Normative Reference of Standing Long Jump for Colombian Schoolchildren Aged 9-17.9 Years: The FUPRECOL Study.

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ABSTRACT

The purpose of the present study was to generate normative values standing long jump (SLJ) scores for 9- to 17.9-year-olds and to investigate sex and age group differences in these measures. The sample was comprised of 8,034 healthy Colombian schoolchildren [boys n=3,488 and girls n=4,546; mean (standard deviation) age 12.8 (2.3) years old]. Each participant performed two SLJ tests. Centile smoothed curves, percentile and tables for the 3rd, 10th, 25th, 50th, 75th, 90th and 97th percentile were calculated using Cole's LMS method. The one-way ANOVA tests showed that the maximum jump height (cm) was higher in boys than in girls ($p<0.01$). The one-way ANOVA tests showed that the maximum jump scores (cm) were higher in boys than in girls ($p<0.01$). Post hoc analyses within the sexes showed yearly increases in SLJ scores in all ages. In boys, the SLJ score 50th percentile ranged from 109.3 to 165.8 cm. In girls, the jump 50th percentile ranged from 96.0 cm to 120.0 cm. For girls, jump scores increased yearly from 9 to 12.9 years before reaching a plateau from 13 to 16.9 years. Our results provide, for the first time, sex- and age-specific SLJ reference values for Colombian schoolchildren aged 9-17.9 years. The normative values presented in this study provide the basis for the determination of the proposed age- and sex-specific standards for the FUPRECOL Study-Physical fitness battery for children and adolescents and can be applied to both health and sport areas.

Key Words: field assessment, lower body, muscle power, percentile, normative data.

INTRODUCTION

Anaerobic power refers to the ability to perform high-intensity exercise for a fraction of a second to several minutes (33). Typically, this energy system can be measured through maximal effort tests in cycling, running, and jumping (14). The jumping test has been considered a valid field-based muscular fitness test, even compared with isokinetic strength exercises (40).

In this regard, several lower body explosive muscular strength tests exist such as the countermovement jump, squat jump, vertical jump, Abalakov jump and Sargent jump tests (4,8); however, the standing long jump (SLJ) can be a practical, time-efficient and affordable method for assessing muscular fitness in children and adolescents (8). Furthermore, is possible measure the SLJ using relatively inexpensive, portable and easy-to-use tools and is a reliable (34) and valid (7) method for strength assessment.

The importance of muscular fitness in children is well-established both in sports performance (16,22) and in health (16,19,22,28,37). Poor anaerobic capacity has been shown to be related to the current cardiometabolic health in youths and adults and the risk of future morbidity and mortality (15,28). Furthermore, both neuromotor fitness (measures of muscular strength, flexibility, speed of movement and coordination) (37) and lower-body power (28) have been linked with health outcomes such as abdominal adiposity, lipid profile and glucose levels in children and adolescents (28,37). Additionally, from a public health perspective, the inclusion of anaerobic power in health surveillance systems is clearly justifiable, and schools may be an ideal setting for monitoring youth fitness to identify those with poor strength (34).

A strong relationship exists between anaerobic power and functional status; therefore, developing normative values in non-athletic populations is very valuable. Moreover, despite the lack of a universal cut-off point for the SLJ, the utility of biological performance as an auxiliary procedure to assess anaerobic fitness in practice is evident (33). For children and adolescents, several studies have generated normative data regarding SLJ (9,11,27,38,39); however, the majority of published reference values of this type of test have been performed in high income countries (9,27,30) or in different populations (5,11). Hence, to date, reference values for children and adolescents using harmonized measures of fitness do not exist in Latin America (18,34).

In addition, anthropometric characteristics (20), genetic factors (31), racial/ethnic differences (1), chronological age and biological maturation (23) are several variables that could modulate the differences in muscular fitness (22). Therefore, normative SLJ tables in a large sample of Latino American children and adolescents should be applied to both health and sport areas. The aims of the present study were to generate normative SLJ scores for 9- to 17.9-year-olds and to investigate differences between sex and age groups in a large sample of Colombian school children.

