European Journal of Clinical Nutrition (2002) 56, 171–180
 0954–3007/02 $25.00
www.nature.com/ejcn

ORIGINAL COMMUNICATION

Italian cross-sectional growth charts for height, weight and BMI (6 – 20 y)

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Objective To trace growth charts for height, weight and body mass index (BMI) that apply to the whole Italian population. Different charts were drawn for central-north and south Italy since children in central-north regions are known to be taller and leaner.
Design: Cross-sectional study.
Setting: A sample of schoolchildren covering 16 of the 20 Italian regions, with data collected between 1994 and 2000.
Subjects: A total of 27 421 girls and 27 374 boys, aged 6 – 20 y.
Methods: Height and weight were measured using portable Harpenden stadiometers and properly calibrated scales, respectively. SIEDP references are presented both as centiles and as LMS curves for the calculation of standard deviation scores. According to International Obesity Task Force, SIEDP charts for BMI include the limits for overweight and obesity, ie the centiles having, at 18 y of age, the value of 25 and 30 kg/m^2, respectively.
Results: The comparison between SIEDP and Tanner *et al*'s charts for height, still in use among most Italian paediatricians, shows that before puberty Italian children are 2 – 4 cm taller than their English peers. Because of these differences, Tanner's charts fail to detect, when applied to Italian children, 50 – 90% of short children aged 6 – 11 y, ie with stature below the 3rd centile of their reference population. Rolland-Cachera *et al*'s centiles for BMI are lower than those of SIEDP standards, mainly during adolescence (up to 6.6 kg/m^2 for the 97th centile), and apply poorly to Italian children. The prevalence of overweight is 27 (boys) and 19% (girls) in south Italy *vs* 17 (boys) and 10% (girls) in central-north Italy.
Conclusions: These references intend to supply Italian paediatricians with a tool that avoids the use of outdated or inadequate charts, and thus should be suitable for monitoring their patients' growth.
Sponsorship: Italian Society for Pediatric Endocrinology and Diabetes (SIEDP).
European Journal of Clinical Nutrition (2002) **56,** 171 – 180. DOI: 10.1038/sj/ejcn/1601314

Keywords: Italian growth charts; height centiles; weight centiles; BMI centiles

Introduction

Somatic growth is an indicator of a child's health and nutrition. For this reason, updated reference growth charts describing the auxological characteristics of the population which his or her patients belong to are particularly useful to the paediatrician. The lack of national data in the past compelled Italian paediatricians to make use of the English norms for height and weight produced by Tanner *et al*

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Received 28 March 2001; revised 24 July 2001; accepted 25 July 2001

(Tanner *et al*, 1966; Tanner & Whitehouse, 1976) more than 30 y ago, or of the French norms for body mass index (BMI; Rolland-Cachera *et al*, 1991). These norms are still used by the large majority of paediatricians, although more recent international charts are available, and some centres refer to charts obtained in their own towns or regions (Falorni, 1998; Nicoletti, 1992; Zoppi *et al*, 1996; Luciano *et al*, 1997; Merola *et al*, 1998; Schwarzemberg *et al*, 1998). Nonetheless, paediatricians are aware that English or French cross-sectional charts can imply non-negligible biases in the assessment of their patients' growth, since there are ethnic differences in the age at pubertal growth spurt and in adult height, and charts have become progressively outdated because of secular trends.

In this paper we present the national cross-sectional growth charts for height, weight and BMI, drawn on the basis of a sample of over 54 000 schoolchildren aged 6–20 y and covering 16 of the 20 Italian regions. The survey was carried out thanks to the initiative of the Directive Council of the Italian Society for Paediatric Endocrinology and Diabetes (SIEDP) and to the collaboration of 16 Centres for Paediatric Endocrinology directed by SIEDP members.

Subjects and methods

Sampling plan

An *ad-hoc* sampling plan was designed in 1996 with the aim of drawing references. In accordance with the protocol of the study, in each region a sample proportional to the size of school population had to be collected, schools being the sampling units. School population and general population overlap between 6 and 14 y, when the attendance at school is obligatory. For children aged 15–19, the school population is about 80% of the general population. The prefixed sample size of 36 000 subjects was suitable for providing the extreme centiles (ie the 3rd and 97th) of height and weight with standard errors lower than 0.4 cm and 0.2 kg at 6 y and lower than 0.5 cm and 0.8 kg at the adult age.

During the study all schools selected participated in the study, and all children at school in the morning of the visit were measured. Nonetheless some protocol violations occurred: no data were collected in Trentino Alto Adige, Friuli Venezia Giulia and Basilicata (these regions were supposed to supply 1850 subjects), whereas Lombardia, Emilia-Romagna, Toscana and Campania exceeded the prefixed sample size by 2–4 times. When the aim of estimating to what extent the lack of data from the three regions mentioned above affects the estimates, we used height data of the conscripts for the 1990 draft, who are the cohort of all Italian boys born in 1972, measured at the age of 18 y as a part of medical examination. The conscripts in Trentino-Alto Adige and Friuli Venezia Giulia are, on average, taller than their peers in central-north (C-N) Italy by 1.9 cm. However, if we exclude these conscripts (who are only 5.8% of all C-N conscripts), we lower the mean height of C-N conscripts only by 0.1 cm. Conscripts from Basilicata (who comprise 3% of all conscripts from south (S) Italy) are, on average, only 0.1 cm shorter than their peers in S Italy. As a consequence, we considered negligible the bias arising from this type of non-response. In order to assess the effect of the disproportion between prefixed and current sample size in some regions, we compare the medians computed without or with adjustment for the size of regional school population. At each age, the unadjusted median is simply the median value of all children (eg girls 16 y old). The adjusted median is the weighted mean of regional medians, weights being the size of the regional school population at that age.

All measurements were taken between 1996 and 2000, except for Campania, which supplied data collected between 1990 and 1994. Growth references presented are based on a sample of 54 795 schoolchildren — 27 421 girls and 27 374 boys (Italian Society for Paediatric Endocrinology and Diabetes (SIEDP) series). For C-N Italy (Piemonte, Lombardia, Veneto, Liguria, Emilia-Romagna, Toscana, Marche, Umbria and Lazio), the sample was made up of 26 535 subjects, while the S Italy sample (Abruzzo, Molise, Campania, Puglia, Calabria, Sicilia and Sardegna) included 28 260 subjects. For age classes from 6 to 18 y, 2000–6000 subjects were recruited; sample size was smaller for age classes 19 (1232 subjects) and 20 (198 subjects). Children of immigrants were excluded from the analysis.

