PHYSICAL FITNESS REFERENCE STANDARDS IN FRENCH YOUTH: THE BOUGE PROGRAM

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ABSTRACT

The aim of this study was to establish gender- and age-specific physical fitness percentiles in French youth. A sample of 11 186 children and adolescents (5 546 boys, 5 640 girls), ages 10-15 years, was assessed in the French national BOUGE study. Participants were tested on cardiorespiratory fitness, muscular endurance, speed, flexibility and agility using the following tests: 20-m shuttle run tests, curl ups test, 50-m sprint test, back-saver sit and reach test and 10 x 5 m shuttle run test. Percentile values were estimated for French youth as a function of age stratified by gender using the generalized additive model for location, scale and shape (GAMLSS). In general, physical fitness was better in boys than girls, except for the back-saver sit and reach test, in which girls performed better. Except for the back-saver sit and reach test and 10 x 5 m shuttle run test, physical fitness performance was significantly associated with age. Gender and age-specific normative values for physical fitness tests in French youth expressed as percentiles from the 5th to the 95th are provided. Reference values provide normative data for French youth. The data are useful in identifying special needs for appropriate intervention programs.

Key Words: Adolescents, Health, Fitness, Reference, Cardiovascular

INTRODUCTION

Physical fitness is an important determinant of health in children and adolescents (32). Physical fitness includes muscular strength and endurance, flexibility, speed, agility, and cardiorespiratory fitness (21). Physically fit adolescents have fewer mental, nutritional, gastroenterological, cardiac, and respiratory diseases, independent of physical activity (31). Poor physical fitness is a strong risk factor for cardiovascular disease, even more powerful than dyslipidemia, hypertension or obesity (29).

Cardiorespiratory fitness is particularly important as a health-related fitness measure and has been widely studied in youth and adolescents (21, 30, 31). Olds et al. summarize results from more than 100 studies of cardiorespiratory fitness in children and adolescents in 37 countries (30). Authors showed that, on 418 026 children tested between 1981 and 2003, the best performance were from the Northern European countries while the worst were from North and South America, Asia and some European countries (30). Physical fitness in childhood and adolescence is a strong or moderate predictor of health (19, 32, 40, 47, 55-56). It has been consistently reported that a low level of cardiorespiratory fitness and muscular strength in children are associated with metabolic risk factors, cardiovascular diseases and premature mortality later in life (1, 35, 50). Results from a systematic review indicated that due to lack of high quality studies, there is limited evidence for a relationship between agility and cardiovascular risk factors, and between flexibility and low back pain (40).

Having percentiles values for physical fitness tests may help to identify the target population for primary prevention as well as be helpful for health promotion policies (32, 40). Indeed, reference values are necessary to classify children and to monitor the fitness status of the population (32). Moreover, in pediatrics, developing percentiles is essential for screening children according to their growth by comparisons to those of the same age and sex. Physical fitness percentiles in children and adolescents have been developed in the United States, England, Portugal, Spain, Belgium, Hungary and Australia (8, 9-11, 17, 20, 41-45, 48). Data in French youth on the physical fitness are scarce and limited (13, 24, 46, 53). Moreover, physical fitness reference data for French youth currently are not available**.** The BOUGE study provides an opportunity to establish normative values for fitness components using common, well-standardized test methodology. The main objective of this study was to establish gender- and age-specific physical fitness reference standards for French youth aged 10-15 years.

METHODS

Study design

The current study was based on data from the French health promotion program "Move, a priority for your health" (http://www.bougetasante.fr/). The principal aim of this program was to promote the benefits of physical activity and physical fitness on the health of youth, ages 9 to 16 years**.** The inclusion criteria in this program were: (*i*) male and female subjects aged 9-16 years old; (ii) schooling in one of the participating classes. Data were collected in 16 regions of France between 2009 and 2013 in 101 schools. All schools in France were invited to participate to the study. Each director of school decided to participate or not to the study. When the director accepted to participate, the students (9-16 years) in the classes were invited to participate to the study. In total, 12082 adolescents (6107 girls and 5975 boys) participated to the BOUGE study. Of these, 9 670 volunteers were included in the present study. Two thousand four hundred twelve were excluded because of missing or incomplete data on anthropometric measurements or age. All procedures were performed in accordance with the ethical standards of the Helsinki Declaration of 1975 as revised in 2008 and the European Good Clinical Practices and with the ethical standards of sport and exercise science research (3). As this study did not involve any interventions and data were retrospectively collected by the study organizational structure (http://www.mutualite.fr/), the study was approved by a

Research Ethical Committee (CPP Nord-Ouest IV, Lille, France) as an epidemiological study. In this context, written informed consent was not required according to French human research regulations. This data collection was approved by the French National Commission of the Informatics Personal Data (Commission Nationale Informatique et Liberté).

