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Establishing sex- and age-specific percentile curves for some aspects of physical fitness in adolescents from the City of Zagreb

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The main purpose of the present study was to develop smoothed percentile curves for physical fitness in adolescents aged 15-18 years from the City of Zagreb. In this cross-sectional study, we recruited 1036 secondary-school students aged 15-18 from eleven randomly selected schools (55.3% of girls). As part of physical fitness, we chose 1-minute sit-ups (#), standing long jump (cm) and sit-and-reach (cm) tests using standardized measuring protocol. The sex- and age-specific smoothed percentile curves with 5th, 10th, 25th, 50th, 75th, 90th and 95th percentile for each physical fitness test were calculated using Lambda-Mu-Sigma method. The 50th percentile for 1-minute sit-ups was between 55 and 58 cm in boys, and between 45 and 47.5 cm in girls. For standing long jump, 50th percentile was between 210 and 215 cm in boys and roughly the same (170 cm) in girls. Finally, 50th percentile for sit-and-reach test was between 60 and 65 cm in boys and between 67.5 and 73 cm in girls. This study aimed to establish physical fitness percentile curves for adolescents from the City of Zagreb. Our reference curves might be used to detect adolescents who are at an extreme risk of having 'low' physical fitness status and to implement school-based interventions for physical fitness level enhancement.

Key words: PHYSICAL FITNESS; ADOLESCENT; STUDENTS

INTRODUCTION

Physical fitness is defined as "the capacity to perform physical activity to a full range of physiological and psychological qualities" (1). Studies have considered it as one of the most important health markers (1) and a significant predictor of all-cause mortality (2). In addition, the level of physical fitness in childhood is associated with both physical fitness and health in adulthood (3), pointing out that strategies aiming to increase the level of physical fitness in school-aged children and adolescents should be of extreme importance. Physical fitness scores and variations according to sex and age are the first step in quantifying and identifying fit ***versus*** unfit individuals by establishing criterion-standard references (4). Previous studies examined and created percentile curves in children and adolescents for several physical fitness tests in Europe (3, 5-12), United States (4, 13), Canada (14), South America (15), Australia (16) and Asia (17). However, physical fitness normative values for Zagreb adolescents have not been established yet. Although studied worldwide, previous studies have shown that the level of physical fitness is region and country specific (18), leading to the conclusion that data which are lacking from specific

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TABLE 1. Basic descriptive statistics of the study participants (Croatia, 2019)

Sex	Age (yrs)	n	1-minute sit-ups (#)		Standing long jump (cm)		Sit-and-reach test (cm)	
			Mean	SD	Mean	SD	Mean	SD
Boys	15	117	55	14	205	26	61	10
	16	105	56	9	207	32	64	13
	17	143	56	11	215	29	62	11
	18	98	57	14	211	28	62	14
Girls	15	182	46	10	167	19	70	13
	16	172	49	9	168	24	73	13
	17	117	47	11	167	21	72	14
	18	102	47	19	166	21	69	13

SD = standard deviation

countries do not allow correct evaluation and interpretation of the collected measurements of particular fitness components (12). Based on the aforementioned, the main purpose of the present study was to develop smoothed percentile curves for some aspects of physical fitness in Zagreb adolescents aged 15-18 years.

