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Growth-related changes in anthropometry and physical fitness in girls aged 10-13 years

Promene povezane sa rastom u antropometrijskim i motoričkim sposobnostima devojčica uzrasta 10–13 godina

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ABSTRACT

This study is aimed at evaluating 10-13-year-old girls' motor skills and anthropometric characteristics as well as their interrelationships during their growth. Three hundred seventy-eight girls from elementary schools underwent a standard anthropometry (body height, weight and body mass index) and motor fitness tests (sprint run for 20 meters, bent knee push-up, sit-up test for 30 seconds, standing long jump and sit and reach). Data was stratified by age. Age-specific percentile values (i.e., P5 to P95) were generated. Significant age-related main effects for body height, body weight, and body mass indexes were observed, including running speed, abdominal strength, and muscle endurance, as well as the explosive leg power. Physical fitness was considerably affected by anthropometric parameters. Body height seemed to be positively correlated with the explosive leg power and abdominal strength and muscles endurance, and negatively with speed, strength and endurance of the upper body muscle groups. Test results for assessing strength were insufficient. Likewise, body weight appeared positively correlated with explosive leg power and negatively with speed, strength and endurance of the upper body muscle groups and flexibility. As for the body mass index, it was proven to be negatively correlated with strength and the endurance of the upper body muscle groups and flexibility.

Keywords:
Body height,
Body weight,
Testing,
School children

SAŽETAK

Ova studija imala je za cilj da proceni motoričke sposobnosti i antropometrijske karakteristike devojčica uzrasta 10–13 godina, kao i njihove međusobne veze u toku rasta. Na uzorku od tri stotine sedamdeset i osam učenica osnovnih škola sprovedena su antropometrijska merenja (telesna visina, težina i indeks telesne mase) i testiranja motoričkih sposobnosti (sprint na 20 metara, sklekovi, ležanje-sed, skok udalj iz mesta i sed i dohvat). Podaci su stratifikovani prema

Ključne reči:
telesna visina,

telesna težina, testiranje, školska deca

starosti. Generisane su specifične percentilne vrednosti po godinama (P5 do P95). Uticaj rasta ima efekta na telesnu visinu, telesnu težinu i indekse telesne mase, kao i na brzinu trčanja, snagu i izdržljivost trbušnih mišića i eksplozivnu snagu nogu. Na motoričke sposobnosti znatno utiču antropometrijske dimenzije. Čini se da je visina tela pozitivno povezana sa eksplozivnom snagom nogu i snagom i izdržljivošću trbušnih mišića, a negativno sa brzinom i snagom i izdržljivošću mišića ruku i ramenog pojasa. Zabeleženi rezultati testova za procenu snage su na nedovoljnom nivou. Isto tako, telesna težina je pozitivno povezana sa eksplozivnom snagom nogu i negativno sa brzinom, snagom i izdržljivošću mišića ruku i ramenog pojasa i fleksibilnošću. Indeks telesne mase je negativno povezan sa snagom i izdržljivošću mišića ruku i ramenog pojasa i fleksibilnošću.

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Introduction

Physical fitness refers to a physiologic state of well-being that allows one to meet the demands of daily living or provides the basis for performance in sport. In research, physical activity and physical fitness are often used interchangeably, with fitness commonly being treated as a more accurate measure of physical activity than self-report (Williams, 2001).

The level of physical fitness of school-aged children, is usually determined using health-related physical fitness test batteries (i.e., field tests) (Ramírez-Vélez et al., 2016). Health-related physical fitness involves the components of physical fitness related to the health status, including cardiovascular fitness, musculoskeletal fitness, body composition and metabolism.

During the last decade in Serbia scientists have unified test procedures for school children, so that results could be compared with those pertaining the level of physical fitness of school kids from other countries.

Test results provide useful information regarding the process of evaluation level of physical fitness and health, effectiveness of the physical education process and early talent identification.

Some countries produced normative-referenced percentile values for single fitness measures across a wide age range (Hoffmann et al., 2019). These percentile values are being used to help interpret the performance of an individual compared to a reference population, which can be used to identify both individuals with low performance who need improvement and to identify high performing individuals as part of a sports talent identification program (Hoare & Warr, 2000).

