Growth references for weight, height, and body mass index for Ecuadorian children and adolescents aged 5-19 years

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ABSTRACT

Introduction. The assessment of growth during childhood and adolescence is a critical component of health care at all levels, but it is also part of nutritional status diagnosis and the timely detection of related conditions. Ecuador lacks national growth references, so it has decided to adopt the international standards proposed by the World Health Organization. The objective of this study was to develop national references for weight, height, and body mass index for children and adolescents.

Methods. Ecuadorian schoolchildren and adolescents aged 5-19 years were studied between 1999 and 2012. The LMS method for cross-sectional data, which uses the Box-Cox transformation to normalize data distribution at each age, was applied to estimate the 3rd, 10th, 25th, 50th, 75th, 90th, and 97th centiles for weight, height, and body mass index.

Results. A total of 5934 healthy subjects (2788 boys and 3146 girls) participated. Boys were heavier and taller than girls. In all cases, values increased with age. At 18 years old, the differences between sexes averaged 8 kg and 12.5 cm.

Conclusion. The tables and curves obtained with this study are the first descriptive growth references for Ecuadorian children and adolescents aged 5-19 years. They are relevant for nutritional assessment. Their use at the primary level of care will aid in nutritional status diagnosis, which has traditionally been done based on the World Health Organization's international standards.

Key words: *height, body mass index, adolescent, growth charts, Ecuador.*

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INTRODUCTION

Physical growth is one of the most useful instruments in the nutritional and health surveillance of children at the primary level of care.[1] Although the growth pattern for children younger than 5 years, resulting from a multicenter study, provides a single international reference corresponding to the best description of physiological growth,[2] this is not the case of growth references for children and adolescents aged 5-19 years[3,4] based on the United States population. These curves are far from depicting the growth characteristics of childhood and adolescence, a period of life during which genetic, socioeconomic, and geographical influences are fully expressed. In this regard, several studies have demonstrated how growth and maturation patterns at this age vary greatly among and within populations.[5-11]

Growth assessment implies comparing the measures reached by an individual based on a standard. It has been argued that, if available, national growth standards may be more adequate to assess growth deviations and abnormal growth.[10,12]

Unlike other countries, like Argentina,[13] Venezuela,[14] Colombia,[15] the United Kingdom,[16] Japan,[17] and Belgium,[18] to date, Ecuador lacked national growth references for children and adolescents aged 5-19 years; therefore, at the time, the United States international growth standards were recommended for their use in this country.[3,4] Since there is no global growth reference for the 5-19 age group, the availability of national references is considered

critical. In this regard, the objective of this study was to develop national references for weight, height, and body mass index (BMI) for Ecuadorian children and adolescents aged 5-19 years.

MATERIALS AND METHODS

Sample

This was a descriptive, cross-sectional study done in schoolchildren and adolescents aged 5 to 19 years. Data were collected across three periods: a) 1999;[19] b) 2007-2009,[20] and c) 2011-2012,[11] in the three continental regions of Ecuador, specifically, the cities of Quito and Tulcán (Andean region), Santa Elena (coastal region), and Tena (Amazon region). This way, the different Ecuadorian and regional ethnic groups (with their ecological differences) would be represented. Galápagos is the fourth region of Ecuador, but its population is very small. Both public and private schools in each city were randomly selected based on the school registry provided by the provincial education boards. Participants were recruited at the schools using a random sample stratified by age, sex, and place of residence (*Table 1*).

Weight and standing height were measured inside the classroom using the anthropometric technique proposed by the World Health Organization (WHO).[21,22] Height was measured to the nearest 1.0 mm using a portable stadiometer (GPM Anthropological Instruments, Switzerland). Weight was measured at the nearest 0.1 kg using a manual scale (Health-o-Meter® HLT Scale), which was periodically calibrated. During the first two periods, measurements were obtained by the research team members and authors of this article, who were experienced in anthropometry. During the third period, there was room for the creation of a learning-teaching space with students from the school of medicine of Universidad Tecnológica Equinoccial de Quito (UTE), who received previous training on how to make the measurements. The intra- and inter-observer technical error of measurement (TEM) was 0.54 % and 1.7 %, respectively. Measurements were obtained only once. All participants received the relevant feedback about their body measurements.

The date of birth was available for most participants in the official school records. Age and sociodemographic data were provided by parents and adolescents through a questionnaire. The central statistical analysis was done at the UTE, where data were digitalized and subjected to a comprehensive quality analysis. Suspicious values (due to rare measurement or typographical errors) were eliminated or corrected (as long as possible). The first step in data processing was to create dispersion plots and charts to exclude atypical values. Any observation above +3 standard deviations (SDs) and below -3 SDs of the sample median value was excluded before developing the growth references. As a result, 26 observations for males (0.9 %) and 49 observations for females (1.5 %) were excluded. Due to logistic limitations, the anthropometric data of these participants were not confirmed.