A manual of operations was developed for the physical education teachers and study participants in order to standardize tests across schools. Included in the manual were: rationale of the study, procedures of tests, and how data were collected using a specific sheet. Data were recorded by teachers into an electronic data system provided by the trial sponsor. An audit of complete data set was performed and the aberrant data were excluded.

Measurements

Anthropometric Measures

Weight was measured in shorts and T shirts without shoes to the nearest 0.1 kg using an electronic scale. Height was measured without shoes to the nearest 0.1 cm using a standard physician's scale. Body mass index (BMI) was calculated from weight (kg) divided by height (m^2).

Physical fitness

Physical fitness was assessed incorporating Eurofit and France-Eval battery tests (13, 16, 24). The test battery assesses cardiorespiratory fitness, muscular endurance, flexibility, and agility. Flexibility and agility tests were performed twice and the best score was recorded. Cardiorespiratory fitness and muscular endurance tests were measured one time because of fatigue and test time issues. Physical education teachers undertook special training to insure that tests were administered correctly.

Cardiorespiratory fitness

Cardiorespiratory fitness was assessed with a 20 meter shuttle run test (23). Subjects were required to run between two lines 20 m apart, while keeping pace with audio signals from a pre-recorded CD. The initial speed of 8.5 $km.h^{-1}$, was increased by 0.5 $km.h^{-1}.min^{-1}$ (1 min equals one stage). Subjects were instructed to run in a straight line, to pivot on completing a shuttle, and to pace themselves in accordance with the audio signals. The test was terminated when the subject failed to reach the end lines concurrent with the audio signals on two consecutive occasions or if the subject stopped because of fatigue. All measurements were carried out under standardized conditions on an indoor rubber-floored gymnasium. Subjects were encouraged to keep running throughout the test. The last completed stage or half-stage was recorded to obtain VO_{2max} (23).

Muscular endurance

Muscular endurance was assessed by the curl ups test (13, 24). The subject lies in a supine position on the mat, knees bent at an angle of approximately 90°, feet flat on the floor, hands behind the head. From this starting position, the subject curls up slowly, leading the elbows up to the knees and returns to the starting position completing as many repetitions as possible. The heels must maintain contact with the mat, and the elbows must touch the knees during the flexion movement and the shoulders must touch the mat during the extension movement. The test is terminated when the subject is not able to maintain the cadence, or to complete the flexion-extension movement correctly. Subjects were encouraged to breathe normally during the test.

Speed

The 50-meter sprint test was used to assess speed (9, 13, 24). The subjects stood still in a comfortable position, feet behind the starting line, with no rocking movements. The test began on the whistle and was concluded when the runner crossed the finish line. Time was recorded using a standard stop watch.

Flexibility

Flexibility was assessed by the back-saver sit and reach test (13, 16, 24). The subject flexes the trunk and reaches forward as far as possible from a seated position with two legs straight. The farthest position of the bar reached was scored in centimetres.

Agility

Agility was assessed using the 10 x 5 m shuttle run test (13, 16, 24). Two parallel lines were drawn on the floor 5 m apart. The subject was instructed to run as fast as possible from the starting line to the second line and return, crossing each line with at least one foot every time. The test was performed twice, covering a distance of 50 m (10 x 5 m). Test time ended when the subject crossed (again, keep verb tenses consistent) the end line with one foot. Time was recorded using a standard stop watch.

Cardiovascular risk

Cardiovascular risk was categorized by sex-specific cut-offs for a healthy cardiorespiratory fitness level in adolescents proposed by FitnessGram (56). These age- and sex-specific cut-offs were based on the associations between these physical fitness components with the metabolic syndrome in a representative sample of US youth (56).

Statistical analysis

Subject characteristics are described as means ± standard deviation (SD) or number (percentage) (Table 1). Analysis of covariance was used to study the association of physical fitness measures with age and gender. Percentile values used included :(5^{th}, 10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th}, 95^{th}) of the physical fitness measures for French youth as a function of age stratified by gender using the generalized additive model for location, scale and shape (GAMLSS) (37). The GAMLSS package (version 4.2-7) of the statistical software R (version 3.2.1) was used (49). The GAMLSS method extends the lambda-mu-sigma (LMS) method that model the age-changing distribution of the measurement in terms of median, coefficient of variation, and skewness (15). GAMLSS allows one to choose the error distributions, the link between predictor and outcome, and include >1 covariate (rather than only age). Different distributions (Box-Cox *t*, Box–Cox power exponential, Box–Cox Cole and Green) were fitted and an automatic smoothing parameter GAMLSS was used (38). The Akaike Information Criterion was used to select the final model and normality of final model residual was checked using Quantile-Quantile (QQ) plots. Since a number of subjects scored 0 in the Curl ups test, we estimated centile values for this test using non-parametric percentiles estimates (i.e. using the percentiles of observed distribution in each age-gender stratum) instead of the GAMLSS method.