SUBJECTS AND METHODS

Study participants

In this cross-sectional study, participants were secondary-school students. More detailed information on sample collection and data used have been described elsewhere (19). In brief, we randomly selected 11 secondary schools in the City of Zagreb. At the second stage, we randomly selected one class representing each grade within the school (from 1st to 4th grade). Each class had ≈25 students. All students were considered healthy and were not affected by diseases. The selection criteria were active participation in physical education classes and absence of injuries. According to the Croatian Bureau of Statistics for the year 2017 (20), there were 36,350 secondary-school students in total. Our sample size was estimated to be 1030 by using 95% confidence level and 3% margin error. At the beginning, we recruited 1247 participants. Of these, 136 did not provide full data and 75 were absent when the study was conducted. Our final sample was based on 1036 secondary-school students (m_{age}±SD=16.3±1.1 yrs; m_{height}±SD=1.74±0.1 m; m_{weight}±SD=64.7±12.4 kg; $m_{body\text{-}mass\ index}$±SD=21.3±3.0 kg/m^2; 55.3% girls). Upon selection of each school and class, we contacted physical education teachers to help us organize the study and obtain approval of the principal. The measurement protocol for the study lasted from January to March 2019. Before the study began, all students had been familiarised with the aims, hypotheses and benefits of participation in the study. All procedures performed in the study were in accordance with the Declaration of Helsinki and approved by the institutional Review Board of the leading author. All participants and their parents/guardians provided their written informed consent for participation in the study.

Physical fitness assessment

We used a part of the EUROFIT Battery Fitness Test to assess the level of physical fitness in adolescents. The same tests were previously used in a similar study (19). These tests are considered reliable and valid instruments to measure the level of physical fitness in children and adolescents (6). Standing long jump, sit-ups in 1 minute and sit-and-reach test were chosen because of their mutual independence to one another (21). Data were collected by two trained researches in order to guarantee the standard measurement methodology (21). Brief explanation of each test is presented below.

1-minute sit-ups: Trunk strength was assessed as the maximum number of sit-ups achieved in one minute. Children were seated on the floor, backs straight, hands clasped behind their neck, knees bent at 90° with heels and feet flat on the mat. Then they lay down on their backs, shoulders touching the mat, and returned to the sitting position with their elbows out in front to touch their knees, keeping the hands clasped behind their neck the whole time. The total amount of correctly performed sit-ups in 60 seconds was the score (22).

Standing long jump: Each subject performed distance jumps from a standing start. While performing the jumps, the subjects were asked to bend their knees with their arms in front of them, parallel to the ground, then to swing both arms, push off vigorously and jump forward as far as possible, trying to land with their feet together and stay upright. The better of two attempts was taken as the final score (expressed in cm) (22).

Sit-and reach test: Sitting on the floor or a mat, legs straight under the angle of 90º, the person being tested reached forward with the arms (hands overlapping). The distance of

TABLE 2. Sex- and age-specific percentiles for 1-minute sit-ups, standing long jump and sit-and-reach test (Croatia, 2019)

Measure	Sex	Age (yrs)	n	Percentile						
				P5	P10	P25	P50	P75	P90	P95
1-minute sit-ups (#)	Boys	15	117	34	39.8	46	55	60	76	83.2
		16	105	41	45	50	55	60	66	74
		17	143	40	43	49	56	62	68.6	78.6
		18	98	39.75	44.9	47	58	63	70.5	82.1
	Girls	15	182	30	35	38.75	45	50.5	60	64
		16	172	35	37	42	47.5	54	60.7	68
		17	117	29.8	32.4	40	47	55	60	67
		18	102	30.3	35	40	46.5	53.25	62	65
Standing long jump (cm)	Boys	15	117	155	170	185	210	221	240	245
		16	105	140	158	195	210	230	240	248.5
		17	143	175	180	195	215	230	250	275
		18	98	160.95	177.7	190	212.5	235	245	255
	Girls	15	182	140	145	153.75	170	180	191	200
		16	172	126.5	136	150	170	183.75	198.5	206.75
		17	117	130	145	155	170	180	191	200
		18	102	140	140	155	167	176.25	195	200
Sit-and-reach test (cm)	Boys	15	117	43.8	46	53	60	70	74	77
		16	105	40.3	45	55.5	65	71.5	80	89.4
		17	143	45	48	55	62	66	73	78.8
		18	98	37.7	42.8	55	61	70	80	82.15
	Girls	15	182	45.15	50.3	61	70	80	85	91
		16	172	52	56	65	73	82	91.4	94
		17	117	47.9	57	63.5	73	82	90	95
		18	102	47	52	59	69.5	78.25	87.4	89

reach was measured in cm using a measuring non-elastic tape attached on the floor (23).