Children who were not of Ecuadorian nationality (18 observations), who had chronic conditions (8 observations) or who were receiving medications that may affect growth (6 observations) were excluded from the study.

TABLE 1. *Distribution of individuals by sex and year of observation*

Place	Boys	Girls	Total
Quito, 1999	459	629	1088
Quito, 2007	730	520	1250
Quito, 2009	344	381	695
Quito, 2011	256	448	704
Santa Elena, 2011	537	535	1072
Tulcán, 2012	233	209	442
Tena, 2012	229	454	683
Total	**2788**	**3146**	**5934**

Data analysis

The Least-Mean-Square algorithm (LMS) method[23] for cross-sectional data was used to estimate weight, height, and BMI percentiles. This allowed to adjust the asymmetry using a Box-Cox transformation (L), which normalized data distribution at each age, considering the median (M) and the coefficient of variation of distribution (S). Data adjustment allowed for L, M, and S values to change smoothly at the x-axis (in this case, age), so that they could be representative of the population with smoothed curves plotted based on the y-axis (weight, height, and BMI). At each age, weight, height, and BMI distribution was summarized into three coefficients: L, M, and S, where L accounted for the symmetry; M, for the median; and S, for the coefficient of variation for each age and sex. These parameters were estimated based on the penalized maximum likelihood method.[24-26]These curves were then estimated using an iterative

algorithm that included penalized cubic splines, where the smoothing level was determined by assigning the number of equivalent degrees of freedom (edf).

The adequate number of edf was selected as per Pan and Cole's description,[27] based on deviation,[23] Q-tests,[28] and the worm plot.[29] LMS curves smoothing and the acceleration and deceleration points of the mean curve were verified by inspecting their derivatives. The final models were validated by comparing the expected and observed proportions of observations in a set of percentile bands by age class, with a chi-square goodness-of-fit test (grid test).[30] No significant deviations in expected frequencies were observed ($p > 0.1$ for all models). All curves were adjusted and validated with the package of functions in R.[31]

The T test was done to compare height, weight, and BMI in the different age groups of the three samples. Such detailed, comparative statistical analysis of the centiles in the three samples showed that, both graphically and statistically, there were no significant differences in the growth status of children in these three data groups: **1.** Quito, 1999, **2.** Quito, 2007, and Quito, 2009, and **3.** Quito, 2011, Santa Elena, 2011, Tulcán, 2012, and Tena, 2012 ($p \geq 0.05$). Therefore, data from all sub-samples were combined to obtain an overall, larger sample that would allow to estimate the percentile lines more accurately.

Ethical considerations

The study was carried out in accordance with the guidelines established by the Declaration of Helsinki, and a written informed consent was obtained from all participating children's and adolescents' parents or legal guardians. The protocol was approved by the Ethics Committee of both associated institutions: the University Development Commission (Commission Universitaire pour le Développement, CUD) from Belgium and the UTE Review Board from Ecuador.

RESULTS

The study sample was made up of 5934 participants (3146 girls and 2788 boys) (*Table* 2). Boys were heavier and taller than girls. At 18 years old, the differences between sexes averaged 8 kg and 12.5 cm.

The required level of smoothing was described in terms of edf, which were selected considering the penalized minimum deviation and maintaining the LMS order.

Height (centimeters)

Boys are taller than girls in all age ranges; the difference is more evident as of 13 years old. The reference percentiles for height-for-age in boys and girls are shown in *Table 3*, together with the M and S values, which provided the best fit to develop the growth references. The LMS models that provided the best fit were LMS ($edf(\lambda) = 0$, $edf(\mu) = 5$, $edf(\sigma) = 3$) for boys and LMS ($edf(\lambda) = 3$, $edf(\mu) = 5$, $edf(\sigma) = 3$) for girls. The curves for boys and girls were modeled without bias (edf = 0, and L was set at 1).

Weight (kilograms)

Boys are heavier than girls in all age ranges; the difference is more evident as of 15 years old. The references for weight-for-age in boys and girls are shown in *Table 4*. The LMS models that provided the best fit to develop the weight references were LMS ($edf(\lambda) = 2$, $edf(\mu) = 5$, $edf(\sigma) = 3$) for boys and LMS ($edf(\lambda) = 3$, $edf(\mu) = 5$, $edf(\sigma) = 3$) for girls. A positive asymmetry (L was below 1) was observed at all ages and in both sexes, so the lower centiles were relatively closer to the median, whereas the upper extreme percentiles were relatively more distant from the median.