Some studies suggested that individuals who perform in the lowest quintile (≤ 20th percentile) are at the potential risk of poor health (Blair et al., 1989; Ortega et al., 2011), whereas a latest one even suggests that the results in zone 55-60 percentile may be at risk of poor health outcomes (Buchan, Knox, Jones, Tomkinson, & Baker, 2019).

Although there is a growing body of evidence, the relationship between physical fitness components, health and anthropometric characteristics in children has not yet been explored in depth (D'Hondt et al., 2011).

Preadolescence, also known as a pre-teen, is a period in human development after early childhood and pre-adolescent years (McKean, 2005), characterized as a time of major change and growth, bringing about psychological, physical and social alterations. This stage is generally defined as the one to which 10 to 13 year-old children belong, (Hatfield & Broadribb, 2008) and at this period girls are heading towards puberty, which physiologically starts between the age of 8 and 13 years (Farello, Altieri, Cutini, Pozzobon, & Verrotti, 2019).

Physical fitness improves with age (Jurimae & Jurimae, 2001) and according to Malina et al. (2004) gender differences in motor development become significant from the age of 10 years (preadolescence) when sexual maturation starts. Also, Balyi and Hamilton (2004) pointed that one of the most important periods of skill development for children is between the ages of 9 and 12. Little et al. (1997) indicated that (with the exception of flexibility) running speed, functional strength, explosive strength, static strength, upper body power, and aerobic power improve significantly with maturation of girls.

The relationship between anthropometric variables and physical performance has a higher complexity during the growth process and multiple variations may occur in the morphological growth and physiological development (Fort-Vanmeerhaeghe, Montalvo, Latinjak, & Unnithan, 2016). The first data on the influence of anthropometrical parameters to physical fitness were presented by Malina, Bouchard and Bar-Or (2004). Some latest research results demonstrated that in the period of growing up chronological age is a main determinant of physical fitness of both boys and girls, sex playing a limited role, while the role of anthropometry was less important (Milanese, Sandri, Cavedon, & Zancanaro, 2020).

Physical activity in this age is associated with improved psychological well-being, cognitive development, social behavior and lower levels of adult cardiometabolic risk factors (Strong et al., 2005; Physical Activity Guidelines Advisory Committee, 2018; WHO, 2010; Australian Government Department of Health, 2019). There is the evidence that physically active adults had significantly better childhood physical fitness (10-11 years old) test scores than the inactive adults did (Dennison, Straus, Mellits, & Charney, 1988).

Unfortunately, over the last few decades, children's physical activity levels have dramatically decreased, worldwide (Anderseen et al., 2006; Hands & Larkin, 2002). In a large study conducted in 146 countries (2001-2016) including 1,6 million students aged 11–17 years (Guthold, Stevens, Riley, & Bull, 2020) in 2016, 81,0% of students aged 11–17 years were insufficiently physically active (77,6% of boys and 84,7% of girls).

The same tendency was also noticed in Serbia. That is, in all age groups of school children decrease of physical activity with aging (Institute of Public Health of Serbia „Dr Milan Jovanovic Batut", 2018) was observed. What is more, there are several domestic studies which point out the low level of physical fitness (Djokic, Idrizovic, Dulic, & Levajac, 2014; Djokic, 2014) and relation to health of Serbian children from 6-14 years of age compared with results of same age in other countries (Ostojic, Stojanovic, M., Stojanovic, V., & Maric, 2010; Ostojic & Stojanovic, 2010; Ostojic, Stojanovic, M.D., Stojanovic, V., Maric, & Njaradi, 2011)

Worldwide studies have confirmed that girls are less active than boys, (Guthold et al., 2020; Caspersen, Pereira, & Curan, 2000; Telama & Yang, 2000; Riddoch et al., 2004). Serbia follows this negative trend as well (Institute of Public Health of Serbia „Dr Milan Jovanovic Batut", 2018). It is proved that girls are physically more inactive and become less active over age unlike boys (Radisavljević, 2009; Živković, Marković, & Stamenković, 2013).

Thus, it seems that girls' school age population needs special attention, which will focus on solving problems regarding their physical activity and potentially higher health risks in adulthood. The leading cause of death in Serbia is the cardiovascular disease. Actually, the country belongs to the group of the 10 most vulnerable countries in the world (Djokic, 2017). With share of women in the total number of deaths in 35 years increased from 52% to 55% (Marinković, 2012), it could be related with the lower level of physical fitness.