Data analysis

Age (without decimal places) and sex were self-reported. The reference 5th, 10th, 25th, 50th, 75th, 90th and 95th percentiles were constructed for each physical fitness test. One-way analysis of variance (ANOVA) was used to calculate differences in 1-minute sit-ups, standing long jump and sit-and-reach test between age and sex groups. We used Cole's Lambda, Mu and Sigma (LMS) method, in which the optimal power to obtain normality is summarized by a smooth (L) curve and trends in the mean (M) and coefficient of variation (S) are similarly smoothed (24). Next, all three curves (L, M and S) are summarized based on the power of age-specific Box–Cox power transformations for normalizing the data (24). All analyses were performed in Statistical Packages for Social Sciences (SPSS Inc., Chicago, Illinois, USA) and in LMS Chartmaker Pro version (The Institute of Child Health, London, UK).

RESULTS

Basic descriptive statistics of the study participants is shown in Table 1. Boys had greater average values in 1-minute sit-ups and standing long jump tests ($p<0.001$), while girls performed better in sit-and-reach test ($p<0.001$). No significant sex*age interaction effects for 1-minute sit-ups ($p=0.876$), standing long jump ($p=0.100$) and sit-and-reach test ($p=0.492$) were observed.

Table 2 shows sex- and age-specific percentile values for each physical fitness test. The same values are also presented graphically for boys (Figure 1) and girls (Figure 2). In boys, 50th percentile values for 1-minute sit-ups were between 55 and 58 repetitions. Similar trends were observed across the age groups, where boys attending 3rd and 4th grade showed somewhat lower values till 25th percentile. For standing long jump, values ranged between 210 and 215 cm, with the largest values on 95th percentile between 245 and 275 cm. In sit-and-reach test, 50th percentile values ranged between 60 and 65 cm, while boys in 2nd grade had the highest results on 95th percentile (89.4 cm). In girls, 50th percentile values for