Body mass index

The references for BMI-for-age in boys and girls are shown in *Table 5*. The LMS models that provided the best fit to develop the BMI references were LMS ($edf(\lambda) = 3$, $edf(\mu) = 5$, $edf(\sigma) = 3$) for

TABLE 2. *Distribution of participants by age*

Age	Boys	Girls	Total
5	69	67	130
6	163	187	350
7	149	183	332
8	156	279	435
9	164	209	373
10	213	268	481
11	224	239	463
12	342	323	665
13	306	281	587
14	286	286	572
15	251	253	504
16	188	230	418
17	182	213	395
18	63	88	151
19	32	40	66
Total	**2788**	**3146**	**5934**

boys and LMS (edf(λ) = 3, edf(μ) = 5, edf(σ) = 3) for girls. Compared to weight, BMI showed a more positive asymmetry but a smaller coefficient of variation.

The information included in the tables was represented in curves using percentiles[32] (*Annexes 1, 2, 3, and 4*). In all cases, values increased with age. The design of the reference curves was the same as that adopted in Norway, Luxembourg, and Algeria.

The reference curves for girls also show the distribution in age centiles at the time of menarche in the Ecuadorian population, based on the methodology developed by Lepage.[33] This tool helps to assess the normality of the maturation rate in girls.

DISCUSSION

In this article, we present cross-sectional growth references for height, weight, and BMI for the Ecuadorian population based on a representative sample of children and adolescents aged 5-19 years. The sample was representative because it provided an adequate social and

TABLE 3. *Height (cm) of children aged 5-19 years, Ecuador*

AGE in years	L	M (p50)	S	p3	p10	p25	p75	p90	p97
BOYS									
5	1	105.8	0.047	96.4	99.4	102.4	109.2	112.3	115.3
6	1	111.6	0.047	101.7	104.8	108	115.1	118.3	121.5
7	1	117.2	0.047	106.8	110.1	113.5	121	124.4	127.7
8	1	122.8	0.048	111.7	115.2	118.8	126.7	130.3	133.9
9	1	127.8	0.049	115.9	119.7	123.5	132	135.9	139.7
10	1	132.6	0.050	119.9	123.9	128	137.1	141.2	145.2
11	1	137.5	0.051	124.2	128.5	132.8	142.3	146.6	150.8
12	1	142.7	0.052	128.6	133.1	137.7	147.8	152.4	156.9
13	1	148.3	0.054	133.2	138	142.9	153.7	158.6	163.4
14	1	154.9	0.052	139.5	144.4	149.3	160.4	165.4	170.3
15	1	160.5	0.048	145.9	150.5	155.2	165.7	170.4	175
16	1	163.8	0.043	150.3	154.6	159	168.6	173	177.3
17	1	165.4	0.041	152.7	156.7	160.8	170	174.1	178.2
18	1	165.9	0.040	153.4	157.4	161.4	170.4	174.5	178.5
19	1	166.0	0.039	153.6	157.5	161.6	170.5	174.5	178.5
GIRLS									
5	1	104.2	0.054	93.6	97	100.4	108.1	111.5	114.9
6	1	110.4	0.050	99.9	103.3	106.7	114.2	117.6	120.9
7	1	115.7	0.048	105.2	108.5	111.9	119.5	122.9	126.2
8	1	120.9	0.047	110.1	113.5	117	124.8	128.3	131.7
9	1	126.3	0.047	114.9	118.5	122.2	130.4	134	137.7
10	1	132.2	0.048	120.1	123.9	127.9	136.5	140.4	144.3
11	1	138.9	0.049	126.1	130.1	134.3	143.4	147.6	151.7
12	1	144.5	0.048	131.3	135.5	139.8	149.2	153.4	157.6
13	1	148.8	0.045	136.1	140.1	144.2	153.4	157.5	161.5
14	1	151.4	0.042	139.2	143.1	147	155.8	159.7	163.6
15	1	152.6	0.041	140.7	144.5	148.3	156.8	160.6	164.4
16	1	153.0	0.040	141.2	145	148.8	157.2	161	164.7
17	1	153.1	0.040	141.4	145.1	148.9	157.3	161	164.8
18	1	153.2	0.040	141.5	145.2	149	157.4	161.1	164.9
19	1	153.4	0.040	141.8	145.5	149.3	157.6	161.3	165

cm: centimeters; L: Box-Cox power transformation; S: generalized coefficient of variation; M: 50th percentile; P3: 3rd percentile; P10: 10th percentile; P25: 25th percentile; P75: 75th percentile; P90: 90th percentile; P97: 97th percentile.

geographical representation by means of a strict sampling design.