Therefore, there is an interest to research relations between anthropometry and physical fitness during the childhood, especially in preadolescence, in order to provide more information on the developmental process. It is not well known whether a relationship actually exists between motor abilities and anthropometric parameters in children or between different motor ability (Milanese et al., 2010). There should also be norms which could be used for recommendations according to obtained tests results.

Consequently, the aim of this study was anthropometric characteristics and physical fitness in a sample of 378 healthy girls aged from 10 to 13. More specifically, age and specific differences in anthropometry (body height, body weight and body mass index), relations with physical fitness (i.e., speed, strength and endurance, muscular power and flexibility) and producing normative percentile values for five physical fitness measures.

Methods

Sample and study design

A cross sectional study was conducted in period of ten weeks to test anthropometry and physical fitness in 10 to 13-year-old girls (i.e., from classes 3 to 6). The sample of participants in this research consisted of 378 girls, attending 5 public primary schools from urban (i.e., cities > 10,000 inhabitants) and rural (i.e., cities/villages – less than 10,000 inhabitants) areas of the city Sremska Mitrovica. The testing period per school lasted for two weeks. The participants' parents (in this study) signed an informed consent for their children's participation prior to data collection. The study was conducted according to the declaration of Helsinki.

Four hundred and twenty students, who attended grades three to six, at the start of the study**,** were invited to take part (in the study). Informed consent and valid data were obtained from 378 children. Chronological age with one decimal was calculated for each child, as the difference between test date and birth date. The Number of participants and the age for analyzed groups (grades) data are shown in Table 1.

Table 1. Age characteristics (means ± SD) of the subjects

	N	Age (years)
3rd grade	92	10.5±0.5
4th grade	80	11.5±0.5
5th grade	97	12.4±0.6
6th grade	109	13.6±0.3
Total	**378**	

Assessment of the Anthropometric Status

Prior to physical fitness testing, body height (cm) was measured without shoes to the nearest 0.5 cm with portable stadiometers (Harpenden, Holtain Ltd., Crymych, UK). In addition, body weight (kg) was determined in light clothing and without shoes (0.1 kg) with body composition monitor (InnerScan BC-610, Tanita, Japan). Body mass index (BMI) was calculated as kg/m^{2}.

Physical fitness tests

Physical fitness was determined using five different tests from motor fitness test batteries of Eurofit (1993) and Fitnessgram (2010). The tests included the following items:

Sprint run for 20 meters – to define the running speed, by measuring the shortest time which the participants can possibly cover a 20-meters distance.

The"bent knee push-up" – to define strength and endurance of the upper body muscle groups. Based on the FITNESSGRAM standards, most elementary school females) could not complete, at least, one of regular push-ups. In the FITNESSGRAM (Cooper Institute, 2001) the reliability coefficient of .96 was obtained using a bent-knee push-up.

Sit-up Test for 30 seconds – to define the abdominal strength and muscles endurance.

Standing long jump – to define explosive leg power.

Sit and reach test – to define flexibility, and specifically, flexibility of the lower back and hamstring muscles.

All tests were performed in the respective school gyms during official physical education classes, using standardized test protocols. The physical fitness tests were conducted by the qualified personnel (ensured by means of frequently conducted instruction classes). The qualification of the personnel was ensured by means of frequently conducted instruction classes. Before testing, all children conducted a 10-minute standardized warm-up program, consisted of light running followed by different conditioning activities (e.g., side steps, backwards run, skipping, submaximal plyometric exercises and short distance sprints).

Statistical Analyses

Anthropometric characteristics and physical fitness test data were analyzed by age. Mean values and standard deviations were calculated for each group.

Age specific percentile values (i.e., P_5 to P_{95}) were generated using the Lambda, Mu, and Sigma method.

Kolmogorov-Smirnov test suggested that the data are not normally distributed, so to determine whether there are statistically significant differences in anthropometric characteristics and motor fitness between the ages, the nonparametric Kruskal-Wallis H test was applied. The *Dunn's post hoc Test* of Multiple Comparisons was also applied between age groups.

A Spearman's correlation was run to determine the relationship between anthropometric characteristics and results of physical fitness tests. Correlation analyses were done on a whole sample, and between age groups (as they grow up). Cohen (1988) convention was used for describing the strength of the correlation as: .00-.19"very weak"; .20-.39"weak"; .40-.59"moderate"; .60-.79"strong" and .80-1.0"very strong".