RESULTS

12 082 subjects ages 9 to 16 years, corresponding to 3% of the age related French youth population, participated to the French health promotion program. Participants came from 16 administrative regions out of 22 in France. Due to small sample size of participants aged of 9 (68 boys and 67 girls) and 16 years (96 boys and 116 girls) in comparison to other age-gender classes, we restricted the analysis to 11 735 participants aged from 10 to 15 years. Among them, 549 participants (265 boys and 284 girls, mean age 12.6 ± 0.8 years) with none physical

fitness measurements were excluded, resulting in a study sample of 11 186 participants (Table 1).

Physical fitness measurements for the study sample are reported by age and gender in Table 1. Because not all subjects took part in all fitness tests, sample sizes varied between 10 293 (Curl ups test) and 10 776 (Back-saver sit and reach test). For the Curl ups test, 56 (0.5%) subjects (25 boys and 31 girls) were scored at 0. Overall, physical fitness performances were better in boys, except for the back-saver sit and reach test, in which girls performed better ($p < 0.0001$, Table 1). Except for the Back-saver sit and reach test (p=0.76) and 10 x 5 m shuttle run test (p=0.42), physical fitness performance was significantly associated with age. Scores in the 20-m shuttle run and curl ups tests increased with increasing age whereas scores in VO_2max and the 50-meter sprint test decreased with increasing age**.** The prevalence of boys and girls with unhealthy cardiorespiratory fitness was 10.8% (n=569/5258) and 15.8% (n=846/5355), respectively (57). The prevalence of underweight, normal weight and overweight with unhealthy cardiorespiratory fitness was 7.1% (n=40/564), 7.0% (n=390/5576) and 21.2% (n=558/2631), respectively (57).

Insert Table 1.

Gender- and age-specific percentiles values (P5, P10, P25, P50, P75, P90, P95) for the different physical fitness measurements are reported in Tables 2-7 and the derived smoothed centiles curves are shown in Figures 1 and 2. As shown in supplemental figure, the residuals of each selected model were approximately normally distributed.

Insert Table 2 to 7.

Insert Figure 1 and 2.

DISCUSSION

Developing gender and age-specific normative values are needed to assess and interpret fitness status in French youth. While reference values have been developed in several countries, there are no normative values for young boys and girls in France. The purpose of this study was to establish gender- and age- specific physical fitness reference data for French youth ages 10–15 years.

In the present study, French youth showed a better cardiorespiratory fitness with respect to Spanish, Australian, Portuguese and Belgium counterparts (7, 11, 21, 45), but worse than Swiss youth (12, 47). For flexibility, French youth resulted similar to Spanish, Portuguese and Belgium peers (8, 20, 45), but worse than Swiss youth (12, 47). Regarding muscular endurance, French and Portuguese boys were similar, although their performances were lower compared to those of Spanish adolescents. The opposite picture emerged for the other sex, with French adolescent girls showing better muscular endurance compared with their Spanish counterparts (10, 45). Finally, speed capability resulted similar for French and Spanish youth (9).

Regarding gender differences, 10-15 year old boys showed better performances with respect to their female counterparts, with the exception of flexibility. These findings confirm previous studies on cardiorespiratory fitness and muscular endurance (11, 12, 17, 20, 30, 34, 47, 53), and flexibility (6, 12, 14, 18, 20, 22, 31, 47, 53) in children and adolescents, generally attributed to the distinct development, growth and maturation of boys and girls, independent of physical activity habits (27-28). In fact, in the developmental years body composition of males tends to vary due to increases in fat-free mass, whereas that of females tends to vary due to increases in fat mass (27). Independently from sex, age-related effects resulted in a consistent decline in physical fitness with advancing age, although the present data were similar to those obtained thirty years ago (13). For girls, increases in fat mass during adolescence has been considered responsible for declines in fitness (27). In considering that also boys showed a similar trend, it could be possible to speculate that the observed age-related declines in cardiorespiratory fitness and sprint performances mirror a reduced physical activity with increasing age (36), being these variables positively associated (41).