The data used to develop these curves were collected in different periods, and this may be considered a limitation of the study. However, a comparative statistical analysis of data from the three periods showed that there was no significant difference in the growth pattern of the children in these groups. In addition, the scientific literature provides a history of studies that combined population samples, as the one published by Tanner.[34] For this reason, we decided to combine the data from the three periods mentioned above to obtain a larger sample that would allow to estimate percentile lines in a more accurate manner. Actually, most likely, the Ecuadorian population does not show a detectable secular trend in the period between the three surveys.

To assess the normality of a child's height/weight, it is necessary to have reference data for percentiles P3 and P97 estimated as accurately as possible. Precisely, such extreme percentiles are the ones used to refer a child for a potential

TABLE 4. *Weight (kg) of children aged 5-19 years, Ecuador*

AGE in years	L	M (p50)	S	p3	p10	p25	p75	p90	p97
BOYS									
5	-1.09	17.6	0.179	13.2	14.3	15.7	20	22.9	26.8
6	-1.01	20.1	0.178	15.1	16.4	18	22.9	26.1	30.3
7	-0.93	22.8	0.178	17	18.5	20.3	25.9	29.5	34.1
8	-0.84	25.5	0.182	18.9	20.6	22.7	29	33.1	38.2
9	-0.74	28.3	0.190	20.6	22.6	25.1	32.4	37.1	42.9
10	-0.62	31.5	0.202	22.4	24.8	27.6	36.3	41.8	48.7
11	-0.49	35.1	0.215	24.3	27.1	30.5	40.8	47.2	55.2
12	-0.37	38.9	0.222	26.4	29.6	33.6	45.4	52.5	61.2
13	-0.29	43	0.218	29.2	32.9	37.3	50	57.6	66.6
14	-0.26	47.9	0.202	33.4	37.3	41.9	55.1	62.7	71.5
15	-0.27	52.6	0.183	37.8	41.9	46.6	59.7	67.1	75.6
16	-0.3	56.1	0.167	41.5	45.6	50.2	62.9	70	78
17	-0.32	58.4	0.152	44.4	48.3	52.8	64.8	71.4	78.8
18	-0.34	59.8	0.140	46.4	50.2	54.4	65.8	71.9	78.8
19	-0.35	60.6	0.132	47.8	51.4	55.5	66.4	72.2	78.7
GIRLS									
5	-0.91	16.9	0.176	12.6	13.7	15.1	19.1	21.7	25
6	-0.87	19.3	0.172	14.5	15.8	17.3	21.8	24.7	28.2
7	-0.84	21.7	0.171	16.3	17.7	19.4	24.5	27.6	31.6
8	-0.83	24.3	0.177	18.1	19.7	21.7	27.6	31.3	35.9
9	-0.72	27.4	0.191	19.8	21.8	24.2	31.3	35.9	41.5
10	-0.45	31.1	0.208	21.7	24.1	27.1	35.9	41.3	47.8
11	-0.15	35.4	0.216	23.8	27	30.6	41	47	53.8
12	0	39.7	0.213	26.6	30.2	34.4	45.9	52.2	59.4
13	-0.14	43.8	0.196	30.5	34.1	38.4	50	56.6	64
14	-0.37	47	0.174	34.5	37.9	41.9	53.1	59.4	66.8
15	-0.54	49.2	0.158	37.3	40.6	44.4	55	61.1	68.2
16	-0.66	50.6	0.147	39.2	42.3	45.9	56.1	62	68.8
17	-0.72	51.4	0.140	40.3	43.4	46.9	56.7	62.4	69
18	-0.76	51.8	0.137	40.9	43.9	47.4	57	62.6	69.1
19	-0.77	52	0.135	41.2	44.2	47.6	57.2	62.7	69.1

kg: kilograms; L: Box-Cox power transformation; S: generalized coefficient of variation; M: 50th percentile; P3: 3rd percentile; P10: 10th percentile; P25: 25th percentile; P75: 75th percentile; P90: 90th percentile; P97: 97th percentile.

additional medical examination. The data set on which references were based is large and representative enough of the study population to warrant the best estimation possible of the P3 and P97 percentile lines. In addition, the percentiles used in the current reference curves have been estimated based on the most advanced techniques, i.e., the LMS method developed by Tim Cole.[23]

