| | Mean Growth (mm) | Mean Growth (mm) | % Growth | % Growth |
| SH | 232 | 177.7 | 17.8 | 13.5 |
| LGR | 143.5 | 108 | 23.5 | 17 |
| FGR | 120.8 | 75.2 | 27.3 | 16.7 |
| SEL | 50.8 | 48 | 18.5 | 17.4 |
| SB | 51.9 | 44.3 | 17.2 | 14.4 |
| EHL | 55.6 | 41.7 | 16 | 12.1 |
| WC | 14.5 | 11.6 | 10.4 | 8.2 |
| BB | 45.2 | 34.4 | 17.3 | 13.2 |
| MFC | 31 | 25.7 | 14.7 | 12.4 |
| CHA | 187.5 | 147 | 19.4 | 14.8 |
| CBA | 26.7 | 36.4 | 12.5 | 17.1 |
| IH | 145.7 | 113.8 | 19.4 | 14.7 |
| BisB | 33.7 | 31.1 | 17.1 | 15.8 |
| VN | 3.2 | 7.6 | 3 | 7.3 |
| EuEu | 6.6 | 1.8 | 4.8 | 1.3 |
| OpFr | 4.6 | 4.5 | 2.5 | 2.5 |
| HC | 22.3 | 15.4 | 4.2 | 3 |
| NC | 39.2 | 21.2 | 14.5 | 7.8 |
| NGn | 8.6 | 8.1 | 9 | 8.4 |
| NSto | 4.8 | 3.2 | 7.3 | 5 |
| StoGn | 4.1 | 1.5 | 11.5 | 4.2 |
| ExEx | 6.2 | 3.7 | 6.6 | 3.9 |
| ZyZy | 7.8 | 4.8 | 8.1 | 4.3 |
| GoGo | 7.8 | 5 | 8.8 | 5.6 |
| TSn | 8.4 | 6.8 | 7.7 | 6.3 |
| TPg | 8.1 | 7.5 | 6.7 | 6.2 |
| GoPg | 7.9 | 5.2 | 9.4 | 6.2 |
| TGo | 6.4 | 3.2 | 11.8 | 6 |

TABLE 4 - *Mean and percentage growth for body and craniofacial sizes (males and females).*

craniofacial dimension from 7 to 12 years are reported in Table 4. For convenience the subjects were divided into three groups (7-8 years, 9-10 years, 11-12 years), as reported by other authors [Snyder et al., 1975; Farkas and Posnick, 1992].

A high percentage of the growth recorded corresponded to all body measurements (standing height, shoulders and arms, torso, pelvis and legs), both for males (min. WC: 14.45 mm = 10.42%; max. EHL: 120.77 mm = 27.32%) and females (min. WC: 11.59 mm = 8.21%; max. SEL: 44.97 mm = 17.39%); a higher percentage of growth for males was recorded. Concerning cranial growth, skull sizes did not increase significantly, either for males (min. Op-Fr: 4.6 mm = 2.48%; max. Eu-Eu: 6.64 mm = 4.8%) or females (min. Eu-Eu: 1.86 mm = 1.32%; max. V-N: 3.17 mm = 7.32%).

Facial bones grew more than skull bones and less than any body dimensions (males min. Ex-Ex: 6.23 mm = 6.61%; max. T-Go: 6.38 mm = 11.81%; females min. Ex-Ex: 3.73 mm = 3.89%; max. N-Gn: 8.13 mm = 8.43%). The increase of mandibular bone was higher for males than females (Sto-Gn: 4.15 mm = 11.46% vs 1.55 mm – 4.22%; T-Go: 6.38 mm = 11.81% vs 3.19 mm = 6.04%).

The assessment of linear correlation coefficients, analyzed separately for males and females, showed that only correlations between body sizes had high coefficients ($p>0.7$), while correlations between body sizes and craniofacial sizes did not have significant coefficients (Tables 5 and 6).

## Discussion

Body growth is a complicated process ending approximately at the age of 14 years for females and 18 years for males [Behrman et al., 2002]. Body growth pattern (stature increase and other sizes like arms and legs as well) is thought to be steady [Burgio, 1997; Cisternino and Livieri, 1997; Behrman et al., 2002] and differs considerably from craniofacial growth pattern [Van Limborg 1970, 1972; Caprioglio, 2000].

The relevant literature reports that 4 to 6 cm/year of growth in stature occurs before the pubertal growth peak [Snyder et al., 1975; Burgio et al., 1997; Cisternino and Livieri, 1997; Behrman et al,. 2002]. The results reported in this paper confirm these findings: the significant increase of stature is 4.7 cm/year for males and 3.6 cm/year for females, with higher percentage differences of growth for males.

There are little data in the literature concerning other body sizes [Snyder et al., 1975]. In our sample there was a big increase for both arms and legs, followed by stature and width sizes.