Measurement techniques

In each region, specifically trained personnel using appropriate equipment measured height and weight. Portable Harpenden stadiometers were used for height, and every child was measured three times in the same morning to the nearest mm according to the technique described by Cameron (1986). In brief, the subject stood straight, with feet placed together and flat on the ground, heels, buttocks and scapulae against the vertical backboard, arms loose and relaxed with the palms facing medially. His head was carefully positioned in the Frankfurt plane, ie with the lower margins of the orbit in the same horizontal plane as the upper margin of external auditory meatus. Body weight was measured in minimal underclothes to the nearest 100 g on portable, accurate and properly calibrated scales. In about 20% of the sample weight could be measured only clothed and estimated clothing weight was then deducted. Body mass index (BMI) was calculated using the following formula: weight (kg)/height (m^2).

Tracing growth charts

When data are derived from cross-sectional surveys, raw nonparametric centiles of height or weight distribution conditional on age show irregular patterns. To draw smooth growth charts, we resorted to the EMGF (extended mechanistic growth function) method (Cortinovis & Milani, 2000), an extension of the Healy *et al* approach (Healy *et al*, 1988) to the case of non-linear functions.

As for height, we introduced into the Preece-Baines PB1 growth function (Preece & Baines, 1978) a few extra-parameters suitable for modelling the distance between centiles (Clementi *et al*, 1999):

$$E(y(t,z)) = \mu_2 + \gamma_2 z - \frac{2((\mu_2-\mu_1)+(\gamma_2-\gamma_1)z)}{\exp\{\beta_1(t-\tau-\lambda z)\}+\exp\{\beta_2(t-\tau-\lambda z)\}} \quad (1)$$

where $E(y(t,z))$ is the height at age t of the centile whose Z-score is z (eg Z-score for the 3rd centile is -1.88), and the five original parameters are the age at peak of the pubertal component of velocity (τ), the height at age $\tau(\mu_1)$, final height (μ_2), and the rate constants for childhood (β_1) and puberty (β_2) growth cycles. The three extra parameters are γ_2 (which is the standard deviation of adult height), γ_1 (which models standard deviation as a function of height), and λ (which allows each centile to have its own inflection point). An analogous function with the further inclusion of a quadratic term ($\gamma_3 z^2$) was used to fit, after log-transformation, weight and BMI raw centiles. The average departure (expressed as root mean square error) of the raw centiles from these references was as follows: 0.7 cm (height), 0.8 kg (weight) 0.15 kg/m^2 (BMI). Weighted least-squares estimates of the smooth centiles were obtained with Marquardt's algorithm (Draper & Smith, 1981), weights being the reciprocal of squared standard errors of raw centiles.

EMGF method leads to growth charts that are completely defined by a low number of constants (8 or 9 in our case), which express the mean pattern of growth according to a prefixed growth model, as well as the standard deviation and skewness of the auxometric trait (height, weight or BMI) distribution conditional on age. EMGF is particularly useful when we need to draw growth charts based on few subjects, as in the case of uncommon pathological conditions (Clementi *et al*, 1999), or when we have to compare several growth charts referring to different populations (as in the case of Italian regions), provided that the shape of mean growth curve can be modelled by a human growth function. Although EMGF model and Cole and Green's LMS model (Cole, 1990; Cole & Green, 1992) have very different structures, they yield similar estimates (differences are within 2%, also for BMI), and the centiles estimated with EMGF can also be expressed in terms of smooth age-specific curves called L, M and S. The M and S curves correspond to the median and coefficient of variation of the auxometric trait at each age, while the L curve allows for the age-dependent skewness of the distribution of the same trait. The value (y) of a trait measured on a child of a given age can be transformed into a standard deviation score (SDS):

$$\mathrm{SDS} = \frac{(y/M)^L - 1}{L \times S} \quad (2)$$

The value of a given centile at a given age can be computed from the L, M and S values for that age. For instance, for the 97th centile (whose SDS is 1.88) of BMI (boys, S Italy), we have $L = -0.980$, $M = 23.4$, $S = 0.136$,

$$y(97th) = 23.4 \times [1 + 1.88 \times (-0.980) \times 0.136]^{1/(-0.980)} = 31.4$$

For BMI we calculated two extra centile curves passing through 25 and 30 kg/m^2 at age 18, to provide cut-off limits for childhood overweight and obesity, as suggested by Cole *et al* (2000).

Results

Different growth charts are here presented for C-N Italy and S Italy, as generally strongly suggested by Italian anthropologists (Nicoletti and Pelissero, 1994), because of the large differences that still exist between C-N Italy and S Italy as regards genetics, environment, socioeconomic conditions, life habits and diet: all these may affect growth. As expected, Table 1 shows that the southern regions have higher values of BMI and lower values of height both in prepubertal period and, to larger extent, after puberty, although regional differences exist both within C-N and S Italy. Growth references were computed without adjustment for the size of regional school populations, which was not proportional to the regional sample size because of the protocol violations mentioned above. Nonetheless, the difference between adjusted and unadjusted medians is slight at all ages and for both sexes (Table 2).

Figure 1 compares the 3rd, 50th and 97th centiles of height, weight and BMI distribution for Italian girls and boys of C-N and S Italy. Tables 3 and 4 give the numerical values of centiles by sex and age. Tables 5 and 6 report the values of power (L), median (M) and coefficient of variation (S), suitable for computing SDSs of height, weight and BMI, or for deriving the centiles reported in Tables 3 and 4 as well as other centiles (eg the 10th or the 90th centile).