Growth references provide authorities with information about children's growth status and are critical to identify groups and individuals at risk for disease or requiring urgent care.[35] Growth curves are used in the detection, surveillance, and follow-up of children's and adolescents' health, and are adequate to detect nutritional disorders.[36] These references are a useful tool for the static and dynamic diagnosis of growth disorders, to track growth in surveillance systems, and analyze and report growth data and trends in different populations.[37]

Reference curves, developed for the Ecuadorian population, allow to detect children whose height/weight is above or below the

TABLE 5. *Body mass index (BMI, kg/m²) of children aged 5-19 years, Ecuador*

AGE in years	L	M (p50)	S	p3	p10	p25	p75	p90	p97
BOYS									
5	-3.35	15.8	0.094	13.8	14.3	15	17	18.5	20.7
6	-2.74	16.2	0.107	13.8	14.4	15.2	17.6	19.2	21.7
7	-2.23	16.6	0.119	13.8	14.5	15.4	18.1	20	22.7
8	-1.82	17	0.132	13.8	14.6	15.6	18.7	20.8	23.6
9	-1.49	17.4	0.142	13.9	14.8	15.9	19.4	21.6	24.6
10	-1.23	18	0.141	14.1	15.1	16.3	20.1	22.5	25.6
11	-1.04	18.5	0.147	14.3	15.4	16.8	20.7	23.2	26.4
12	-0.91	19	0.148	14.6	15.8	17.2	21.3	23.8	27
13	-0.81	19.5	0.147	15	16.2	17.6	21.8	24.3	27.4
14	-0.73	20	0.142	15.4	16.7	18.1	22.3	24.7	27.6
15	-0.66	20.5	0.146	15.9	17.2	18.6	22.7	25	27.8
16	-0.58	20.9	0.139	16.4	17.6	19.1	23.1	25.3	27.8
17	-0.49	21.3	0.133	16.8	18.1	19.5	23.4	25.5	27.9
18	-0.4	21.7	0.127	17.2	18.5	19.9	23.7	25.7	27.9
19	-0.31	22	0.122	17.6	18.9	20.3	23.9	25.8	27.9
GIRLS									
5	-1.88	15.6	0.116	12.9	13.6	14.5	16.9	18.6	20.7
6	-1.65	15.9	0.121	13.1	13.9	14.7	17.4	19.1	21.2
7	-1.46	16.3	0.128	13.2	14	15	17.8	19.6	21.9
8	-1.29	16.7	0.136	13.4	14.3	15.3	18.4	20.4	22.8
9	-1.12	17.2	0.144	13.6	14.5	15.7	19.1	21.2	23.8
10	-0.96	17.8	0.130	13.8	14.9	16.1	19.8	22	24.7
11	-0.83	18.4	0.133	14.2	15.3	16.6	20.5	22.8	25.6
12	-0.75	19	0.133	14.7	15.8	17.2	21.2	23.5	26.3
13	-0.69	19.8	0.150	15.3	16.5	17.9	22	24.3	27.1
14	-0.65	20.5	0.145	15.9	17.2	18.6	22.7	25	27.7
15	-0.62	21.1	0.139	16.5	17.8	19.2	23.2	25.5	28.1
16	-0.58	21.6	0.134	17	18.3	19.8	23.7	25.9	28.3
17	-0.54	21.9	0.129	17.5	18.7	20.2	24	26.1	28.5
18	-0.5	22.2	0.124	17.8	19.1	20.5	24.2	26.3	28.5
19	-0.47	22.5	0.120	18.1	19.4	20.8	24.4	26.4	28.6

L: Box-Cox power transformation; S: generalized coefficient of variation; M: 50th percentile; P3: 3rd percentile; P10: 10th percentile; P25: 25th percentile; P75: 75th percentile; P90: 90th percentile; P97: 97th percentile

"normal variation" (in general, above or below the P97 or P3, respectively). Such curves constitute a reliable tool only if they correctly represent the population, i.e., if data may be considered a representative sample of the population. For this reason, reference curves based on a study population always have a better performance than any other type of curves.

The reference curves published by the WHO are of great value as a common global reference that enables countries to establish their growth status. However, the WHO curves may hardly be representative of all other populations, especially during puberty and adolescence, when genetic, geographical, and socioeconomic differences are fully expressed. They are very useful for countries that lack their own growth data to develop local reference curves.[12]

It is worth noting some of the limitations of this study, such as the small number of data corresponding to the extreme ages (5 and 19 years), which did not prevent us from achieving a good fit. In fact, based on the statistical analysis, the models meet the assumption of normality after performing the power transformation.

Since at that time there was no global growth reference for this age group, these new curves should be used in the clinical practice in Ecuador as a complement of growth assessment, which, to date, has been done based exclusively on international tools.