Gender-specific cut-offs that represent healthy cardiorespiratory fitness in children and adolescents were developed by FITNESSGRAM (56). The criterion referenced standards is based on the association between cardiorespiratory fitness and metabolic syndrome using ROC analysis (5). To our knowledge, no data are available assessing cardiorespiratory fitness and cardiovascular risk in French youth. Using cardiorespiratory fitness thresholds associated with increased cardiovascular risk, we estimated the percentage of young boys and girls at cardiovascular risk in adulthood as 10.8% and 15.8%, respectively. The prevalence of French youth in our study with healthy cardiorespiratory fitness was 89.2% and 84.2% for boys and girls, respectively. Compared with previous studies carried out in Sweden and Spain (33-34), the prevalence of French girls with a healthy cardiorespiratory fitness resulted slightly higher (Spanish girls: 83%; Swedish girls: 84%), whereas the relative picture for French boys was higher when compared to Spain boys (81%) and comparable to that of Swedish boys (91%). Others studies suggested that European, Portuguese and United States adolescents have a lower percentage of youth with healthy cardiorespiratory fitness compared to our findings, i.e. 65% of adolescents from the United States, 63.1% of boys and 59.2% of girls from Portugal and 61% of boys and 57% of girls from Europe (30, 34, 44). Recently, Bai et al. provided new data about the prevalence of youth fitness in the United States (2). This updated health-related fitness profiles shows that the prevalence of youth with healthy cardiorespiratory fitness is also lower compared to our findings (62.1% to 37.6% of boys and 49.1% to 26.1% of girls according to age) (2). Nevertheless, it is difficult to interpret the difference found between the prevalence in France with those in Europe or the United States. Methodological issues in assessing cardiorespiratory fitness and sample size differences might explain the discrepancies found in the present study. In addition, the cut-off points used to discriminate healthy and unhealthy were different between the studies (5, 25, 33, 37, 57).

The current study has strengths and limitations. The strengths of the study are the large sample size of children and adolescents with gender-specific information across France, the use of standardized procedures, and the strong methodology to assess physical fitness (manual of harmonization for physical fitness tests). The main limitation is the design of this study (cross-sectional design). Indeed, due to the changes of individual growth and maturation in children and adolescents, physical fitness reference values should be obtained throughout a longitudinal study. Moreover, even if our study allows to detect accurately individual improvements, further studies should be performed in order to more fully characterize and identify cut-points related to health outcomes for all fitness components. Despite the present data derive from a large sample belonging to 73% of the administrative French regions, this study did not used a stratified sample design. Therefore, it is not possible to assume that the studied cohort is fully representative of the French children and adolescent populations. Unfortunately, to perform such an extensive data collection a four-year period was necessary, which might have affected the results of the study.

PRACTICAL APPLICATIONS

Gender and age-specific normative values for physical fitness tests in the French youth expressed as tabulated percentiles from 5th to 95th were established. The reported normative values can be used for different purposes. Our normative values in all physical fitness tests have been reported as 5th to 95th percentiles in order the adolescents can assess their own physical fitness level. Adolescents can assess their level using a specific scale according these reference values developped: very poor (X<P10), poor (P10≤X<P25), medium (P25≤X<P75), good (P75≤X<P90) and very good (X≥P95). The reference values provided can also be used as normative data in French youth for practitioners in order to identify youth with low physical fitness status. This is particularly interesting for the health care practitioners in order to develop intervention programs on this target population.

Acknowledgements

The authors thank all participating adolescents and teachers for their collaboration in the study. The authors declared no conflict of interest.

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Legends

Figure 1. Centile curves for cardiorespiratory fitness using the 20-m shuttle run test.

Figure 2. Centile curves for flexibility, speed, agility and muscular endurance.

Table 1. Subject characteristics studied according to the sex

Table 2. Centiles estimation for cardiorespiratory fitness (20-m shuttle run test, stages) by sex and age in French adolescents (n = 10613).

Table 3. Centiles estimation for cardiorespiratory fitness (20-m shuttle run test, VO_2max in $ml.kg^{-1}.min^{-1}$) by sex and age in French adolescents (n = 10613).

Table 4. Centiles estimation for physical fitness (curl ups test, n) by sex and age in French adolescents (n = 10293).

Table 5. Centiles estimation for physical fitness (50-meter sprint test, sec) by sex and age in French adolescents (n = 10308).

Table 6. Centiles estimation for physical fitness (back-saver sit and reach test, cm) by sex and age in French adolescents (n = 10776).

Table 7. Centiles estimation for physical fitness (10 x 5 m shuttle run test, sec) by sex and age in French adolescents (n = 10547).