Height

At all ages the median stature of girls is higher in C-N than in S Italy, the smallest difference being 0.8 cm at age 9 and the largest 2.3 cm at age 16. The 3rd and 97th centiles are larger by similar amounts. An analogous pattern emerges for boys: the median stature of C-N boys is higher than that of S boys by 1.5 cm at age 8, and 2.9 cm at age 16. Table 7 compares Italian references with Tanner *et al*'s cross-sectional norms (Tanner *et al*, 1966) at some key ages. At 6 y of age, C-N girls and S girls are on average taller than English girls by 4.6 and 2.6 cm, respectively. In boys, the largest differences occur at 13 y of age (C-N, 5.0 cm; S, 2.4 cm), but adult height is slightly lower in S boys than in Tanner's boys. An important practical consequence of these differences is that the actual proportion of Italian children below the 3rd centile of Tanner's norms is consistently lower than the expected value (ie 3%), mainly in C-N Italy and at younger ages,

Table 1 Minimum and maximum values of regional median values for central-north (C-N) and south Italy (S)

		Height				*Weight*				*BMI*			
		Italy C-N		*Italy S*		*Italy C-N*		*Italy S*		*Italy C-N*		*Italy S*	
Sex	*Age (y)*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*
Girls	6	117.4	119.2	115.5	118.7	22.2	23.6	21.7	23.6	15.8	16.7	16.0	16.6
	10	139.1	140.3	138.1	139.7	34.8	35.9	34.4	36.9	17.8	18.2	17.9	18.7
	12	152.0	153.4	150.7	151.7	44.6	46.2	44.4	46.8	19.1	19.7	19.5	20.3
	16	162.2	163.6	156.5	160.8	54.4	56.7	52.5	56.4	20.6	21.4	21.5	21.8
Boys	6	118.1	120.0	115.6	118.8	22.8	23.6	21.7	23.0	15.8	16.3	15.7	16.2
	11	144.3	145.8	142.4	143.7	39.3	40.9	38.0	40.7	18.4	18.9	18.3	19.3
	13	157.5	159.0	155.3	157.4	50.3	51.6	49.2	51.6	19.9	20.4	20.1	21.0
	18	175.3	177.1	173.5	176.3	67.9	70.5	68.1	70.9	21.5	22.4	21.9	23.0

Table 2 Difference between median values computed with (adj) or without (unadj) adjustment for the size of regional school populations

		Height				*Weight*				*BMI*			
		Italy C-N		*Italy S*		*Italy C-N*		*Italy S*		*Italy C-N*		*Italy S*	
Sex	*Age (y)*	*Unadj*	*Adj*	*Unadj*	*Adj*	*Unadj*	*Adj*	*Unadj*	*Adj*	*Unadj*	*Adj*	*Unadj*	*Adj*
Girls	6	118.0	118.1	116.0	116.6	23.0	23.0	22.2	22.4	16.3	16.4	16.3	16.3
	10	139.6	139.8	138.6	138.4	35.3	35.4	34.9	34.8	18.0	18.0	18.2	18.2
	12	152.6	152.7	150.9	151.1	45.8	45.7	45.2	45.5	19.6	19.5	19.8	19.9
	16	162.7	162.8	160.4	159.1	55.2	55.5	55.7	54.6	20.8	21.0	21.6	21.6
Boys	6	118.4	118.7	116.6	116.6	23.0	23.1	22.2	22.3	16.0	16.0	15.9	16.1
	11	145.0	145.1	143.2	143.0	40.1	40.0	39.0	38.8	18.7	18.7	18.7	18.7
	13	158.4	158.5	155.8	155.8	51.1	50.9	49.3	49.8	20.2	20.1	20.2	20.4
	18	176.5	176.5	173.8	174.7	68.6	69.0	69.7	68.6	22.0	22.0	22.9	22.4

while it is higher for S subjecs during late adolescence and adulthood (Table 8).

Weight

In girls the 3rd and 50th centiles of C-N and S growth references display similar values at all ages, the differences being lower than 1.0 kg. However, the 97th centile of S girls becomes progressively higher than that of C-N girls, with a difference of 4.4 kg at the end of growth. As for boys, the 3rd and 50th centiles of S references are lower than those of C-N up to the end of adolescence, but are higher at 20 y of age by 0.8 and 2.7 kg, respectively (Figure 1). The 97th centile of S boys becomes progressively higher than that of C-N boys, with a difference of 6.8 kg at the end of growth.

Compared to Tanner's norms, girls are heavier during childhood and adolescence both in C-N and in S Italy, the differences being generally higher in the 97th centile (up to 7.6 kg in S girls at 12 y of age). At the end of growth, the 3rd and 50th centiles of Italian girls become lower than in English norms. Italian boys are heavier than their English peers during the whole growth period, the largest differences emerging in the 97th centile; +13.4 kg at 13 y for C-N boys and +16.1 kg at 18 y for S boys.

BMI

C-N and S references do not differ in the 3rd centile of BMI for both sexes. A moderate difference emerges in median values after 13 and 15 y of age in girls and boys, respectively: at the end of growth BMI is higher by 1.0 kg/m^2 in S girls and 1.3 kg/m^2 in S boys. As for the 97th centile, S children show BMI values higher than C-N children; in girls the difference increase from 0.4 at 6 y to 2.0 at 14 y and is 2.6 kg/m^2 at the end of growth, while in boys the difference is negligible until 11 y of age and increases up to 2.5 kg/m^2 at 20 y.

At 18 y of age, the prevalence of overweight subjects (BMI > 25 kg/m^2) is higher in boys (C-N, 16.7%; S 27.4%) than in girls (C-N, 10.0%; S, 19.3%). A similar tendency can be observed for obesity (BMI > 30 kg/m^2), the prevalence being 1.8% (C-N) and 4.5% (S) in boys, and 1.3% (C-N) and 3.5% (S) in girls. Table 9 shows the values that can be regarded as thresholds for overweight and obesity during growth in the Italian population. These cut-off points are computed according to the method suggested by Cole *et al*