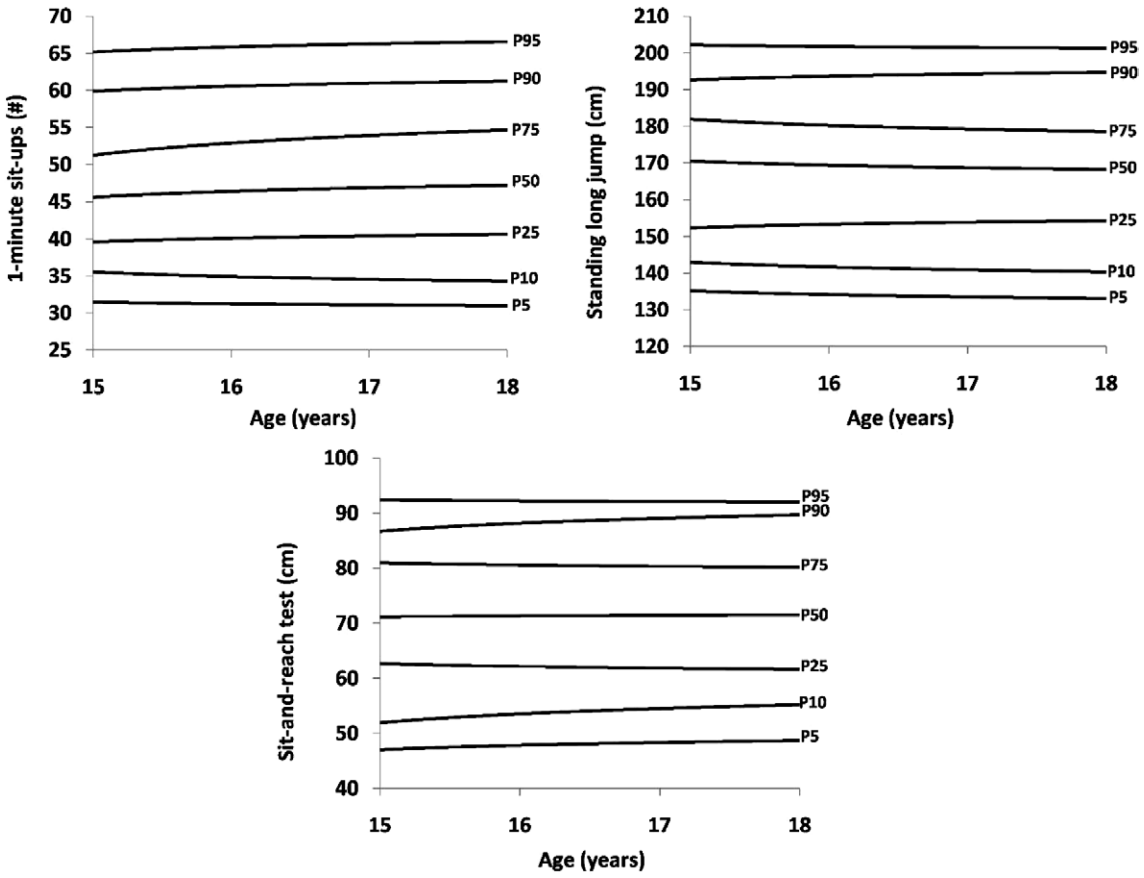

FIGURE 1. Percentile values for 1-minute sit-ups, standing long jump and sit-and-reach test in boys (Croatia, 2019).

1-minute sit-ups ranged between 45 and 47.5 repetitions, showing no significant age differences. However, girls from 2nd grade had the highest values on the 95th percentile curve (68 repetitions). For standing long jump, values ranged between 167 cm in 4th grade and 170 cm in 1st, 2nd and 3rd grade. Again, girls attending 2nd grade performed best (206.75 cm) on 95th percentile curve. Finally, the results in sit-and-reach test on 50th percentile ranged between 69.5 and 73 cm, while girls in 2nd and 3rd grade showed highest values on 95th percentile (94 cm and 95 cm).

DISCUSSION

The main purpose of the present study was to develop smoothed percentile curves for some aspects of physical fitness in Zagreb City adolescents aged 15-18 years. The study included a relatively large sample of secondary-school students to establish reference standards for physical fitness. To date, several studies have examined and created normative values for different physical fitness tests (3-17). Although such standards have been discussed worldwide, region and country are important determinants of physical fitness (18), and such results should be established and compared in different settings to generate comparable data. Our results regarding 1-minute sit-ups are not in line with previous evidence (8). Specifically, a study conducted among Portuguese children aged 7-19 years showed that the 50th percentile values ranged between 45 and 53 cm in 15-18-year-old boys and between 32 and 38 cm in 15-18-year-old girls (8). The discrepancy between the data could be explained by chronological age obtained from the participants. *Santos et al.* (8) calculated chronological age as the difference between the date of birth and date of data collection, while we simply asked the participants about their age, which might have led to different age group. Unfortunately, we did not collect data on the maturation status of study participants. Second, we used different measuring protocol to assess repetitive strength of the upper body (please see the Physical fitness assessment section), where *Santos et al.* (8) followed the procedure of the FITNESSGRAM Test Battery v. 8.0 (25).

Next, our results showed that the median value of standing long jump for boys ranged between 210 and 215 cm, which is partially in line with the results from Poland (9) and Hungary (10). A study by *Dobosz et al.* (9) conducted among 7-19-year-old Polish children showed that the 50th percentile values of standing long jump ranged between 205 and