Level of significance was set at *p*<0.05for each analysis. All statistical analyses were performed in SPSS statistical software (SPSS23.0, IBM Inc., Chicago, IL, USA).

Results

Results of descriptive analyses

Table 2 demonstrates descriptive characteristics and mean of anthropometric characteristics, results of physical fitness tests and differences in overall period (10-13 years) and between age groups.

Table 2. Descriptive characteristics of the sample

	Age	N	Mean±SD	Difference between ages	
Body height	10	92	137,6±6,5	10 - 13	**20,0**
	11	80	145,2±7,5	10 - 11	7,7
	12	97	150,1±7,3	11 – 12	4,8
	13	109	157,6±7,1	12 – 13	7,5
Body weight	10	92	32,9±7,6	10 - 13	**15,2**
	11	80	37,8±9,2	10 - 11	4,9
	12	97	42,5±9,8	11 – 12	4,7
	13	109	48,2±11,2	12 – 13	5,7
BMI	10	92	17,2±2,9	10 - 13	**2,0**
	11	80	17,8±3,3	10 - 11	0,6
	12	97	18,7±3,3	11 – 12	0,9
	13	109	19,3±3,6	12 – 13	0,5
Sprint Run for 20 meters	10	92	4,99±0,42	10 - 13	**-0,44**
	11	80	4,78±0,40	10 - 11	-0,21
	12	97	4,56±0,44	11 – 12	-0,22
	13	109	4,56±0,41	12 – 13	-0,01
Bent knee push-up	10	92	15,5±12,5	10 - 13	**-1,5**
	11	80	16,3±11,9	10 - 11	0,9
	12	97	15,6±12,1	11 – 12	-0,7
	13	109	14,0±7,1	12 – 13	-1,6
Sit-up	10	92	16,1±4,3	10 - 13	**3,6**
	11	80	18,4±4,1	10 - 11	2,4
	12	97	19,6±4,5	11 – 12	1,2
	13	109	19,7±3,2	12 – 13	0,1
Standing long jump	10	92	117,8±18,5	10 - 13	**26,2**
	11	80	125,6±20,2	10 - 11	7,8
	12	97	138,8±22,0	11 – 12	13,2
	13	109	143,9±23,2	12 – 13	5,1
Sit and reach	10	92	20,1±6,4	10 - 13	**-0,3**
	11	80	21,0±7,4	10 - 11	0,9
	12	97	19,3±6,4	11 – 12	-1,7
	13	109	19,8±6,9	12 – 13	0,5

Numbers indicate the arithmetic mean, followed by the respective standard deviation.

Table 3. Smoothed age percentile values for the physical fitness tests

Age (years)	P_5	P_{10}	P_{20}	P_{30}	P_{40}	P_{50}	P_{60}	P_{70}	P_{80}	P_{90}	P_{95}
Sprint Run for 20 meters											
10	5,58	5,52	5,40	5,23	5,10	5,00	4,94	4,79	4,61	4,43	4,25
11	5,47	5,33	5,05	4,98	4,84	4,78	4,70	4,59	4,40	4,30	4,19
12	5,29	5,10	4,83	4,73	4,65	4,56	4,44	4,32	4,22	4,07	3,87
13	5,42	5,09	4,85	4,73	4,64	4,52	4,44	4,35	4,21	4,06	3,91
Bent knee push-up											
10	1	3	5	6	10	14	17	20	26	32	40
11	2	5	7	10	12	14	16	20	24	32	40
12	4	4	7	10	11	13	15	17	20	29	40
13	2	4	9	10	11	14	15	18	20	21	28
Sit-up											
10	9	11	13	14	15	16	17	18	19	21	23
11	12	13	16	17	18	19	20	21	22	23	25
12	14	15	16	17	18	19	20	21	23	25	28
13	15	16	17	18	19	19	20	21	22	24	25
Standing long jump											
10	90,0	97,0	100,6	107,9	113,2	118,0	121,8	128,0	134,2	139,7	150,4
11	88,4	98,1	110,0	114,3	121,0	123,5	130,0	137,8	145,0	153,0	160,7
12	108,0	113,4	119,0	124,0	129,2	136,0	143,0	150,0	156,4	171,6	180,6
13	104,5	118,0	124,0	131,0	135,0	142,0	150,0	157,0	162,0	177,0	187,5
Sit and reach											
10	9,0	12,0	14,0	16,5	18,0	21,0	22,0	24,0	25,0	29,0	31,0
11	9,1	11,0	13,2	16,3	19,4	22,0	23,0	24,7	28,0	30,0	34,9
12	11,0	13,0	14,8	16,2	18,0	19,0	20,9	22,0	23,0	26,2	30,1
13	8,0	11,0	14,0	16,0	17,0	19,0	21,0	23,0	25,5	29,0	31,0