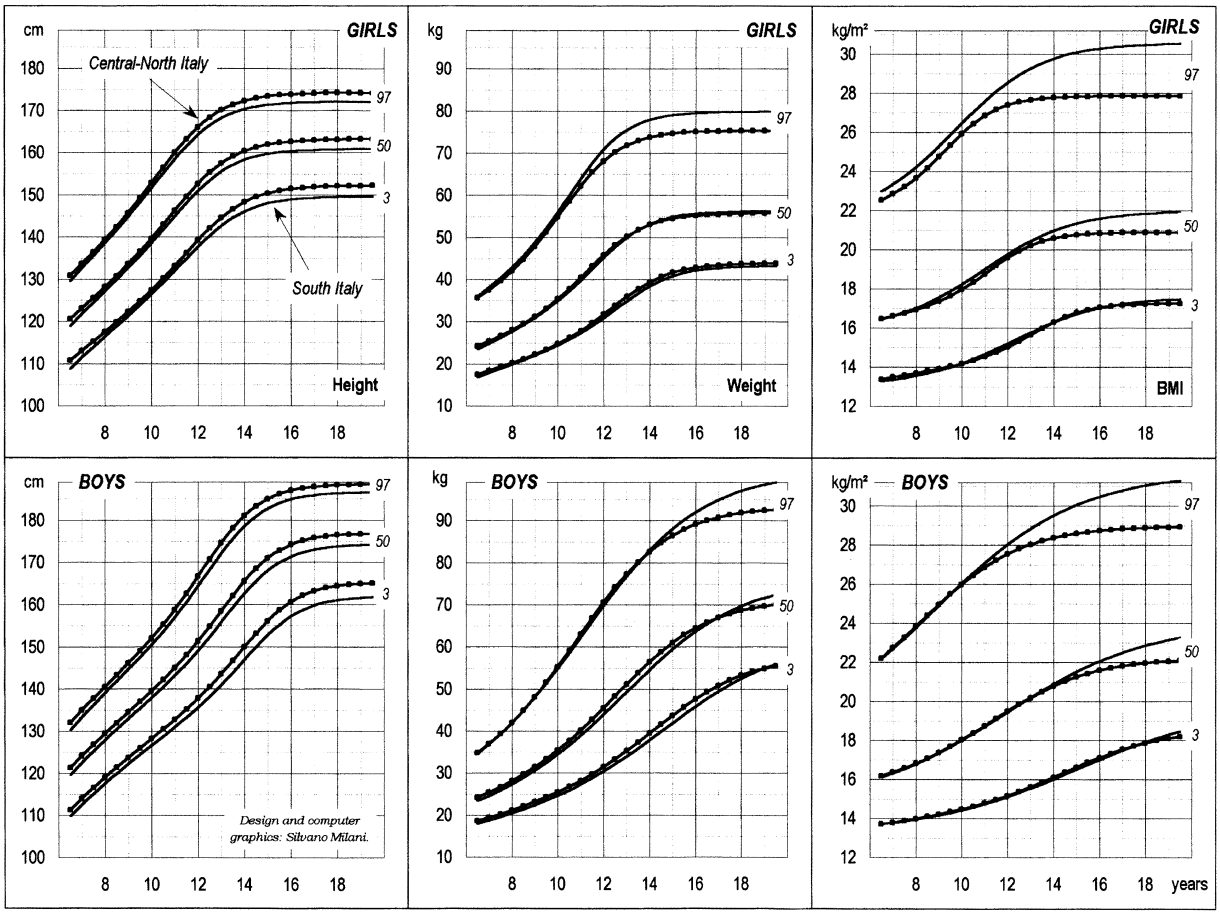

Figure 1 3rd, 50th and 97th centiles of height (left), weight (middle) and BMI (right) distribution for Italian girls (top) and boys (bottom) of central-north (dotted line) and south Italy (continuous line).

(2000). The centiles of Italian references are higher than those of Rolland-Cachera *et al*'s norms (Rolland-Cachera *et al*, 1991 Table 10), mainly during adolescence. The differences are larger in the 97th centile for both sexes (up to 6.6 kg/m^2).

Discussion

Data in the SIEDP series, covering all ages from 6 y to the end of growth and almost all Italian regions, allowed us to estimate the current auxological differences between the north and south of Italy during late childhood, adolescence and adulthood. This difference has been reported in the past by many authors (Nicoletti & Pelissero, 1994), but was never documented systematically, mainly as regards BMI. In the last decade of the 20th century, children are still taller in C-N Italy than in S Italy during the whole growth period: at the end of growth the average differences is 2.4 (girls) and 2.7 cm (boys). After puberty, BMI values of children in S Italy become higher than those of children in C-N Italy. At 18 y of age, the prevalence of overweight (BMI > 25 kg/m^2) and obesity (BMI > 30 kg/m^2) in S Italy is 27.4% and 4.5% (boys), and 19.3 and 3.5% (girls), respectively; these percentages are far higher than in Central-north Italy, where the prevalence of overweight and obesity is 16.7 and 1.8% (boys), and 10.0 and 1.3% (girls), respectively.

We cannot say whether the differences found in height and BMI between C-N Italy and S Italy are due to differences in genetics, environment, socioeconomic conditions, diet or lifestyle, since all these differences are known to exist. We know that there are important genetic differences between C-N and S Italy, for instance in the incidence of some genetic disease, such as cystic fibrosis or thalassemia, or in the distribution of blood groups. As for height, differences are unlikely to be due to socioeconomic factors, nutritional intake and lifestyle all being suitable for allowing each girl or boy to reach her or his target height, at least in the last two decades. Wide differences in diet and physical activity could be the reason why the prevalence of overweight and obesity is much higher in S Italy.

Table 3 Height, weight and BMI growth norms, expressed as 3rd, 50th and 97th centiles (central-north Italy)