Table 1. Subject characteristics studied according to the sex

	Overall	Boys	Girls
N	11186	5546	5640
Age	12.2 ± 0.9	12.2 ± 0.9	12.2 ± 0.9
10-10.9 years	711 (6.3)	365 (6.6)	346 (6.1)
11-11.9 years	3548 (31.7)	1687 (30.4)	1861 (33.0)
12-12.9 years	4472 (40.0)	2167 (39.1)	2305 (40.9)
13-13.9 years	2056 (18.4)	1091 (19.7)	965 (17.1)
14-14.9 years	399 (3.6)	236 (4.2)	163 (2.9)
Weight (*kg*)	45.1 ± 11.2	45.0 ± 11.6	45.2 ± 10.8
Height, *cm*	152.7 ± 8.9	152.4 ± 9.3	153.1 ± 8.5
Body mass Index (kg/m^2)	19.2 ± 3.5	19.2 ± 3.5	19.2 ± 3.5
20-m shuttle run test (*stages*)	5.6 ± 2.5	6.3 ± 2.6	4.9 ± 2.2*
VO_2max ($ml.kg^{-1}.min^{-1}$)	47.2 ± 6.5	49.0 ± 6.8	45.5 ± 5.7*
Curl ups test (n)	29.7 ± 18.9	33.0 ± 19.5	26.5 ± 17.6*
50-meter sprint test (*sec*)	9.3 ± 1.4	9.1 ± 1.3	9.5 ± 1.4*
Back-saver sit and reach test (*cm*)	20.5 ± 8.6	17.9 ± 7.8	23.1 ± 8.6*
10 x 5 m shuttle run test (*sec*)	19.9 ± 3.3	19.3 ± 3.2	20.6 ± 3.3*

Values are mean ± standard deviation or number (%)
*$P < 0.0001$ for comparison between boys and girls (analysis of covariance, including age and BMI as covariate)

Table 2. Centiles estimation for cardiorespiratory fitness (20-m shuttle run test, stages) by sex and age in French adolescents (n = 10613).

		Percentiles						
	Mean ± SD	5	10	25	50	75	90	95
Boys								
10-10.9 years	6.2 ± 2.3	2.6	3.2	4.4	5.8	7.4	9.0	10.1
11-11.9 years	6.2 ± 2.4	2.5	3.1	4.4	6.0	7.7	9.4	10.5
12-12.9 years	6.3 ± 2.7	2.4	3.0	4.3	6.1	8.0	9.8	10.8
13-13.9 years	6.5 ± 2.8	2.3	2.9	4.3	6.2	8.4	10.1	11.1
14-14.9 years	7.0 ± 2.9	2.1	2.8	4.2	6.4	8.7	10.5	11.4
Girls								
10-10.9 years	4.9 ± 2.2	1.9	2.4	3.3	4.6	6.1	7.9	9.2
11-11.9 years	4.7 ± 2.2	1.8	2.2	3.1	4.4	5.9	7.5	8.7
12-12.9 years	5.0 ± 2.2	1.9	2.4	3.3	4.7	6.3	8.0	9.1
13-13.9 years	4.9 ± 2.1	1.9	2.3	3.3	4.6	6.3	7.9	8.9
14-14.9 years	4.8 ± 2.0	1.8	2.3	3.2	4.5	6.1	7.5	8.4

Centile values were estimated by using GAMLSS model (Box–Cox power exponential distribution) for exact ages. SD indicates standard deviation.

Table 3. Centiles estimation for cardiorespiratory fitness (20-m shuttle run test, VO_2max in $ml.kg^{-1}.min^{-1}$) by sex and age in French adolescents (n = 10613).

		Percentiles						
	Mean ± SD	5	10	25	50	75	90	95
Boys								
10-10.9 years	51.6 ± 5.5	41.7	43.0	45.5	49.1	53.4	57.8	60.6
11-11.9 years	50.0 ± 6.0	40.0	41.3	43.9	47.7	52.3	56.7	59.4
12-12.9 years	48.7 ± 6.9	38.5	39.9	42.6	46.8	51.8	56.5	59.3
13-13.9 years	47.6 ± 7.2	36.8	38.1	41.0	45.5	50.9	55.6	58.4
14-14.9 years	47.5 ± 7.9	34.6	36.1	39.2	44.2	50.1	55.2	58.1
Girls								
10-10.9 years	47.5 ± 7.9	41.4	42.4	44.4	47.2	50.7	54.4	57.0
11-11.9 years	48.4 ± 5.2	39.7	40.7	42.9	45.9	49.7	53.6	56.2
12-12.9 years	46.4 ± 5.3	38.2	39.3	41.6	45.0	49.2	53.4	56.1
13-13.9 years	45.4 ± 5.7	36.3	37.5	39.9	43.4	47.6	51.7	54.2
14-14.9 years	41.5 ± 5.5	34.0	35.2	37.6	41.1	45.3	49.0	51.2

Centile values were estimated by using GAMLSS model (Box–Cox power exponential distribution) for exact ages. SD indicates standard deviation.