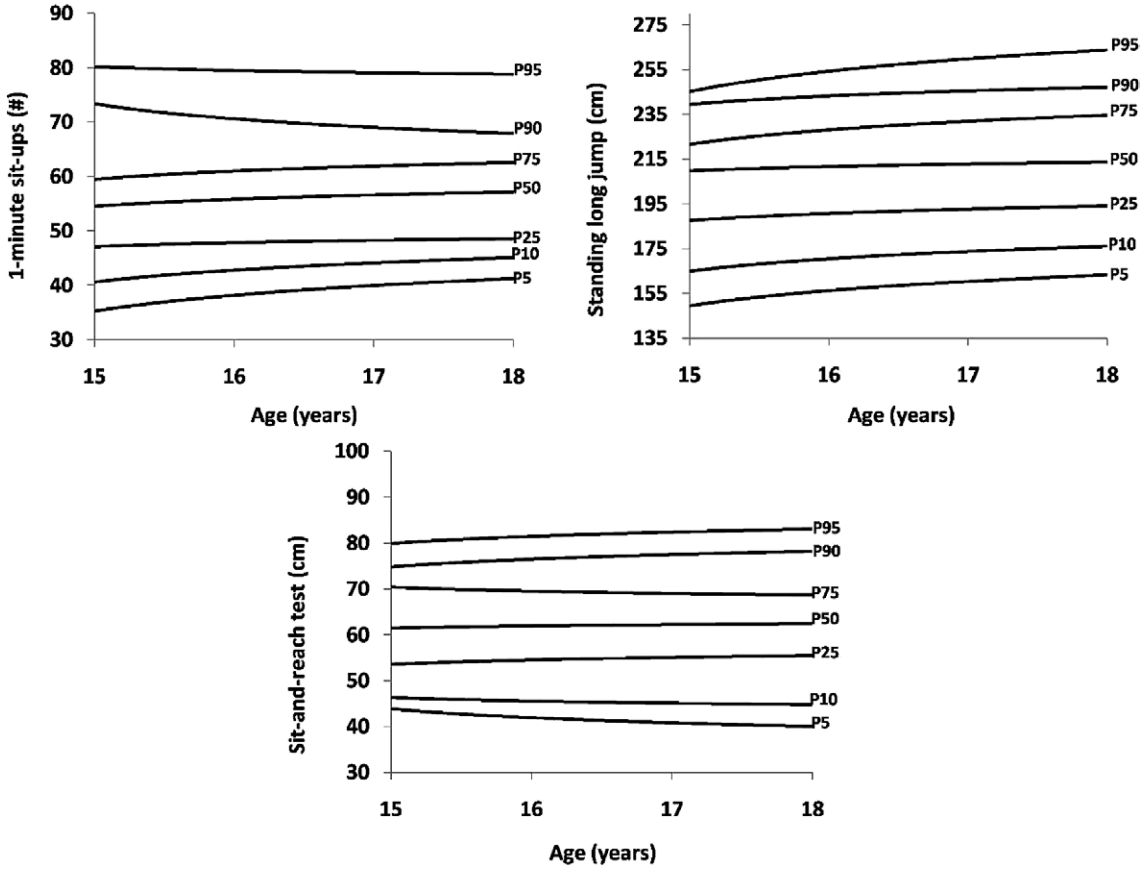

FIGURE 2. Percentile values for 1-minute sit-ups, standing long jump and sit-and-reach test in girls (Croatia, 2019).

216.9 cm in 15-18 year-old boys; however, the respective values were lower than ours and ranged between 160.2 and 162.4 cm in girls. On the other hand, *Welk et al.* (10) also report results similar to ours for boys but lower for girls, which ranged between 150.1 and 156.1 cm. Previous studies have shown that boys participate more in organized physical activity (26), receive more social support (27), and perceive more enjoyment when taking part in physical education (28) as compared with girls. However, girls from our study performed better in standing long jump compared to Polish and Hungarian ones, leading to a conclusion that they were more motivated to take part in the study and the drop-out rate was only around 8% (573/623). In addition, all participants were awarded by an 'excellent' grade if completed the whole study procedure. On the other hand, our results are not in line with previously published results from Europe (6), Australia (16) and South America (15). As highlighted by one recent study (12), many biological and environmental factors play an extreme role in modifying the level of physical fitness. In that way, reference-based standards from random and large representative sample of children and adolescents are required.