METHODS

Experimental Approach to the Problem

During the 2014–2015 school year, we conducted a cross-sectional study that was a component of the FUPRECOL project (in Spanish, ASOCIACIÓN DE LA **FU**ERZA **PRE**NSIL CON MANIFESTACIONES DE RIESGO CARDIOVASCULAR TEMPRANAS EN NIÑOS Y ADOLESCENTES **COL**OMBIANOS). Briefly, this study aimed to examine the relationships between physical fitness levels in children and adolescents with cardiometabolic risk factors and (un) healthy habits. These data were used to evaluate their health status (32,34,35) and to establish reference values for anthropometric, metabolic and physical fitness (SLJ) among children and adolescents aged 9 to 17.9 years from Bogota, Colombia.

Subjects

The sample comprised 8,034 healthy Colombian schoolchildren [boys n=3,488 and girls n=4,546, means ± standard deviations (SD) age 12.8 (2.3) y, weight 45.1 (12.1) kg, height 1.50 (0.1) m, BMI 19.7 (3.4) kg/m^2]. The schoolchildren were of low-middle socioeconomic status (SES, 1–3 defined by the Colombian government) and were enrolled in public elementary and high schools (grades 5 and 11) in the capital district of Bogota in a municipality in the Cundinamarca Department in the Andean region. Notably, this region is located approximately 2,625 meters (min: 2,500, max: 3,250) above sea level.

A sample of volunteers was included and grouped by sex and age with 1-year increments (a total of 9 groups). Power calculations were based on the mean of maximum jump height (in cm) from the first 200 participants in the ongoing data collection (range, 120-135 cm), with a group SD of approximately 51.2 cm (34). The significance level was set to 0.05, and the required power was set to at least 0.80. The sample size was estimated to be approximately 200 to 400 participants per group. Exclusion factors included a clinical diagnosis of cardiovascular disease, diabetes mellitus 1 and 2, pregnancy, the use of alcohol or drugs, and, in general, the presence of any disease not directly associated with nutrition or problems with the muscles, joints, and bones. Exclusion from the study was made effective *a posteriori*, without the students being aware of their exclusion, to avoid any undesired situations.

Ethics Statement

The Review Committee for Research on Human Subjects at the University of Rosario [Code Nº CEI-ABN026-000262] approved all of the study procedures. A comprehensive verbal description of the nature and purpose of the study and its experimental risks were provided to the participants and their parents/guardians. This information was also sent to parents/guardians by regular mail, and written informed consent was obtained from the parents and subjects before participation in the study. The protocol was in accordance with the latest revision of the

Declaration of Helsinki and current Colombian laws governing clinical research on human subjects (Resolution 008430/1993 Ministry of health).

Procedures

Anthropometrics variables were measured by a Level 2 anthropometrist certified by the International Society for the Advancement of Kinanthropometry (ISAK), in accordance with the ISAK guidelines (25), in the morning (7:00-10:00 a.m.) following an overnight fast. Body weight was measured with the subjects in their underwear and with no shoes, using electronic scales (Tanita® BC544, Tokyo, Japan) with a low technical error of measurement (TEM = 0.510%). Height was measured using a mechanical stadiometer platform (Seca® 274, Hamburg, Germany; TEM = 0.019%). BMI was calculated as the body weight in kg divided by the square of height in meters. The data were recorded on paper with FUPRECOL evaluators (34). To measure SLJ, each participant began in a standing position, with both feet touching a starting line and were allowed to swing their arms before the jump. Two jumps were performed with one minute allowed for recovery between attempts, and the average score was recorded as the peak SLJ (cm). The distance between takeoff and the heel of the closest foot at landing was recorded in centimeters, and the participants were allowed one more try if they landed with their hands behind their feet (38). All of the personnel were trained in testing and calibration procedures, and a calibration log was maintained. The systematic error when the SLJ assessments were performed twice was 2.355, and the standard deviation (SD) was 16.827 [95% CI= -30.625 % to 35.336 %; n = 207].