Considering smoothed age percentile values for the physical fitness tests (Table 3) showed in Figure 1. curvilinear enhancements were detected for measures of running speed, abdominal strength and muscle endurance and explosive leg power. Notably, no performance development was observed for strength and endurance of the upper body muscle groups and the sit and reach test.

Furthermore, margins between P10, P50, and P90 hardly changed over time for the Bent knee push-up and standing long jump test. Margins between percentile curves decreased with advancing age for the Bent knee push-up test and increased for the long jump test.

A Kruskal-Wallis H test demonstrated that there was a statistically significant difference in all anthropometric characteristics between classes in: Body height $\chi^2(3)$ = 203,177, p = 0.000, body weight $\chi^2(3)$ = 114,591, p = 0.000, BMI $\chi^2(3)$ = 25,523, p = 0.000 and physical fitness tests for running speed $\chi^2(3)$ = 65,904, p = 0.000, abdominal strength and muscles endurance $\chi^2(3)$ = 44,888, p = 0.000 and explosive leg power $\chi^2(3)$ = 74,521, p = 0.000. There was no significant difference in terms of results of tests for strength and endurance of the upper body muscle groups and flexibility. The post hoc the *Dunn's Test* of Multiple Comparisons was done between age groups and results are illustrated in Table 4.

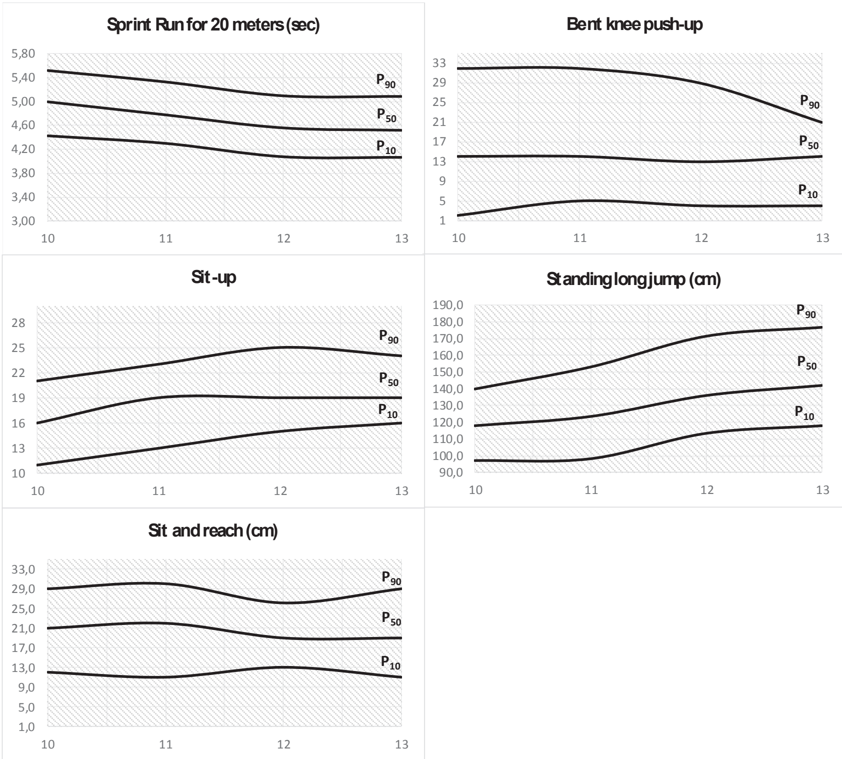

Figure 1. Smoothed LMS curves for the 10th, 50th, and 90th percentiles of the physical fitness tests in girls from age 10 to 13 years.