Finally, we also presented percentile curves for sit-and-reach test. However, the majority of previous studies used modified back-saver sit-and-reach test with different measurement assessment and methodology (6). Thus, we cannot compare our results to the previous ones. On the other hand, we followed the methodology of President's Council on Physical Fitness and Sports (23), which showed that V sit-and-reach test was a reliable and valid instrument to assess the level of flexibility in children and adolescents. Since Croatian adolescents were not included in the aforementioned studies, our results could be an important addition to current country-specific standards.

In addition, we observed sex-related differences in all physical fitness tests. The reason for this probably lies in the fact that boys genetically have different body composition, including higher fat-free mass and lower fat-mass values as compared to girls (29, 30). Therefore, boys obtained significantly better results in standing long jump and 1-minute sit-ups. On the other hand, girls had better results in flexibility test because of genetic predisposition of generally better flexibility and higher fat-mass values as compared to boys (29, 30).

Our study had a few limitations. First, we used a cross-sectional design and therefore could not make a conclusion about the exact physical fitness growth charts of the study

participants. Second, we did not collect data on the maturation status (by using Tanner's stages) since chronological and biological age are often not the same. Third, we only chose students from urban area of the City of Zagreb, limiting the generalizability of our results to other mixed populations (rural area). Fourth, we also did not collect data on cardio-respiratory fitness or other motor abilities, including balance, precision, sprint or agility/coordination. However, a most recent meta-analysis of longitudinal studies has revealed moderate-large negative association between muscular fitness in childhood/adolescence and adiposity and cardiometabolic parameters in adulthood, pointing out that muscle-strengthening activity has beneficial effects on health during lifespan (31). Future studies should use more detailed physical fitness assessment in longitudinal design and adjusting for potential biological and environmental covariates, in order to establish normative values important for clinical settings.

CONCLUSIONS

This study established sex- and age-specific normative values for physical fitness in 15-18-year-old adolescents. Our main findings provided an insight into some aspects of physical fitness and those parameters should be used as a starting point in measuring the level of physical fitness and detecting 'risky' population of adolescents with 'poor' physical fitness scores. In addition, special interventions that lever 'higher' levels of physical fitness through extracurricular organized physical activity and engagement in sports within the school-based system should be of crucial interest.

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SAŽETAK

Određivanje spolno i dobno specifičnih percentilnih krivulja za neke aspekte fizičke sposobnosti kod adolescenata grada Zagreba

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Glavni cilj ove studije bio je napraviti percentilne krivulje tjelesne spremnosti u adolescenata u dobi od 15 do 18 godina u Gradu Zagrebu. U ovoj poprečno-presječnoj studiji sudjelovalo je 1036-ero srednjoškolaca u dobi od 15 do 18 godina, izabrani slučajnim odabirom iz 11 škola (55,3% djevojaka). Kao dio tjelesne spremnosti izabrali smo podizanje trupa u 1. minuti (broj ponavljanja), skok udalj s mjesta (cm) i test dohvata (cm). Spolno dobne percentilne krivulje sa 5, 10, 25, 50, 75, 90 i 95 percentilom su napravljene služeći se Lambda, Mu i Sigma metodom. Pedeseti percentil za podizanje trupa u 1. minuti je bio između 55 i 58 ponavljanja u dječaka, dok je kod djevojaka bio 45 do 47.5. Za skok udalj s mjesta 50 percentil nalazio se u vrijednosti između 210 i 215 cm kod dječaka i oko 170 cm kod djevojčica. Konačno, 50 percentil kod testa dohvata bio je između 60 i 65 cm kod dječaka i 67,5 i 73 cm kod djevojčica. Ova studija utvrđuje dobno spolne percentile krivulje tjelesne spremnosti kod adolescenata u Gradu Zagrebu. Naše referentne krivulje mogle bi poslužiti u otkrivanju onih adolescenata s povećanim rizikom od „niske" razine tjelesne spremnosti i u implementaciji školskih intervencija koje povećavaju razinu tjelesne spremnosti.

Ključne riječi: TJELESNA SPREMNOST; ADOLESCENTI; UČENICI