Statistical Analyses

Anthropometric characteristics and SLJ from the study sample are presented as the mean with SD. Normality for selected variables was verified using histograms and Q-Q plots. Data were then split by sex and a one-way ANOVA with *post hoc* tests (Tukey) was used to identify differences between age groups within sexes. The Cole's LMS method assumes that the outcome variable has a normal distribution after a Box-Cox power transformation is applied, using the LMS method implemented in the LMSChartMaker Pro Version 2.54, (Medical Research Council, London, UK, http://www.healthforallchildren.com/shop-base/software/lmschartmaker-light/). Smoothed and specific curves for each age were obtained via a penalized maximum likelihood with the following abbreviations: (1) M (median), (2) L (Box-Cox transformation) and (3) S (coefficient of variation) (13). The appropriate number of degrees of freedom was selected on the basis of the deviance, Q-tests and worm plots, following the suggestions of Royston and8 Wright (36). The 3rd, 10th, 25th, 50th, 75th, 90th and 97th smoothing centiles were chosen as age- and gender-specific reference values. We used SPSS V. 21.0 software for Windows (SPSS, Chicago, Illinois, USA) for everything but the LMS method calculations. Statistical significance was set at $p<0.05$.

RESULTS

Descriptive characteristics

Descriptive statistics for each sex are shown in Table 1. All of the anthropometric variables, except the BMI (aged 9 to 12.9 years old), were higher in boys than in girls ($p<0.01$). The oneway ANOVA tests showed that the maximum jump scores (cm) were higher in boys than in girls ($p<0.01$). Post hoc analyses within sexes showed yearly increases in SLJ scores in all ages.

**** Insert Table 1 ****

Table 1. Descriptive statistics for anthropometric and standing long jump in 9–17.9-year-old in Colombian Schoolchildren

Smoothed LMS curves (3rd, 10th, 25th, 50th, 75th, 90th and 97th percentile) for boys and girls of the SLJ score are shown in Figure 1. The equivalent numerical values are shown in Table 2. Together, these data show that boys performed better on the test at all ages compared with girls. Regarding the boys, the SLJ score 50th percentile ranged from 109.3 to 165.8 cm. In girls, the

50th percentile jump scores ranged from 96.0 cm to 120.0 cm. For girls, the jump scores increased yearly from 9 to 12.9 years before reaching a plateau aged 13 to 16.9 years old.

**** Insert Table 2 ****

Table 2. Standing long jump (cm) percentiles in boys and girls by age.

**** Insert Figure 1 ****

Figure 1. Centile curves for standing long jump (cm) in boys and girls by age. Finally, comparisons between the 50th percentile values for SLJ scores (cm) from this study and other studies are presented in Table 3. This comparison was used to improve the quality of the discussion. We found studies in adolescents from Australia, the European Union (EU), Hungary, Hong Kong and Greece.

**** Insert Table 3 ****

Table 3. Reference values (50th percentile) for standing long jump (cm) from cited studies

DISCUSSION

To our knowledge, this is the first study in generate normative values of SLJ scores for 9- to 17.9-year-olds and to investigate the differences between sex and age groups in a large sample of Latino American children and adolescents. Other studies have generated a normative value of SLJ for their populations (9,11,27,38,39); however, anthropometric characteristics and genetics factors can affect the jump performance (1,20,31), and the current normative values are not useful for our population. For example, the Saint-Maurice et al. (2015) (38) study found similar results regarding SLJ with both the HELENA Study (27) and a study applied in Australian children (9); however, the Hungarian normative scores tend to be slightly higher than these two studies.