	Girls									*Boys*								
	Height			*Weight*			*BMI*			*Height*			*Weight*			*BMI*		
Age (y)	*3rd*	*50th*	*97th*	*3rd*	*50th*	*97th*	*3rd*	*50th*	*97th*	*3rd*	*50th*	*97th*	*3rd*	*50th*	*97th*	*3rd*	*50th*	*97th*
6.0	108.3	118.0	128.2	16.6	23.0	33.9	13.3	16.3	22.3	108.5	118.4	129.0	17.8	23.0	32.8	13.6	16.0	21.7
6.5	110.7	120.5	130.9	17.5	24.2	35.7	13.4	16.5	22.5	111.3	121.3	132.0	18.6	24.1	34.8	13.7	16.2	22.2
7.0	113.0	123.0	133.6	18.3	25.3	37.6	13.5	16.6	22.9	114.0	124.1	134.9	19.4	25.3	36.9	13.8	16.4	22.7
7.5	115.3	125.6	136.4	19.2	26.6	39.7	13.6	16.8	23.2	116.6	126.8	137.8	20.2	26.7	39.3	13.9	16.6	23.3
8.0	117.6	128.1	139.4	20.2	28.0	42.0	13.7	16.9	23.7	119.0	129.4	140.5	21.1	28.1	42.0	14.0	16.8	23.8
8.5	119.9	130.8	142.4	21.1	29.5	44.7	13.8	17.1	24.2	121.4	132.0	143.3	22.1	29.7	44.9	14.1	17.1	24.4
9.0	122.3	133.5	145.7	22.2	31.2	47.8	13.9	17.4	24.8	123.7	134.5	146.1	23.1	31.4	48.1	14.2	17.4	24.9
9.5	124.8	136.5	149.2	23.4	33.1	51.2	14.0	17.6	25.4	126.0	137.0	149.0	24.2	33.3	51.5	14.3	17.7	25.5
10.0	127.4	139.6	152.8	24.7	35.3	54.9	14.2	18.0	25.9	128.2	139.5	152.0	25.4	35.4	55.2	14.5	18.0	26.0
10.5	130.2	142.9	156.5	26.1	37.8	58.6	14.3	18.3	26.4	130.5	142.2	155.3	26.7	37.6	59.0	14.6	18.4	26.5
11.0	133.2	146.3	160.0	27.8	40.4	62.2	14.5	18.8	26.9	132.8	145.0	158.8	28.1	40.1	62.9	14.8	18.7	26.9
11.5	136.2	149.6	163.2	29.7	43.1	65.4	14.8	19.2	27.2	135.2	148.0	162.6	29.7	42.7	66.8	15.0	19.1	27.2
12.0	139.2	152.6	166.0	31.7	45.8	68.1	15.0	19.6	27.4	137.7	151.3	166.6	31.4	45.4	70.5	15.2	19.5	27.5
12.5	142.1	155.3	168.3	33.8	48.2	70.2	15.3	19.9	27.6	140.5	154.8	170.7	33.2	48.2	74.1	15.4	19.8	27.8
13.0	144.5	157.4	170.1	35.9	50.2	71.8	15.7	20.2	27.7	143.5	158.4	174.6	35.2	51.1	77.3	15.6	20.2	28.0
13.5	146.6	159.2	171.4	37.8	51.8	73.0	16.0	20.4	27.7	146.7	162.1	178.1	37.3	53.8	80.1	15.8	20.5	28.2
14.0	148.3	160.4	172.3	39.4	53.0	73.8	16.3	20.6	27.8	150.0	165.5	181.0	39.4	56.4	82.6	16.1	20.8	28.4
14.5	149.5	161.3	173.0	40.7	53.9	74.3	16.6	20.7	27.8	153.2	168.5	183.3	41.5	58.8	84.7	16.4	21.0	28.5
15.0	150.4	162.0	173.4	41.6	54.5	74.7	16.8	20.8	27.8	156.1	170.9	185.0	43.7	61.0	86.5	16.6	21.2	28.6
15.5	151.0	162.4	173.7	42.4	54.9	74.9	16.9	20.8	27.8	158.6	172.8	186.2	45.7	62.9	87.9	16.9	21.4	28.7
16.0	151.4	162.7	173.9	42.9	55.2	75.1	17.0	20.8	27.9	160.6	174.2	187.0	47.6	64.5	89.1	17.1	21.6	28.7
16.5	151.7	162.9	174.0	43.2	55.4	75.2	17.1	20.9	27.9	162.1	175.1	187.5	49.3	65.9	90.0	17.3	21.7	28.8
17.0	151.9	163.0	174.1	43.4	55.5	75.3	17.2	20.9	27.9	163.2	175.7	187.9	50.8	67.0	90.8	17.5	21.8	28.8
17.5	152.0	163.1	174.1	43.6	55.6	75.3	17.2	20.9	27.9	163.9	176.2	188.1	52.1	67.9	91.4	17.7	21.9	28.9
18.0	152.1	163.1	174.2	43.7	55.7	75.3	17.2	20.9	27.9	164.4	176.5	188.3	53.2	68.6	91.8	17.9	22.0	28.9
19.0	152.2	163.2	174.2	43.8	55.7	75.4	17.2	20.9	27.9	165.0	176.7	188.4	54.9	69.7	92.5	18.1	22.1	28.9
20.0	152.2	163.2	174.2	43.8	55.7	75.4	17.3	20.9	27.9	165.2	176.9	188.5	56.0	70.3	92.8	18.3	22.1	28.9

The SIEDP cross-sectional references for height, weight and BMI presented in this paper are the first references to apply to the whole Italian population from 6 to 20 y of age. SIEDP references are presented in terms of centiles, since the classic reference charts can easily be interpreted by parents as well as by health personnel. In addition, the same SIEDP references are expressed in terms of LMS curves based on the EMGF method, to enable auxologists to express auxometric traits as standard deviation scores.

Among the indirect measurements of adiposity, such as skinfold thickness or waist/hip ratio (Malina & Katzmarzyk, 1999), BMI is largely used to assess weight excess during the whole life, since it applies not only to adults (Garrow & Webster, 1985) but also to children (Rolland-Cachera *et al*, 1982). These should be carefully monitored, since overweight children are at higher risk of becoming overweight adults and suffering, as adults, from metabolic and cardiovascular diseases. A workshop organised by the International Obesity Task Force (Bellizzi & Dietz, 1999; Dietz and Robinson, 1998) and a recent paper by Cole *et al* (2000) proposed that BMI thresholds used for adults (25 kg/m^2 for overweight and 30 kg/m^2 for obesity) should be linked to BMI centiles for children to provide cut-off points for the growth period. According to this recommendation, we added to SIEDP charts for BMI the centiles passing though 25 and 30 at 18 y of age. These extra-centiles provide population- sex- and age-specific cut-off points that can be useful in clinical practice.

The comparison between SIEDP charts and Tanner's charts for height, still in use among most paediatricians, shows that before puberty Italian children are 2–4 cm taller than their English peers. Differences exist also in adult height; about −2 cm for girls of S Italy and about +2 cm for boys of C-N Italy. Because of the above differences, Tanner's charts fail to detect, when applied to Italian children, 70—90% of short children aged 6–8 y (ie with stature below the 3rd centile of their reference population), and 50—70% of short children aged 9–11 y. The choice of critical reference limits can be a matter for debate (Cotterill *et al*, 1996). As for weight, Italian girls are heavier than their English peers during childhood and adolescence and Italian boys during the whole growth period, with larger differences in the 97th centile: 5–8 kg for girls and 6–16 kg for boys. SIEDP centiles for BMI are higher than those of Rolland-Cachera *et al*'s norms (Rolland-Cachera *et al*, 1991) particularly during adolescence. The large difference in the 97th centile (up to 6.6 kg/m^2) suggests that French norms are not suitable for the Italian population. The differences between

Table 4 Height, weight and BMI growth norms, expressed as 3rd, 50th and 97th centiles (south Italy)