Table 4. Centiles estimation for physical fitness (curl ups test, n) by sex and age in French adolescents (n = 10293).

		Percentiles						
	Mean ± SD	5	10	25	50	75	90	95
Boys								
10-10.9 years	32.5 ± 19.8	5.0	10.0	17.0	30.0	45.0	67.0	75.0
11-11.9 years	31.0 ± 18.1	5.0	9.0	17.0	30.0	42.0	56.0	70.0
12-12.9 years	32.7 ± 19.6	4.0	8.0	17.0	30.0	45.0	61.0	75.0
13-13.9 years	35.6 ± 20.2	5.0	11.0	20.0	33.0	50.0	67.0	75.0
14-14.9 years	40.0 ± 21.3	3.0	11.0	24.0	40.0	54.0	75.0	75.0
Girls								
10-10.9 years	26.4 ± 18.7	3.0	7.0	12.0	22.0	39.0	55.0	64.0
11-11.9 years	24.3 ± 16.3	3.0	6.0	12.0	21.0	33.0	47.0	57.0
12-12.9 years	27.2 ± 17.3	3.0	6.0	15.0	25.0	37.0	51.0	61.0
13-13.9 years	28.6 ± 19.1	3.0	7.0	15.0	25.0	38.0	58.0	75.0
14-14.9 years	31.9 ± 22.0	3.0	7.0	14.0	27.0	45.0	73.0	75.0

Centile values were estimated using standard procedures (non-parametric estimation) using the class of age.

Table 5. Centiles estimation for physical fitness (50-meter sprint test, sec) by sex and age in French adolescents (n = 10308).

		Percentiles						
	Mean ± SD	5	10	25	50	75	90	95
Boys								
10-10.9 years	9.0 ± 1.1	7.7	8.0	8.5	9.0	9.6	10.3	10.9
11-11.9 years	9.2 ± 1.3	7.7	8.0	8.5	9.0	9.6	10.3	10.9
12-12.9 years	9.1 ± 1.2	7.7	8.0	8.5	9.0	9.7	10.5	11.1
13-13.9 years	8.9 ± 1.5	7.5	7.7	8.1	8.7	9.4	10.3	11.0
14-14.9 years	8.7 ± 1.8	7.3	7.5	7.9	8.5	9.3	10.3	11.3
Girls								
10-10.9 years	9.6 ± 1.8	8.0	8.4	8.9	9.5	10.1	10.9	11.5
11-11.9 years	9.6 ± 1.4	8.0	8.3	8.9	9.5	10.1	10.9	11.6
12-12.9 years	9.4 ± 1.3	8.0	8.3	8.8	9.3	10.0	10.8	11.5
13-13.9 years	9.4 ± 1.4	7.9	8.1	8.6	9.1	9.8	10.6	11.3
14-14.9 years	9.3 ± 1.2	7.9	8.1	8.6	9.1	9.8	10.7	11.5

Centile values were estimated by using GAMLSS model (Box-Cox *t* distribution) for exact ages. SD indicates standard deviation.

Table 6. Centiles estimation for physical fitness (back-saver sit and reach test, cm) by sex and age in French adolescents (n = 10776).