SLJ is a very good assessment tool, reliable and safe and has been linked to both upper (R^2 =

0.694–0.851) and lower body muscular strength (R^2 = 0.829–0.864) (8). In addition, the SLJ performance in young boys and girls depend on various factors such as biomechanical (20,29), biological variables (24) and body composition (20). In relation with the first mentioned factor,

SLJ needs a high level of technique, (e.g., use two arms to enhance the performance during a SLJ by approximately 21%) (2), however, this type of test is based on natural skill and is frequently present in many games and sports (8). Important factors that affect SLJ performance is a higher center of mass and longer leg length in children (3). Hraski et al. (2015) (20) studied kinematic parameters relevant for SLJ performance and found that children who were taller and who had longer arms and legs achieved better results. Taller children may jump longer than shorter ones with the same leg muscle power (10).

Secondly, maturity and gender differences may be the most important biological factors that affect SLJ performance. Rapid growth in long bones relative to muscle lengthening has been related to structure, neuromuscular function and physical performance disruptions (23). Additionally, hormonal influence during puberty such as steroid hormones and growth hormones can generate important variations in bone mineral content or muscle mass increase between boys and girls (11). Furthermore, children with a more mature neuromuscular system may have an advantage (3).

Regarding the body composition factor, the results are not conclusive. A study in healthy adult females found no significant correlations between SLJ scores and muscle mass (42). Hraski et al. (2015) (20) studied morphological characteristics linked to SLJ performance and found that in adults, adolescents and children (only males), their body mass, subcutaneous fat tissue and body fat percentage affected SLJ length. This finding demonstrates that gender and age are modulators of SLJ performance and should be considered.

In addition, two studies in schoolchildren have shown that BMI and waist circumference have an inverse relationship with explosive strength measured through SLJ (6,26), and subcutaneous fat is a better predictor of physical fitness (6), strength and SLJ performance (21). Notably, when the percentage of fat mass is lower, the lean body mass is higher; however, strength (main responsible for the ability of the jump) not only is result of the amount of muscle mass but is a combination of muscular, neural and biomechanical factors (22). In adults, high muscular strength level is inversely and independently associated with death from all causes and cancer even after adjusting for cardiorespiratory fitness and other co-factors such as age, body fat, smoking, alcohol, and hypertension (41). A study performed in Latin American children (n= 669, mean age 11.5 ± 1.13 years, 47% female) showed that handgrip strength and cardiorespiratory fitness were associated with a worse metabolic risk profile; however, the association between strength and risk factors was more consistent (12).

Accordingly, Table 3 shows a complementary analysis to improve the understanding of our results, and the table shows that Colombian schoolchildren achieved lower values than their peers from other countries. For example, when we compare 13-15.9 year-old boys (6 studies present all values for this range of ages), differences of 17.8%, 19.8%, 24.9% 17.3% and 12.1% were observed in comparison with boys of this age from the EU, Australia, Hungary, Greece and China, respectively (9,11,27,38,39). Notably, similar results were found to occur in girls. The reasons for this difference may be linked to biomechanical, anthropometric, and biological factors and body composition. Nevertheless, we believe that height and body composition play an important role. Latino American population are shorter than Non-Hispanic white and NonHispanic blacks (17) and although Colombia has one of the lowest overweight and obesity rates in the region, these rates have increased abruptly during the last 10 years (18). Our findings reinforce the importance of generate normative values of SLJ for our population and is one of the most significant contributions of this study.

PRACTICAL APPLICATION

SLJ is a reliable, safe, practical, time-efficient, and low-cost test that has a strong relationship with global body strength. A high level of muscular fitness is an important factor linked both to health and sport performance; however, no normative SLJ values for a large sample of Latin American children and adolescents were available. The results of the present work are an important tool for trainers and health specialists to improve, among other things, the early detection of sport talent and the prevention of chronic diseases. Simultaneously, this work allows a more accurate categorization considering the children's age and gender and enables comparisons among normative values from other countries.