CONCLUSION

The tables and curves obtained with this study are the first descriptive growth references for Ecuadorian children and adolescents aged 5-19 years; therefore, they may be used as a national, supplementary instrument for growth assessment and serve as the starting point for further research about this topic in Ecuador. ■

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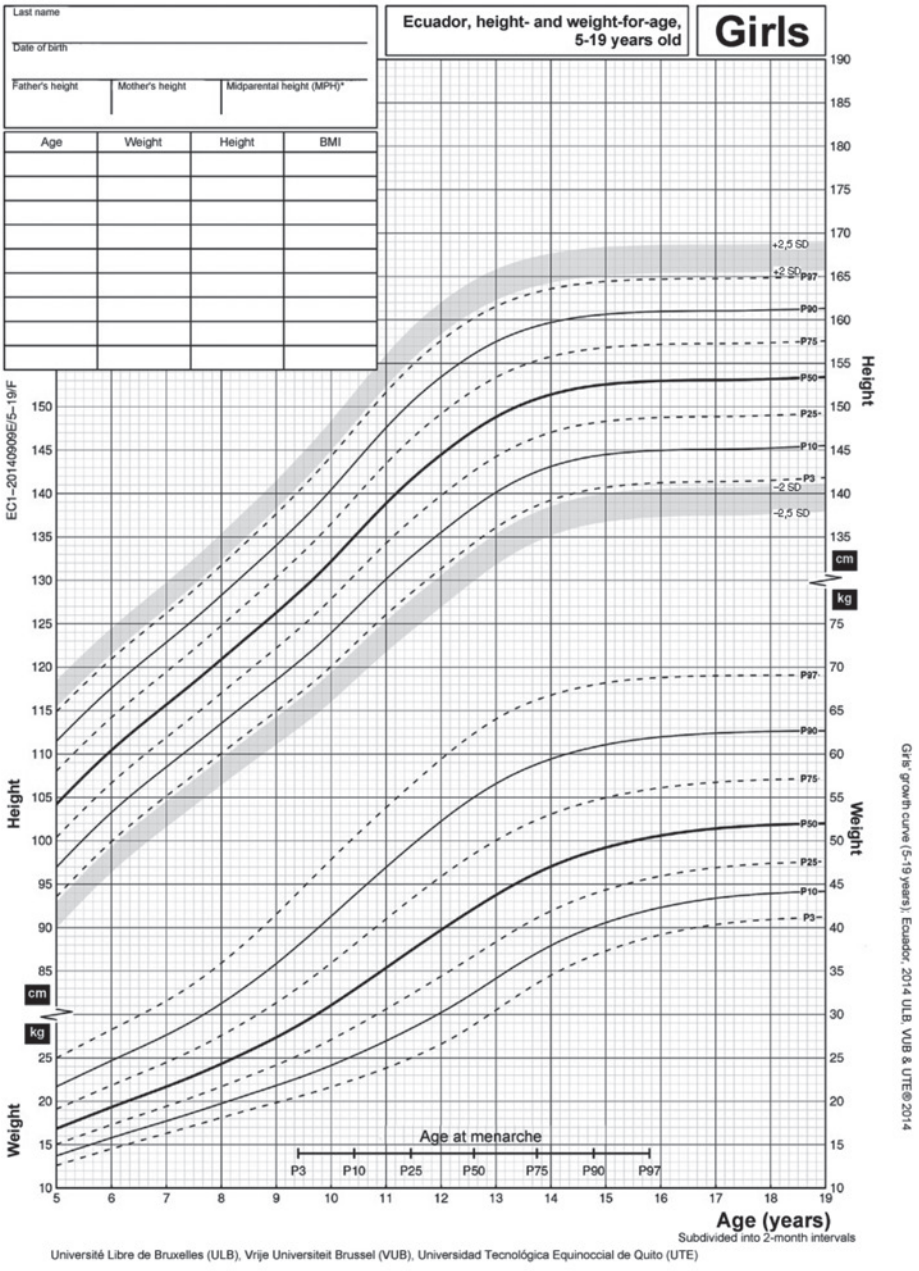
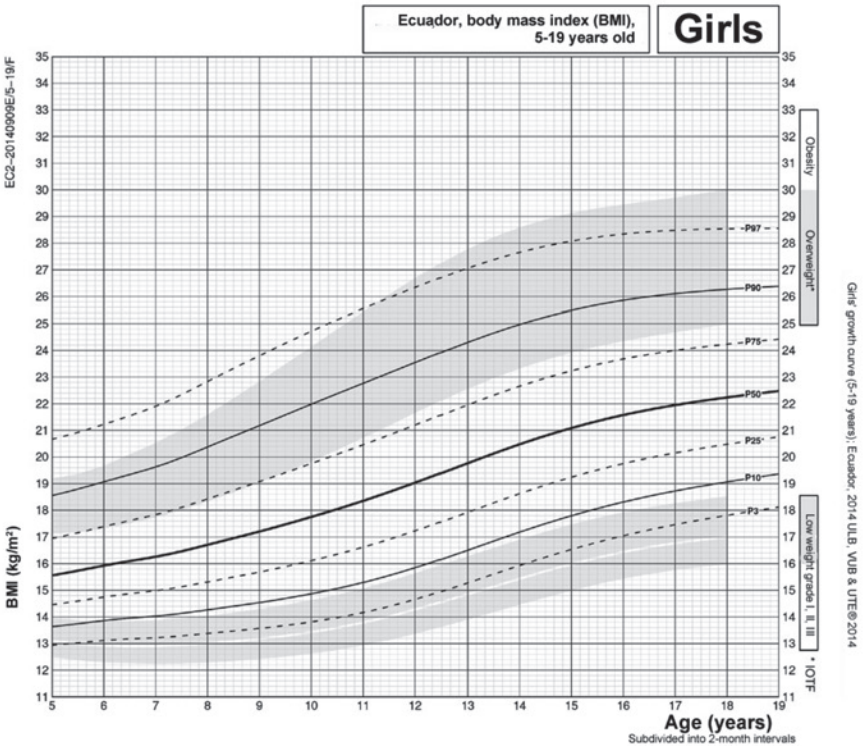
Annex 1. *Ecuador, height- and weight-for-age, 5-19 years old. GIRLS*