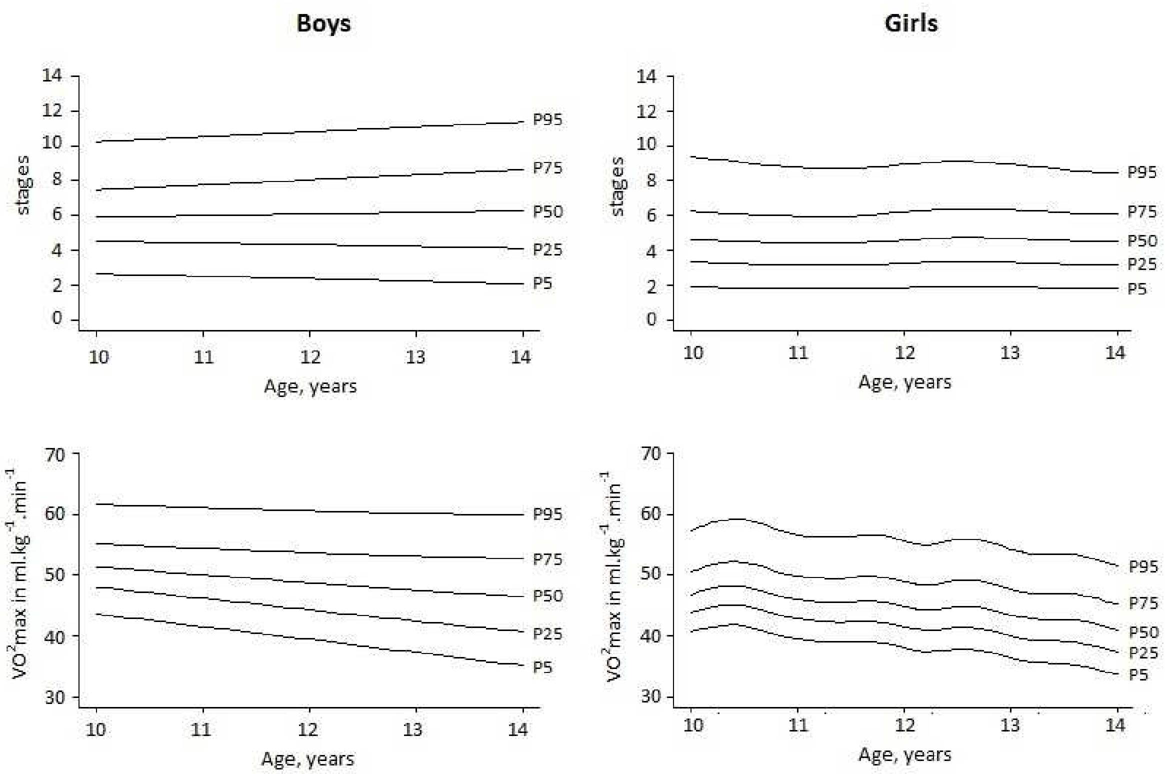
	Mean ± SD	Percentiles						
		5	10	25	50	75	90	95
Boys								
10-10.9 years	17.8 ± 7.8	5.3	7.8	12.8	18.4	23.8	28.5	31.4
11-11.9 years	18.1 ± 7.7	5.3	7.9	12.8	18.2	23.5	28.0	30.7
12-12.9 years	17.7 ± 7.8	4.9	7.4	12.3	17.8	23.2	27.9	30.8
13-13.9 years	17.7 ± 7.8	4.8	7.4	12.2	17.7	23.1	27.8	30.6
14-14.9 years	17.9 ± 8.4	4.4	6.9	11.8	17.5	23.1	28.3	31.4
Girls								
10-10.9 years	22.7 ± 7.6	8.9	12.1	17.6	23.1	28.1	32.7	35.7
11-11.9 years	22.9 ± 8.4	8.5	11.8	17.4	23.2	28.5	33.0	35.6
12-12.9 years	23.0 ± 8.9	8.1	11.5	17.3	23.4	29.0	33.6	36.3
13-13.9 years	23.6 ± 8.8	7.7	11.1	17.2	23.8	29.8	34.9	37.8
14-14.9 years	23.3 ± 8.3	8.3	11.7	17.5	23.6	29.2	34.0	36.7