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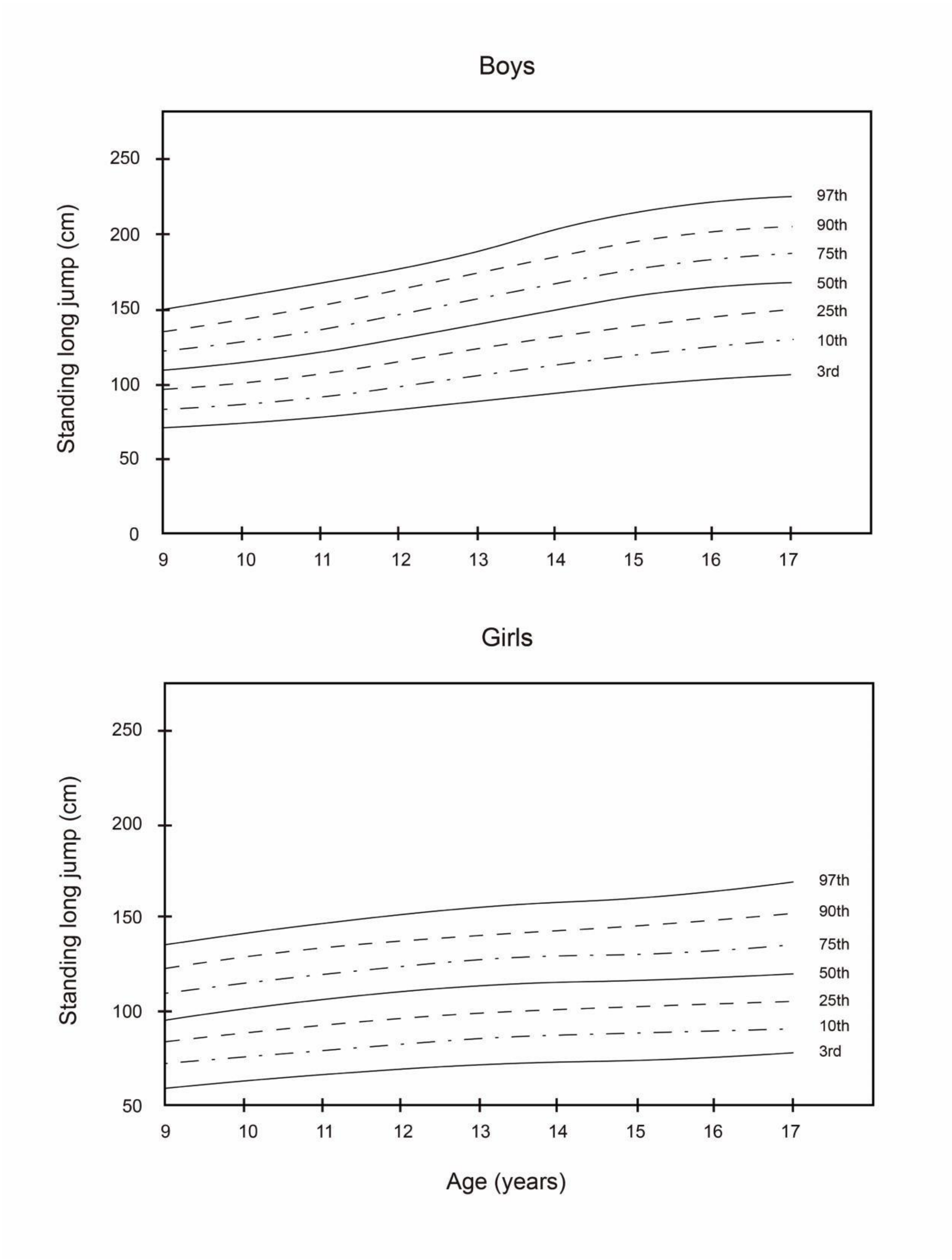

Figure 1. Centile curves for standing long jump (cm) in boys and girls by age.