* Midparental height (MPH) = (father's height + mother's height - 13)/2; genetic range = MPH ± 9 cm.

Annex 2. *Ecuador, body mass index, 5-19 years old. GIRLS*



Height and weight standards[1]

C. Monnier, M. Roelants, W. Tarupi, Y. Lepage, R. Hauspie, J. Campbell, M.L. Félix, R. Hidalgo, and M. Vercauteren.
The attached curves outline the height and weight growth in a group of more than 6000 Ecuadorian children and adolescents aged 5-19 years. Biometric, cross-sectional surveys were administered in Quito (1999, 2007, 2009, and 2011), Santa Elena (2011), Tulcán (2012), and Tena (2012) to students from public and private schools.[2] Measured children came from different socioeconomic groups. Their parents' level of education and occupation reflect the diversity of Ecuadorian populations.

Chart interpretation: The curves show a measurement distribution in a group of children and allow to see the position of an individual within such group. Above the 50th percentile, which corresponds to the median, you can locate 50% of the group below and 50% of the group above. For example, the 10th percentile represents, at each age, the value below which 10% of the population is located. Individuals outside the 2.5th and 97.5th percentiles are more than 2 standard deviations away from the median. It is recommended to control these children because they are at risk for developing a disease, as well as those whose growth curve is deviated before puberty.

Measurement technique: Weight. The child is weighted wearing light underwear and with no shoes on. **Height**. The child has to be standing upright but not rigidly, with the back against the stadiometer, the heels together, and the arms and hands hanging on the side of the body. The neck should not be bent forward and the child has to be looking straight ahead. The mobile piece of the stadiometer should be lowered towards the vertex (peak of the head), without pressing down. **BMI** (body mass index). Mass or weight (in kilograms) divided by the square of the height (in meters), kilograms/meters.[2]

[1] This project was conducted with the help of: Universidad Libre de Bruxelles (ULB), Vrije Universiteit Brussel (VUB) and Universidad Tecnológica Equinoccial (UTE Quito), and a CUD program.
[2] Data were collected by: C. Monnier, Y. Lepage, G. Pierard, A. Lepage, C. Reynaerts, J. Cruz-Albornoz (logistics), R. Buitron, W. Tarupi, J. Campbell; and fifth and sixth semester students for the 2011-2012 academic year of the school of medicine of the School of Health Sciences Eugenio Espejo.