Table 4. Results of Post Hoc *Dunn's Test* of Multiple Comparisons

Variable	Sample 1	Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig,
Body height	10	11	-80,421	16,697	-4,817	0,000	0,000
	11	12	-54,7889	16,495	-3,322	0,001	0,005
	12	13	-78,989	15,245	-5,181	0,000	0,000
Body weight	10	11	-50,675	16,703	-3,034	0,002	0,014
	11	12	-54,219	16,502	-3,286	0,001	0,006
	12	13	-52,553	15,251	-3,446	0,001	0,003
BMI	11	12	-69,526	23,814	-2,92	0,004	0,021
Sprint Run for 20 meters	10	11	-51,325	16,702	3,073	0,002	0,013
	11	12	57,029	16,500	3,456	0,001	0,003
Sit-up	10	11	-70,084	16,643	-4,211	0,000	0,000
Standing long jump	11	12	-57,502	16,499	-3,485	0,000	0,003

Body height and body weight displayed significant increase in all age groups as they grow up and their ratio (body mass index) was significant in age between 11 and 12 years old. This period of growth pointed significant difference in running speed at the ages of 10-12, abdominal strength and muscles endurance at the ages of 10-11 and explosive leg power at 11-12 years of age.

Significant positive interaction of age on all samples were detected for body height ($r_s(378) = .73$, $p < .000$), weight ($r_s(378) = .55$, $p < .000$) and in BMI ($r_s(378) = .26$, p < .000), whereas, considering motor abilities, there is a moderate positive relation with regards to explosive leg power (r_s(378) = .44, p < .000), weak positive relation with running speed (r_s(378) = -.39, p < .000) and abdominal strength and muscles endurance (r_s(378) = .31, p < .000).

In all samples there was found out/noticed/revealed a weak negative correlation between body height and speed (r_s(378) = -.33, p < .001), considerably weak negative correlation with strength and endurance of the upper body muscle groups (r_s(378) = -.13, p < .05), and weak positive correlation between explosive leg power (r_s(378) = .38, p < .001) and abdominal strength and muscles endurance (r_s= .21, n = 378, p < .001).

In case the of body weight, there was observed very weak negative correlation between speed, (r_s(378) = .16, p < .001), strength and endurance of the upper body muscle groups (r_s(378) = .18, p < .001) and flexibility (r_s(378) = .11, p < .05), and weak positive correlation with explosive leg power (r_s(378) = .21, p < .001).

As for BMI index, it appears to be in very weak negative correlation with strength and endurance of the upper body muscle groups (r_s(378) = .16, p < .01) and flexibility (r_s(378) = .14, p < .01).

Correlation analyses were also carried out between age groups to determine relations between anthropometric variables and fitness results.

At age 10-11 years significant interactions were detected between body height (r_s(172) = .46, p < .000) and weight (r_s(172) = .28, p < .000). Considering motor abilities, weak positive relation with abdominal strength and muscles endurance (r_s(172) = .31, p < .000), weak positive relation with speed (r_s(172) = -.27, p < .000) and with explosive leg power (r_s(172) = .20, p < .01), were noticed.

Results of the correlation analyses regarding 10 and 11 year-old girls, indicated a weak negative correlation between body height and speed (r_s(172) = -.24, p < .05) and strength and endurance of the upper body muscle groups (r_s(172) = .21, p < .01), whilst concerning abdominal strength and muscles endurance (r_s(172) = .24, p < .01) and explosive leg power (r_s(172) = .21, p < .01) weak positive association was found out. In case of body weight, there was noted a very weak negative association between strength and endurance of the upper body muscle groups (r_s(172) = .17, p < .05), while BMI index seemed to be in very weak negative correlation with flexibility (r_s(172) = .17, p < .05).

Significant positive main effects regarding subjects 11-12 years of age were detected for body height (r_s (177) = .30, p < .000), weight (r_s(177) = .28, p < .000) and body mass index (r_s(177) = .18, p < .05).

As far as the motor abilities are concerned, a weak positive relation with speed (r_s(177) = -.28, p < .000) and explosive leg power (r_s(177) = .27, p < .01) was identified.

Results correlation analyses regarding 11 and 12 year-old girls, demonstrated a very weak negative correlation between body height and speed (r_s(177) = -.19, p < .05), weak negative correlation with strength and endurance of the upper body muscle groups (r_s(177) = .22, p < .01) and weak positive association between explosive leg power (r_s(177) = .21, p < .01). In case of Body weight, weak negative association between strength and endurance of the upper body muscle groups (r_s(177) = .26, p < .01) and flexibility (r_s(177) = .20, p < .01), was observed. What is more, body mass index proved in weak negative correlation with strength and endurance of the upper body muscle groups (r_s(177) = .24, p < .01) and flexibility (r_s(177) = .21, p < .01).