Table 1. Descriptive statistics for anthropometric and standing long jump in 9–17.9-year-old in Colombian Schoolchildren

Sex	n	Body mass (kg)	Height (cm)	BMI (kg/m^2)	Jump height (cm)	Difference *D* (cm)	Difference %
Boys							
9 to 9.9	253	32.1 (7.5)	133.5 (6.5)	17.8 (3.1)	107.9 (24.2) **		
10 to 10.9	453	34.5 (8.5)	137.3 (7.4)*	18.1 (3.3)	117.6 (22.5) **	9.7	126.9
11 to 11.9	436	37.2 (8.8)*	141.9 (8.2)*	18.3 (3.2)	121.1 (25.6) **	13.2	130.7
12 to 12.9	407	41.3 (9.1)*	147.1 (8.2)*	18.9 (3.2)	126.5 (26.7) **	18.6	136.5
13 to 13.9	411	46.0 (9.8)*	153.5 (9.3)*	19.4 (3.3)**	140.2 (30.7) **	32.3	151.3
14 to 14.9	454	50.0 (9.7)*	158.9 (9.1)**	19.7 (3.0)**	144.3 (35.2) **	36.4	155.7
15 to 15.9	432	54.4 (9.7)*	163.3 (8.9)**	20.3 (3.0)**	154.0 (36.8) **	46.1	166.2
16 to 16.9	378	57.7 (8.7)**	166.7 (7.2)**	20.8 (2.9)**	156.4 (41.5) **	48.5	168.8
17 to 17.9	264	60.8 (10.3)**	168.1 (7.4)**	21.5 (3.3)**	161.1 (41.4) **	53.2	173.8
Total	*3488*	*45.5 (13.0)**	*151.9 (14.1)***	*19.4 (3.3)***	*139.2 (31.1)* **		
Girls							
9 to 9.9	325	32.1 (7.4)	134.6 (7.6)	17.6 (3.0)	94.9 (22.2)		
10 to 10.9	690	35.0 (7.9)	138.4 (7.6)	18.1 (3.0)	100.9 (22.5)	6	95.8
11 to 11.9	638	38.3 (7.9)	143.7 (7.5)	18.4 (2.9)	107.1 (20.3)	12.2	101.6
12 to 12.9	538	42.8 (8.6)	148.5 (7.3)	19.3 (3.0)	109.4 (22.2)	14.5	103.8
13 to 13.9	478	47.4 (9.0)	152.4 (6.3)	20.3 (3.2)	113.1 (24.4)	18.2	107.3
14 to 14.9	608	51.0 (8.9)	154.6 (6.5)	21.3 (3.3)	113.0 (26.6)	18.1	107.2
15 to 15.9	518	52.7 (8.6)	155.7 (6.8)	21.7 (3.1)	112.8 (29.4)	17.9	107.0
16 to 16.9	446	53.9 (8.6)	156.4 (5.8)	22.0 (3.1)	115.4 (29.0)	20.5	109.5
17 to 17.9	305	55.1 (9.3)	156.8 (6.5)	22.4 (3.6)	117.5 (35.1)	22.6	111.5
Total	*4546*	*44.8 (11.5)*	*148.7 (10.1)*	*20.0 (3.5)*	*111.0 (22.2)*		

Note: Data values are reported as mean (±) standard deviation (SD).

D = between-year differences (9.9, 10–10.9, 11–11.9, 12–12.9, 13–13.9, 14–14.9, 15–15.9, 16–16.9, 17–17.9 years) in absolute scores and % = relative change in SLJ.

Significant difference between boys and girls within the same age group: *p<0.01, **p<0.0001.