	Girls									*Boys*								
	Height			*Weight*			*BMI*			*Height*			*Weight*			*BMI*		
Age (y)	*3rd*	*50th*	*97th*	*3rd*	*50th*	*97th*	*3rd*	*50th*	*97th*	*3rd*	*50th*	*97th*	*3rd*	*50th*	*97th*	*3rd*	*50th*	*97th*
6.0	106.0	116.0	126.5	15.8	22.2	33.9	13.2	16.3	22.7	107.0	116.6	127.1	17.2	22.2	32.5	13.7	15.9	21.7
6.5	108.7	118.9	129.5	16.8	23.5	35.9	13.3	16.4	23.0	109.8	119.6	130.2	17.9	23.3	34.6	13.7	16.1	22.2
7.0	111.4	121.7	132.5	17.8	24.8	38.0	13.4	16.6	23.3	112.5	122.5	133.3	18.7	24.5	36.8	13.8	16.3	22.7
7.5	113.9	124.4	135.5	18.8	26.2	40.3	13.4	16.8	23.8	115.1	125.2	136.2	19.5	25.9	39.3	13.9	16.5	23.2
8.0	116.4	127.1	138.5	19.9	27.7	42.8	13.6	17.0	24.2	117.6	127.9	139.0	20.4	27.3	42.0	13.9	16.8	23.8
8.5	118.8	129.9	141.6	20.9	29.3	45.6	13.7	17.3	24.7	120.0	130.4	141.8	21.3	28.9	44.9	14.0	17.1	24.3
9.0	121.3	132.7	144.8	22.0	31.0	48.7	13.8	17.6	25.3	122.2	132.9	144.6	22.3	30.6	48.0	14.2	17.4	24.9
9.5	123.8	135.6	148.1	23.2	32.8	52.1	14.0	17.9	25.9	124.5	135.4	147.5	23.4	32.5	51.3	14.3	17.7	25.5
10.0	126.4	138.6	151.6	24.4	34.9	55.9	14.2	18.2	26.5	126.6	137.9	150.4	24.6	34.5	54.9	14.4	18.0	26.0
10.5	129.1	141.7	155.1	25.8	37.2	59.9	14.4	18.6	27.1	128.8	140.5	153.6	25.9	36.6	58.5	14.6	18.3	26.6
11.0	131.9	144.9	158.5	27.3	39.8	63.9	14.6	19.0	27.6	131.0	143.2	156.9	27.3	39.0	62.3	14.7	18.7	27.1
11.5	134.8	148.0	161.6	29.0	42.5	67.6	14.9	19.4	28.1	133.3	146.0	160.5	28.8	41.4	66.0	14.9	19.1	27.6
12.0	137.6	150.9	164.3	30.9	45.2	70.9	15.2	19.8	28.6	135.7	149.1	164.4	30.4	44.0	69.7	15.1	19.4	28.0
12.5	140.3	153.4	166.5	32.9	47.7	73.5	15.5	20.1	28.9	138.2	152.4	168.3	32.1	46.6	73.3	15.3	19.8	28.4
13.0	142.6	155.5	168.2	34.8	50.0	75.5	15.8	20.4	29.3	141.0	155.8	172.1	33.9	49.3	76.8	15.5	20.2	28.8
13.5	144.6	157.1	169.4	36.7	51.8	76.9	16.0	20.7	29.5	143.9	159.3	175.6	35.8	51.9	80.0	15.8	20.5	29.2
14.0	146.1	158.3	170.3	38.4	53.2	77.9	16.3	21.0	29.8	146.9	162.6	178.6	37.8	54.5	83.0	16.0	20.9	29.5
14.5	147.2	159.2	170.9	39.8	54.2	78.6	16.5	21.2	29.9	149.9	165.5	180.9	39.8	57.1	85.6	16.3	21.2	29.8
15.0	148.0	159.7	171.3	40.8	54.9	79.0	16.7	21.3	30.1	152.7	168.0	182.7	41.9	59.4	88.0	16.5	21.5	30.0
15.5	148.6	160.1	171.6	41.6	55.4	79.3	16.9	21.5	30.2	155.2	169.9	184.0	43.9	61.6	90.2	16.8	21.8	30.3
16.0	148.9	160.4	171.8	42.1	55.7	79.5	17.0	21.6	30.3	157.2	171.3	184.9	45.8	63.6	92.0	17.0	22.0	30.5
16.5	149.2	160.5	171.9	42.5	55.9	79.6	17.1	21.7	30.4	158.7	172.3	185.5	47.7	65.4	93.6	17.3	22.3	30.6
17.0	149.3	160.7	171.9	42.8	56.0	79.7	17.2	21.7	30.4	159.8	173.0	185.9	49.4	67.1	94.9	17.5	22.5	30.8
17.5	149.4	160.7	172.0	42.9	56.1	79.7	17.3	21.8	30.4	160.6	173.5	186.2	51.0	68.5	96.1	17.7	22.7	30.9
18.0	149.5	160.8	172.0	43.0	56.2	79.8	17.4	21.8	30.5	161.1	173.8	186.3	52.4	69.7	97.1	17.9	22.9	31.0
19.0	149.6	160.8	172.0	43.1	56.2	79.8	17.4	21.9	30.5	161.6	174.1	186.5	54.9	71.6	98.6	18.3	23.1	31.2
20.0	149.6	160.8	172.1	43.2	56.2	79.8	17.5	21.9	30.5	161.9	174.2	186.6	56.8	73.0	99.6	18.6	23.4	31.4

Table 5 Height, weight and BMI growth norms, expressed as *LMS* (central-north Italy). The standard deviation score corresponding to the value (*y*) of the auxometric trait is computed according to eqn (2) (see text)