Significant positive main effects concerning 12-13 year-old subjects, were detected only for body height (r_s(206) = .46, p < .000) and body weight (r_s(206) = .28, p < .000).

Results of correlation analysis in girls at the age of 12 and 13, indicated that Body weight is in weak negative association with abdominal strength and muscles endurance (r_s(206) = .23, p < .01) and strength and endurance of the upper body muscle groups (r_s(206) = .020, p < .01), while BMI index is in weak negative correlation with abdominal strength and muscles endurance (r_s(206) = .23, p < .01), strength and endurance of the upper body muscle groups (r_s(206) = .22, p < .01) and in considerably weak correlation with explosive leg power (r_s(206) = .16, p < .05).

Discussion

The main purpose of this study was to examine anthropometric characteristics and physical fitness in girls over the grow period of age 10 to 13. The main findings of the study were that significant main effects of age were detected for body height, body weight and body mass indexes and that this period of intensive body size changes revealed significant positive effect on some components of physical fitness, especially in speed, abdominal strength and endurance and leg explosive power.

Average values for anthropometry and physical fitness with previous researches in Serbia, conducted in the city of Belgrade (Gajević, 2009) and with available data from some other countries of European Union (EU), such as Italy, Spain, Belgium and Slovakia – for girls 10, 12 and 13 years old (Thomas & Palma, 2018; Sainz, 1996; Lefèvre, Bouckært, & Duqet, 1998; Ružbarská, 2016; Moravec, Kampmiller, & Sedlácek, 1996).

Comparing results dating back in 2009 in Serbia, girls of all ages were spotted with a lower body height and body weight and nearly the same BMI values. The body height of girls aged 12 and 13 was higher than of those in European Union.

In the test of speed run for 20 meters, girls were slower than the same population in Italy (Thomas & Palma, 2018). For bent knee push-ups we did not find comparison data, but we used norms for school children population in Serbia (Sudarov, 2007), and all achieved results were under average results. Average Sit up test results maintain the same as those back in 2009 (Gajević, 2009), and in same range as the results in the EU. Standing long jump test results are more or less the same (Gajević, 2009) as in European girls. Sit and reach test results were better than in those recorded in 2009 (Gajević, 2009), but lower than those drawn in EU countries concerning 12 and 13-year-old girls.

As it has already been mentioned, nowadays most countries in order to carry out fitness tests for specific populations provide age-related fitness percentile values (Ortega et al., 2011; Thomkinson, et al., 2018), thus is why the normative – referenced percentile values were provided for this population, as well.

Enhancements were detected for running speed, abdominal strength and muscle endurance and explosive leg power; yet, no performance development was observed for other tests. Changes overtime between P10, P50 and P90 changed decreasing in strength and endurance of the upper body muscle groups and increasing in explosive leg power.

Comparing our results with European Normative values for 30 countries (Thomkinson et al., 2018) with values at 50th percentile, we found out that results of abdominal strength and muscles endurance are more or less equal, in explosive leg power much lower in all ages and in flexibility were higher at the age of 10 and 11. On the other hand, they were lower at the age of 12 and 13, and much contrasting Canadian normative values in all ages (Hoffman et al., 2019).

Concerning the percentage of girls that perform in the lowest quantile (≤ 20th percentile), which means the level of potential poor health risk (Blair et al., 1989; Ortega et al., 2011), we noted that in tests of speed there were 15,2 to 19,7% of participants – with highest number at the age of 11. Results for strength and endurance of the upper body muscle groups showed that 20,0 - 26,1% of girls belong to the risk group, most of them aged 10. Abdominal strength results revealed a worse outcome and 18,8 - 29,4% of girls were in the zone of results lower than 20th percentile, with highest number at the age of 13 and in explosive leg power 20,6 - 21,3%, with highest number exhibited at the age of 13. The percentage of the lowest results in test results for flexibility was 19,6 - 21,3 with the highest number displayed at the age of 11.

Applied test battery in this research evaluates muscular fitness component and speed/agility. These results of physical fitness level could be used as markers of health (cardiovascular, skeletal and mental health).