Table 2. Standing long jump (cm) percentiles in boys and girls by age.

	n	M	SD	P_3	P_{10}	P_{25}	P_{50}	P_{75}	P_{90}	P_{97}
Boys										
9 to 9.9	253	107.9	24.2	65.4	83.4	97.5	109.3	121.9	134.3	146.5

10 to 10.9	453	117.6	22.5	79.0	91.4	102.9	118.0	132.6	145.0	157.2
11 to 11.9	436	121.1	25.6	75.0	93.0	107.1	123.6	137.0	151.0	160.5
12 to 12.9	407	126.5	26.7	78.0	99.6	112.3	126.3	143.5	157.8	170.8
13 to 13.9	411	140.2	30.7	82.7	108.1	124.1	139.0	160.4	175.2	196.6
14 to 14.9	454	144.3	35.2	67.7	107.6	129.5	148.2	165.3	178.8	201.0
15 to 15.9	432	154.0	36.8	85.4	117.0	136.0	158.0	178.5	192.0	209.8
16 to 16.9	378	156.4	41.5	0.0	117.0	139.4	163.4	181.5	197.0	214.9
17 to 17.9	264	161.1	41.4	0.0	118.3	145.7	165.8	185.5	206.5	216.5
Total	*3488*	*139.2*	*31.1*	*86.5*	*101.4*	*116.5*	*136.4*	*160.6*	*181.5*	*201.3*
Girls										
9 to 9.9	325	94.9	22.2	56.9	71.6	83.3	96.0	107.2	121.1	135.5
10 to 10.9	690	100.9	22.5	60.2	74.3	87.2	102.0	115.1	128.2	141.1
11 to 11.9	638	107.1	20.3	71.8	83.3	95.2	107.0	119.3	131.4	143.8
12 to 12.9	538	109.4	22.2	70.6	83.8	96.5	110.0	123.5	136.5	146.9
13 to 13.9	478	113.1	24.4	69.7	87.4	99.9	114.8	128.7	139.1	153.7
14 to 14.9	608	113.0	26.6	63.9	84.2	100.8	115.8	128.0	143.4	157.4
15 to 15.9	518	112.8	29.4	12.6	86.5	99.7	115.6	129.1	141.9	159.1
16 to 16.9	446	115.4	29.0	24.0	90.2	104.3	117.1	130.5	145.0	156.8
17 to 17.9	305	117.5	35.1	0.0	90.3	105.0	120.0	138.5	153.1	171.8
Total	*4546*	*111.0*	*22.2*	*70.5*	*83.5*	*96.3*	*110.9*	*125.0*	*139.1*	*152.6*

M, mean; SD, standard deviation; P, percentile

Table 3. Reference values (50th percentile) for standing long jump (cm) from cited studies

Sex and age	FUPRECOL Study n = 8034	EU* n = 3528	Australians n = 11194	Hungarian n = 2427	Greek n = 424,328	Chinese n = 12712

Boys						
9 to 9.9	109	-	138	-	131	142
10 to 10.9	118	-	143	-	140	142
11 to 11.9	123	-	149	147	147	150
12 to 12.9	126	-	156	162	154	154
13 to 13.9	139	159	166	175	164	160
14 to 14.9	148	176	178	186	175	165
15 to 15.9	158	189	189	195	183	174
16 to 16.9	163	199	-	202	188	181
17 to 17.9	165	208	-	207	188	188
Girls						
9 to 9.9	96	-	126	-	120	120
10 to 10.9	102	-	133	-	127	127
11 to 11.9	107	-	140	140	134	125
12 to 12.9	110	-	145	143	136	123
13 to 13.9	114	140	150	147	137	122
14 to 14.9	115	144	154	150	135	124
15 to 15.9	115	145	156	152	134	140
16 to 16.9	117	147	-	153	132	124
17 to 17.9	120	150	-	154	133	127

Note: * EU from 10 European cities in Austria, Belgium, France, Germany, Greece (an inland city and an island city), Hungary, Italy, Spain and Sweden.