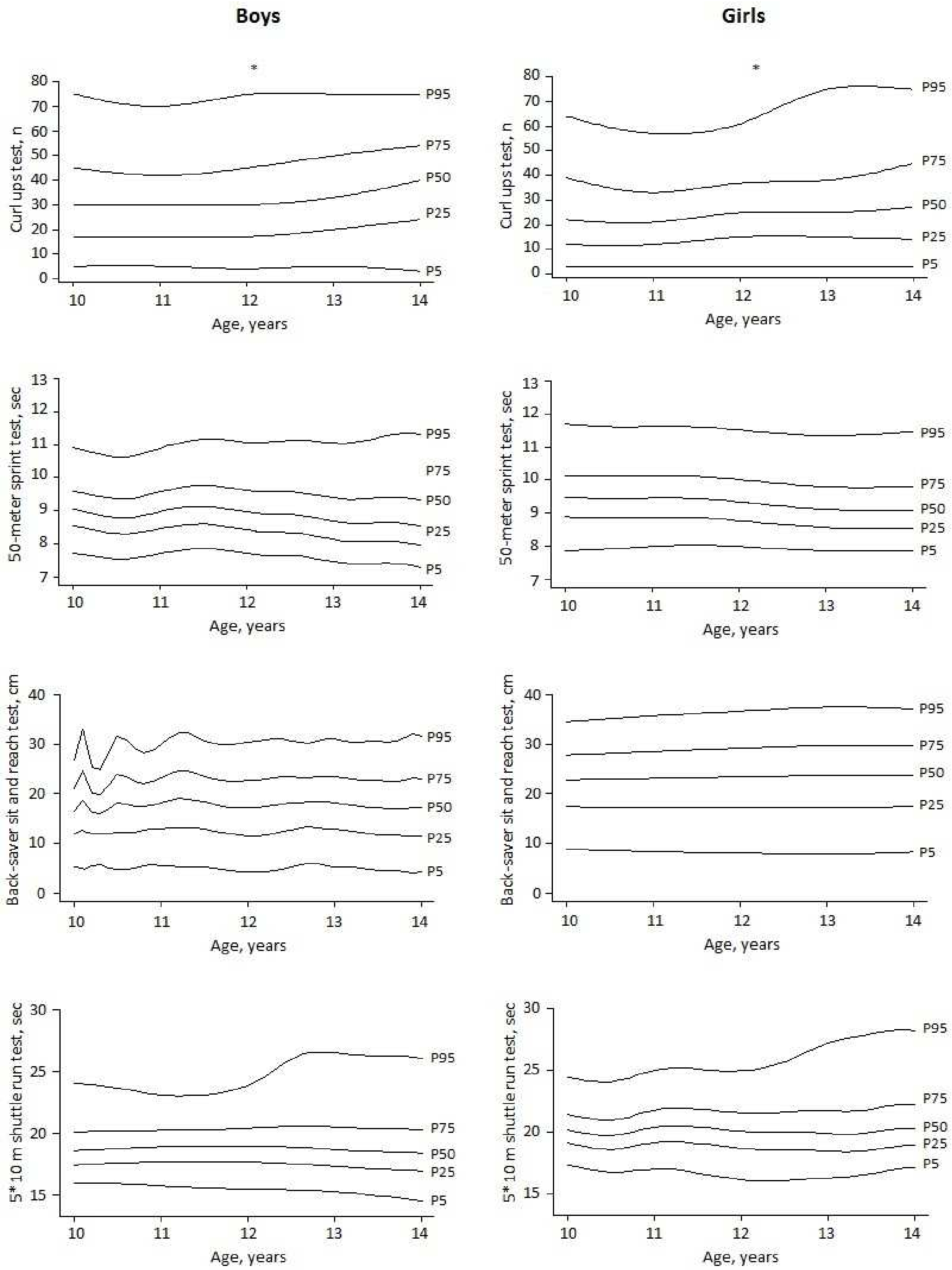
Centile values were estimated by using GAMLSS model (Box-Cox *t* distribution) for exact ages. SD indicates standard deviation.

Table 7. Centiles estimation for physical fitness (10 x 5 m shuttle run test, sec) by sex and age in French adolescents (n = 10547).

		Percentiles						
	Mean ± SD	5	10	25	50	75	90	95
Boys								
10-10.9 years	19.2 ± 2.9	15.5	16.0	17.3	18.6	20.2	22.6	24.8
11-11.9 years	19.2 ± 2.6	15.4	16.4	17.7	18.9	20.2	22.0	23.4
12-12.9 years	19.4 ± 3.3	15.3	16.3	17.7	19.0	20.4	22.4	23.9
13-13.9 years	19.4 ± 3.7	14.8	15.7	17.3	18.7	20.5	23.3	25.8
14-14.9 years	18.7 ± 3.7	14.1	15.2	16.9	18.4	20.1	22.8	25.2
Girls								
10-10.9 years	20.5 ± 3.3	18.2	18.7	19.4	20.3	21.5	23.4	25.2
11-11.9 years	20.6 ± 2.8	17.1	18.0	19.2	20.5	21.8	23.5	25.0
12-12.9 years	20.4 ± 3.5	16.1	17.2	18.7	20.1	21.6	23.4	24.9
13-13.9 years	20.7 ± 3.7	16.4	17.2	18.5	19.9	21.7	24.4	27.4
14-14.9 years	21.1 ± 3.7	17.1	17.8	19.0	20.3	22.2	25.2	28.1

Centile values were estimated by using GAMLSS model (Box-Cox *t* distribution) for exact ages. SD indicates standard deviation.


Boys
Girls
stages
Age, years
P95
P75
P50
P25
P5
VO2max in ml.kg-1.min-1


Boys
Girls
*
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Curl ups test, n
50-meter sprint test, sec
Back-saver sit and reach test, cm
5*10 m shuttle run test, sec
Age, years
P95
P75
P50
P25
P5