Ortega, Ruiz, Castillo and Sjöström (2008) found out that muscular fitness together with cardiorespiratory fitness seem to have a combined and accumulative effect on cardiovascular profile in this population, changes in muscular fitness and speed/agility seem to have a positive effect on skeletal health and increased fitness level may have a direct effect on mental health (neurochemicals in the brain such as serotonin or endorphins that function to elevate mood).

When proceeding to comparisons regarding the results of 95th percentile value, we can safely claim that they were nearly the same as those described in these researches.

In this study, body height and body weight showed a significant increase in all age groups as they grow up. That is**,** in relation with Peak height velocity (PHV) – the period of time when a child experiences their fastest upward growth in their stature, change in body size (body height, weight and BMI) (Beunen & Malina, 1988; Malina, Bouchard, & Bar-Or, 2004) and in girls PHV approximately occurs at the age 11 (Rogol, Clark, & Roemmich, 2000). Body mass index was significantly increased in a time period between 11 and 12 years of age.

Concerning physical fitness differences during the growth period, results revealed significant improvement in running speed at the of 10-12**,** which appears to be in accordance with those drawn by Issurin (2009) and Viru (1998). This can be related to findings by Borms (1986) according to which there is a period of accelerated adaptation for speed reported to occur around the age of 12 years in girls. The results of the beforementioned study are contradictory with the statement made by Butterfield et al. (2004), who found no association between longitudinal growth rates of height and body mass and improved running speed in children aged 11–13 years. The role of age in improving running speed in this period is possibly associated with an increasing stride length and frequency and neuromuscular coordination (Milanese et al., 2020). According to Whithall (2003) claims, the rate of progression of speed development is dramatically reduced in females at the age of 12, as we also confirm in our research.

Concerning strength, we noticed improvement in results of tests for abdominal strength and muscles endurance in age 10-11. Normally, strength and muscle endurance should increase at this age until the age of 14, when it begins to plateau in girls (Viru, 1998; Issurin, 2009; Ford et al., 2011). In addition, as Beunen (1997) and Issurin (2009) clearly reported, there was a substantial increase in explosive leg power of 11-12 years of age. Besides, Butterfield et al. (2004) reported a clear association between the vertical jump height and pre-adolescent growth levels of their study. Growth-related changes were associated with increased vertical jump height in both leg length and muscle mass.

Chronological age affects performance by improving the integration of the central nervous system and the skeletal-muscle system for intended motor performance (Haywood & Getchell, 2001) and can modulate muscular strength in youth (Langendorfer & Roberton, 2002).

Growth-related changes demonstrated association with all physical fitness test results. Increasing in body height, displayed positive correlation with the explosive leg power and abdominal strength and endurance, while a negative impact on speed and upper body strength and endurance was detected.

As far as the increase in body weight is concerned, positive impact on explosive leg power was traced, yet it was found to be negatively correlated with speed, upper body strength, endurance and flexibility. Similar results were also recently announced in a research conducted by He et al. (2019), in which he claims that the body weight increase has a negative association with strength of lifting the body. Regarding BMI index, it was found to be in a very weak negative correlation with strength and endurance of the upper body muscle groups and flexibility, as described in the study of Hu et al. (2020).

Since that results in this research showed a moderate relation with explosive power and a weak relation with running speed and muscular strength and endurance, that is in relation findings of Malina et al. (2004) and Milanese et al. (2020) that anthropometry dimensions are not a major determinant of performance in childhood, but the chronological age is.

The findings of this study have to be seen in the light of some limitations. First, cross-sectional studies, such as this, may not provide definite information about cause-and-effect relationships like longitudinal studies. Second, the relatively small number of the tested subjects in age categories could have led to an overestimation of the differences. Third, the participants were recruited from a limited geographical area. Fourth, differences in testing conditions (practice and testing surfaces) and measurement errors might have occurred. Fifth, performance of the tests depended on volitional effort, thus there was no specific criteria to indicate that maximal performance was attained.

Conclusion

The information obtained from this study can provide a useful context for understanding both growth-related changes in anthropometric characteristics and physical fitness and their association.

The continuous monitoring of physical fitness and anthropometry status, considering growth-related changes should be carried on in the context of physical education classes with a view to providing information of their level, with the purpose of offering recommendations and advice for participating in physical activity and improvement of motor potential.

STATEMENT

In their statements, the authors confirmed the absence of any conflict of interest.

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