	Height (cm)						*Weight (kg)*						*BMI (kg/m^2)*					
	Girls			*Boys*			*Girls*			*Boys*			*Girls*			*Boys*		
Age (y)	*L*	*M*	*S*	*L*	*M*	*S*	*L*	*M*	*S*	*L*	*M*	*S*	*L*	*M*	*S*	*L*	*M*	*S*
6	0.406	118.0	0.045	0.219	118.4	0.046	− 0.506	23.0	0.187	− 1.065	23.0	0.157	− 1.590	16.3	0.130	− 2.895	16.0	0.108
7	0.342	123.0	0.044	0.219	124.1	0.045	− 0.551	25.3	0.188	− 1.054	25.3	0.165	− 1.650	16.6	0.132	− 2.728	16.4	0.116
8	0.233	128.1	0.045	0.172	129.4	0.044	− 0.590	28.0	0.192	− 0.999	28.1	0.176	− 1.697	16.9	0.136	− 2.484	16.8	0.124
9	0.125	133.5	0.047	0.031	134.5	0.044	− 0.590	31.2	0.200	− 0.908	31.4	0.188	− 1.673	17.4	0.142	− 2.162	17.4	0.134
10	0.190	139.6	0.048	− 0.174	139.5	0.045	− 0.507	35.3	0.209	− 0.773	35.4	0.200	− 1.466	18.0	0.150	− 1.781	18.0	0.143
11	0.488	146.3	0.049	− 0.388	145.0	0.048	− 0.353	40.4	0.213	− 0.611	40.1	0.210	− 1.112	18.8	0.157	− 1.419	18.7	0.150
12	0.939	152.6	0.047	− 0.320	151.3	0.051	− 0.202	45.8	0.203	− 0.433	45.4	0.213	− 0.789	19.6	0.157	− 1.087	19.5	0.153
13	1.238	157.4	0.043	0.266	158.4	0.052	− 0.184	50.2	0.184	− 0.272	51.1	0.208	− 0.713	20.2	0.149	− 0.842	20.2	0.153
14	1.314	160.4	0.040	1.021	165.5	0.050	− 0.332	53.0	0.166	− 0.161	56.4	0.197	− 0.941	20.6	0.139	− 0.712	20.8	0.149
15	1.203	162.0	0.038	1.686	170.9	0.045	− 0.535	54.5	0.154	− 0.128	61.0	0.181	− 1.263	20.8	0.130	− 0.710	21.2	0.143
16	1.098	162.7	0.037	1.689	174.2	0.040	− 0.695	55.2	0.147	− 0.188	64.5	0.167	− 1.496	20.8	0.125	− 0.809	21.6	0.136
17	1.062	163.0	0.036	1.467	175.7	0.037	− 0.782	55.5	0.144	− 0.320	67.0	0.154	− 1.628	20.9	0.122	− 0.981	21.8	0.130
18	1.004	163.1	0.036	1.250	176.5	0.036	− 0.825	55.7	0.142	− 0.485	68.6	0.144	− 1.688	20.9	0.121	− 1.178	22.0	0.124
19	1.027	163.2	0.036	1.121	176.7	0.035	− 0.844	55.7	0.142	− 0.639	69.7	0.137	− 1.712	20.9	0.121	− 1.352	22.0	0.121
20	1.027	163.2	0.036	1.062	176.9	0.035	− 0.853	55.7	0.142	− 0.770	70.3	0.133	− 1.721	20.9	0.120	− 1.479	22.1	0.118

Table 6 Height, weight and BMI growth norms, expressed as *LMS* (south Italy). The standard deviation score corresponding to the value (*y*) of the auxometric trait is computed according to eqn (2) (see text)

	Height (cm)						*Weight (kg)*						*BMI (kg/m²)*					
	Girls			*Boys*			*Girls*			*Boys*			*Girls*			*Boys*		
Age (y)	*L*	*M*	*S*	*L*	*M*	*S*	*L*	*M*	*S*	*L*	*M*	*S*	*L*	*M*	*S*	*L*	*M*	*S*
6	0.453	116.0	0.047	0.002	116.6	0.046	−0.628	22.2	0.199	−1.303	22.2	0.160	−1.668	16.3	0.135	−3.161	15.9	0.105
7	0.406	121.7	0.046	0.049	122.5	0.045	−0.665	24.8	0.198	−1.203	24.5	0.170	−1.616	16.6	0.139	−2.823	16.3	0.114
8	0.342	127.1	0.046	0.049	127.9	0.045	−0.700	27.7	0.200	−1.083	27.3	0.182	−1.537	17.0	0.145	−2.450	16.8	0.125
9	0.266	132.7	0.047	−0.045	132.9	0.045	−0.710	31.0	0.205	−0.949	30.6	0.195	−1.420	17.6	0.151	−2.088	17.4	0.135
10	0.283	138.6	0.048	−0.203	137.9	0.046	−0.668	34.9	0.215	−0.806	34.5	0.206	−1.281	18.2	0.157	−1.741	18.0	0.145
11	0.503	144.9	0.049	−0.373	143.2	0.048	−0.551	39.8	0.222	−0.668	39.0	0.214	−1.152	19.0	0.161	−1.446	18.7	0.152
12	0.893	150.9	0.047	−0.356	149.1	0.051	−0.406	45.2	0.219	−0.532	44.0	0.217	−1.076	19.8	0.162	−1.207	19.4	0.157
13	1.174	155.5	0.044	0.060	155.8	0.053	−0.352	50.0	0.204	−0.425	49.3	0.215	−1.051	20.4	0.159	−1.005	20.2	0.159
14	1.250	158.3	0.041	0.781	162.6	0.052	−0.453	53.2	0.186	−0.344	54.5	0.207	−1.090	21.0	0.155	−0.868	20.9	0.159
15	1.156	159.7	0.039	1.379	168.0	0.047	−0.631	54.9	0.173	−0.311	59.4	0.197	−1.160	21.3	0.150	−0.794	21.5	0.156
16	1.092	160.4	0.038	1.519	171.3	0.043	−0.775	55.7	0.165	−0.330	63.6	0.185	−1.232	21.6	0.147	−0.765	22.0	0.152
17	1.033	160.7	0.037	1.391	173.0	0.040	−0.856	56.0	0.162	−0.394	67.1	0.173	−1.292	21.7	0.145	−0.778	22.5	0.148
18	1.016	160.8	0.037	1.215	173.8	0.039	−0.893	56.2	0.160	−0.498	69.7	0.162	−1.334	21.8	0.143	−0.829	22.9	0.144
19	1.027	160.8	0.037	1.092	174.1	0.038	−0.909	56.2	0.159	−0.619	71.6	0.154	−1.363	21.9	0.142	−0.900	23.1	0.139
20	0.998	160.8	0.037	1.033	174.2	0.038	−0.916	56.2	0.159	−0.735	73.0	0.147	−1.380	21.9	0.141	−0.980	23.4	0.136

Table 7 Comparison between cross-sectional centiles for height (cm) and weight (kg) by Tanner *et al* (1966) and Italian growth norms 2000 (C-N = central-north; S = south)