During the prepubertal period the body's growth is higher for cranial and facial growth, as shown in other papers [Rose 1960; Singh et al., 1967; Bishara et al., 1981; Moore et al., 1990; Van der Beek et al., 1996]. The skull increases very quickly in size; the cranium almost completes its growth before 7 years of age [Burgio 1997; Cisternino and Livieri, 1997; Behrman et al., 2002], while the face takes more time to increase in size, however it is faster than the rest of the body [Rose, 1960; Bambha, 1961; Burstone, 1963; Pike,

| | SH | LGR | SEL | SB | EHL | WC | BB | MFC | CHA | IH | BisB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LGR | 0.94 | | | | | | | | | | |
| SEL | 0.93 | 0.9 | | | | | | | | | |
| SB | 0.74 | 0.79 | 0.7 | | | | | | | | |
| EHL | 0.79 | 0.78 | 0.8 | | | | | | | | |
| WC | 0.76 | 0.78 | 0.73 | 0.72 | 0.73 | | | | | | |
| BB | 0,77 | 0.79 | 0.75 | 0.76 | | | | | | | |
| MFC | 0.88 | 0.88 | 0.84 | 0.77 | 0.76 | 0.83 | 0.77 | | | | |
| CHA | 0.96 | 0.89 | 0.89 | 0.71 | 0.75 | 0.71 | | 0.83 | | | |
| IH | 0.9 | 0.84 | 0.8 | | | | | 0.76 | 0.89 | | |
| BisB | 0.78 | 0.79 | 0.74 | | | 0.76 | 0.72 | 0.79 | 0.72 | 0.7 | |
| NC | 0.84 | 0.87 | 0.8 | 0.76 | 0.73 | 0.83 | 0.7 | 0.81 | 0.79 | | 0.81 |

**TABLE 5 -** *Significant linear correlation coefficients for body and craniofacial sizes for males.*

| | SH | LGR | FGR | SEL | SB | EHL | WC | BB | MFC | CHA | BisB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LGR | 0.88 | | | | | | | | | | |
| FGR | 0.82 | 0.84 | | | | | | | | | |
| SEL | 0.85 | 0.83 | 0.82 | | | | | | | | |
| SB | 0.72 | 0.83 | 0.78 | 0.77 | | | | | | | |
| EHL | 0.74 | 0.75 | | | | | | | | | |
| WC | 0.73 | 0.76 | 0;73 | 0.71 | 0.85 | | | | | | |
| BB | 0.7 | 0.73 | | 0.73 | 0.75 | | | | | | |
| MFC | 0.78 | 0.78 | 0.79 | | 0.79 | | 0.85 | 0.72 | | | |
| CHA | 0.95 | 0.8 | 0.8 | 0.78 | | 0.700 | | | 0.75 | | |
| CBA | | | | | 0.71 | | 0.73 | | 0.72 | | |
| IH | 0.94 | 0.88 | 0.84 | 0.8 | 0.71 | 0.720 | 0.73 | | 0.76 | 0.91 | |
| BisB | | 0.76 | | | 0.82 | | 0.76 | 0.75 | 0.75 | | |
| HC | | | | | | | | | 0.73 | | |
| NC | | 0.78 | 0.72 | | 0.89 | | 0.82 | | 0.73 | | 0.73 |
| TPg | 0.74 | | | | | | 0.7 | | | 0.7 | |

**TABLE 6 -** *Significant linear correlation coefficients for body and craniofacial sizes for females.*

1968; Baume et al., 1983; Moore et al., 1990]. Therefore, body sizes are not good indicators of facial growth. Accordingly, growth of any of the body's indicies cannot be used to predict a determinate type of facial growth.

The only exception to this seems to be the vertical growth of the jaw. From data analysis, the jaw is the facial area showing the greater development, particularly at lower face height Sto-Gn and posterior face height T-Go. There is also a higher percentage increase in those two areas than in other facial areas, as shown by Moore et al. [1990] and Van der Beek et al. [1996].

Facial areas closer to the skull, as biocular distance Ex-Ex and upper facial height N-Sto, show a smaller increase than other facial areas. This can be explained by the influence of cranial base on the increase of such structures [Pike 1968; Shah et al., 1980; Baume et al., 1983]. Three different growth patterns can therefore coexist during the prepubertal period: skull growth, facial growth and body growth, as was originally proposed by Bishara et al. [1981]. During this period, before the statural growth peak that coincides with sexual maturation, the jaw has a remarkable development. Therefore it is for this reason that the action of functional appliances on maxillary bones can benefit from a fundamental aid represented by the same increase of growth of the lower facial areas.

## Conclusions

A comparison between craniofacial and body growth during the prepubertal period, in a population of Italian Caucasian children, using medical anthropometry for body and craniofacial measurements, showed that the development of different sizes, as stature, length of arms and legs, width dimensions, was found to be higher than cranial and facial growth, as the facial complex increased more than skull dimensions.

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