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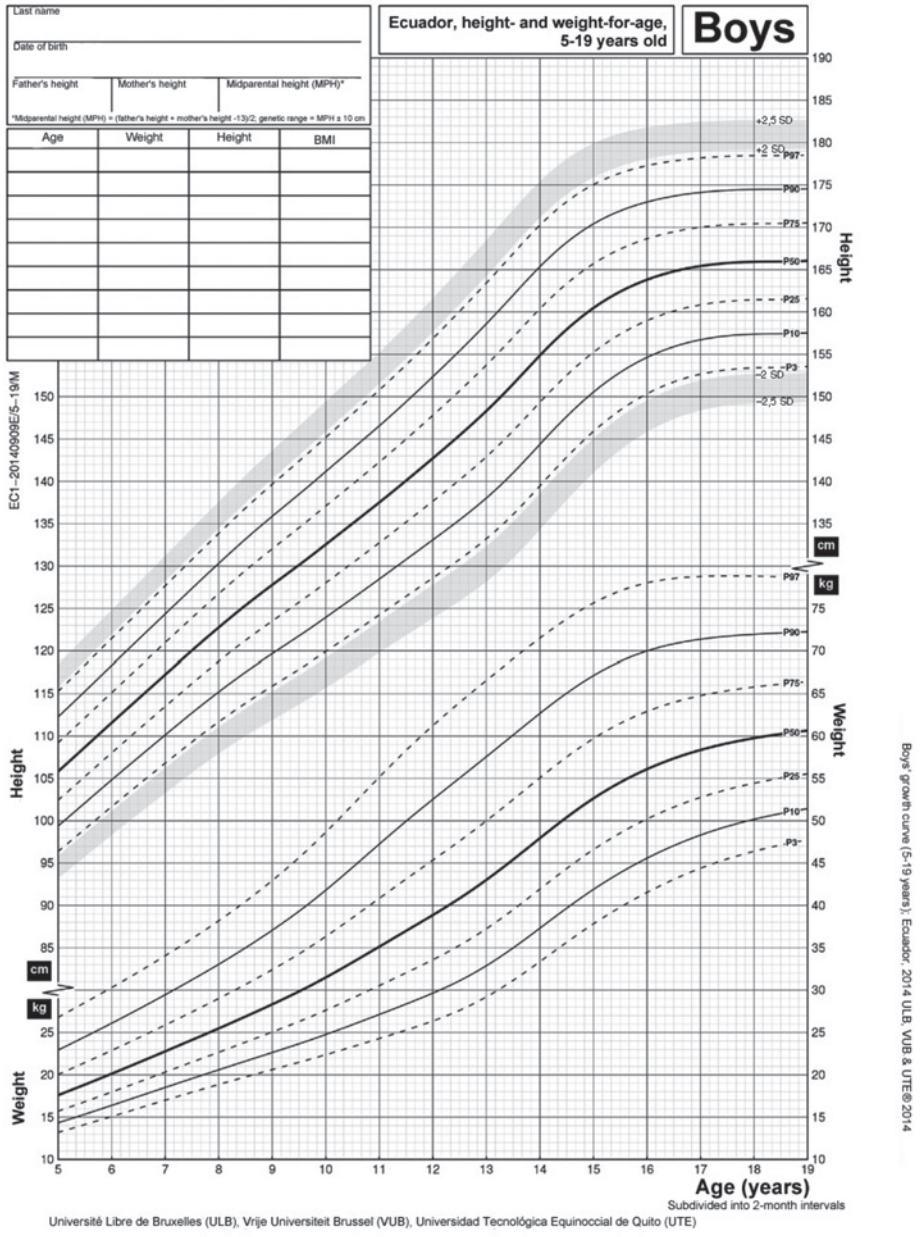
Annex 3. *Ecuador, height- and weight-for-age, 5-19 years old. BOYS*



*Midparental height (MPH) = (father's height + mother's height -13)/2; genetic range = MPH ± 10 cm.

Annex 4. *Ecuador, body mass index, 5-19 years old. BOYS*

Height and weight standards[1]

C. Monnier, M. Roelants, W. Tarupi, Y. Lepage, R. Hauspie, J. Campbell, M.L. Félix, R. Hidalgo, and M. Vercauteren.
The attached curves outline the height and weight growth in a group of more than 6000 Ecuadorian children and adolescents aged 5-19 years. Biometric, cross-sectional surveys were administered in Quito (1999, 2007, 2009, and 2011), Santa Elena (2011), Tulcán (2012), and Tena (2012) to students from public and private schools.[2] Measured children came from different socioeconomic groups. Their parents' level of education and occupation reflect the diversity of Ecuadorian populations.

Chart interpretation: The curves show a measurement distribution in a group of children and allow to see the position of an individual within such group. Above the 50th percentile, which corresponds to the median, you can locate 50% of the group below and 50% of the group above. For example, the 10th percentile represents, at each age, the value below which 10% of the population is located. Individuals outside the 2.5th and 97.5th percentiles are more than 2 standard deviations away from the median. It is recommended to control these children because they are at risk for developing a disease, as well as those whose growth curve is deviated before puberty.

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