		Tanner et al (1966)			*Italy C-N*			*Italy S*			*C-N vs T*			*S vs T*		
Sex	*Age (y)*	*3rd*	*50th*	*97th*	*3rd*	*50th*	*97th*	*3rd*	*50th*	*97th*	*3rd*	*50th*	*97th*	*3rd*	*50th*	*97th*
Height																
Girls	6	103.8	113.4	123.1	108.3	118.0	128.3	106.0	116.0	126.5	4.5	4.6	5.2	2.2	2.6	3.4
	10	124.5	136.4	148.3	127.4	139.6	152.8	126.4	138.6	151.6	3.3	3.2	4.5	1.9	2.2	3.3
	12	135.0	149.3	163.6	139.2	152.6	166.0	137.6	150.9	164.3	4.2	3.3	2.4	2.6	1.6	0.7
	16	150.9	162.2	173.5	151.4	162.7	173.9	148.9	160.4	171.8	0.5	0.5	0.4	−2.0	−1.8	−1.7
Boys	6	104.9	114.6	124.3	108.5	118.4	129.0	107.0	116.6	127.1	3.6	3.8	4.7	2.1	2.0	2.8
	11	129.4	141.9	154.4	132.8	145.0	158.8	131.0	143.2	156.9	3.4	3.1	4.4	1.6	1.3	2.5
	13	138.7	153.4	168.2	143.5	158.4	174.6	141.0	155.8	172.1	4.8	5.0	6.4	2.3	2.4	3.9
	18	162.2	174.7	187.2	164.4	176.5	188.3	161.1	173.8	186.3	2.2	1.8	1.1	−1.1	−0.9	−0.9
Weight																
Girls	6	16.2	20.4	26.8	16.6	23.0	33.9	15.8	22.2	33.9	0.4	2.6	7.1	−0.4	1.8	7.1
	10	22.7	31.1	47.7	24.7	35.3	54.9	24.4	34.9	55.9	2.0	4.2	7.2	1.7	4.2	7.2
	12	27.8	40.5	63.3	31.7	45.8	68.1	30.9	45.2	70.9	3.9	5.3	4.8	3.1	4.7	7.6
	16	44.6	55.8	74.5	42.9	55.2	75.1	42.1	55.7	79.5	−1.7	−0.6	0.6	−2.5	−0.1	5.0
Boys	6	15.9	20.5	26.5	17.8	23.0	32.8	17.2	22.2	32.5	1.9	2.5	6.3	1.3	1.7	6.0
	11	24.9	33.6	49.5	28.1	40.1	62.9	27.3	39.0	62.3	3.2	6.5	13.4	2.4	5.4	12.8
	13	29.6	42.6	64.4	35.2	51.1	77.3	33.9	49.3	76.8	5.6	8.5	12.9	4.3	6.7	12.4
	18	50.0	63.0	81.0	53.2	68.6	91.8	52.4	69.7	97.1	3.2	5.6	10.8	2.4	6.7	16.1

Table 8 Percentage (%) of Italian children below the 3rd centile of Tanner *et al* (1966) norms for height

	Central-north		*South*	
Age (y)	*Girls*	*Boys*	*Girls*	*Boys*
6–8	0.3	0.8	0.9	0.8
9–11	0.9	0.9	1.6	1.5
12–14	1.7	1.0	2.7	2.8
15–18	1.8	1.4	7.1	3.7

the charts in use and SIEDP charts are expected to result in different estimates of the prevalence of subjects labelled as short stature or overweight or obese: this fact should be clearly explained to Italian clinicians when they will begin to adopt SIEDP charts.

SIEDP references intend to supply paediatricians with a tool that avoids the use of charts that are outdated or that refer to other populations, and thus should be suitable for monitoring adequately the growth of their patients.

Table 9 Thresholds of BMI for overweight and obesity during growth (values computed on SIEDP series, according to Cole *et al*'s method (2000)

	Central-north				*South*			
	Overweight		*Obesity*		*Overweight*		*Obesity*	
Age (y)	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*	*Boys*
6	19.8	18.1	24.1	23.1	18.6	17.1	22.3	20.6
7	20.2	18.7	24.9	24.3	19.0	17.6	23.0	21.6
8	20.8	19.4	26.0	25.6	19.6	18.2	23.8	22.6
9	21.6	20.2	27.4	26.7	20.3	19.0	24.8	23.7
10	22.5	21.1	28.6	27.6	21.2	19.8	26.0	24.8
11	23.6	22.0	29.3	28.4	22.1	20.6	27.1	25.8
12	24.4	22.9	29.5	29.0	23.0	21.5	28.1	26.8
13	24.8	23.6	29.6	29.3	23.7	22.3	28.8	27.7
14	25.0	24.2	29.7	29.5	24.2	23.1	29.3	28.4
15	25.0	24.5	29.9	29.7	24.6	23.7	29.6	29.0
16	25.0	24.8	29.9	29.8	24.8	24.2	29.8	29.4
17	25.0	24.9	30.0	29.9	24.9	24.7	29.9	29.7
18	25.0	25.0	30.0	30.0	25.0	25.0	30.0	30.0

Table 10 Comparison between cross-sectional centiles for BMI (kg/m^2) by Rolland-Cachera *et al* (1991) and Italian growth norms 2000 (C-N = central-north; S = south)

		Rolland-Cachera			*Italy C-N*			*Italy S*			*C-N vs R-C*			*S vs R-C*		
Sex	*Age (y)*	*3rd*	*50th*	*97th*	*3rd*	*50th*	*97th*	*3rd*	*50th*	*97th*	*3rd*	*50th*	*97th*	*3rd*	*50th*	*97th*
Girls	6	13.1	15.1	17.7	13.3	16.3	22.3	13.2	16.3	22.7	0.2	1.2	4.6	0.1	1.2	5.0
	10	13.5	16.2	19.9	14.2	18.0	25.9	14.2	18.2	26.5	0.7	1.8	6.0	0.7	2.0	6.6
	12	14.2	17.4	22.0	15.0	19.6	27.4	15.2	19.8	28.6	1.0	2.4	6.6	1.0	2.4	6.6
	16	16.2	20.0	25.7	17.0	20.8	27.9	17.0	21.6	30.3	0.8	0.8	2.2	0.8	1.6	4.6
Boys	6	13.4	15.4	17.9	13.6	16.0	21.7	13.7	15.9	21.7	0.2	0.6	3.8	0.3	0.5	3.8
	11	14.0	16.7	20.6	14.8	18.7	26.9	14.7	18.7	27.1	0.8	2.0	6.3	0.7	2.0	6.5
	13	14.8	17.8	22.3	15.6	20.2	28.0	15.5	20.2	28.8	0.8	2.4	7.7	0.7	2.4	6.5
	18	17.1	20.8	26.1	17.9	22.0	28.9	17.9	22.9	31.0	0.8	1.2	2.8	0.8	2.1	4.9

Acknowledgements

The authors thank all the Local School Authorities for the permission to measure children and the personnel of the Local Health Units for their collaboration in the project. Copies of the height, weight and BMI charts will be capillary distributed in Italy; for further information, contract Professor E Cacciari.

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