Vztah mezi stavbou těla a kardiovaskulární zdatností

Association between Body Composition and Cardiovascular Fitness

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Abstract
The purpose of this study was to examine associations between body composition measures and cardiorespiratory fitness in Slovak high school students. Data on body composition and cardiorespiratory fitness were obtained from students attending 14 high schools in Presov self-governing region. Body composition was measured using a direct segmental multi-frequency bioelectrical impedance analyzer InBody 230 (Biospace, 2006). Cardiorespiratory fitness was determined by multistage shuttle run and Ruffier test. The results showed that boys had higher level of cardiorespiratory fitness indicated by VO_2max and Ruffier index than girls across all age groups. Overall, maximal oxygen uptake of both boys and girls increased with age. According to VO_2max the level of cardiorespiratory fitness was poor for boys and girls. The physical development was found to be normal as expressed by BMI. Mean values of WHR and VFA showed normal degree of abdominal obesity and visceral fatness. Correlation analysis showed inverse association of percent body fat and waist-hip ratio with performance in multistage shuttle run for both genders. Body height of girls negatively correlated with performance in Ruffier test. There were no statistically significant associations between Ruffier index and body composition measures for boys.

Key words: *health, adolescence, physical fitness, fatness.*

Body composition and aerobic capacity are important components of health-related physical fitness (Welk & Meredith, 2008). Cardiorespiratory fitness reflects the overall capacity of the cardiovascular system to carry out prolonged strenuous exercise (Ruiz et al., 2006). A low score on the field test estimates of aerobic capacity may be influenced by many factors including body composition (Lloyd, Bishop, Walker, Sharp, & Richardson, 2003; Meredith & Welk, 2008). Excess amount of body fat negatively correlates with other fitness components, especially with aerobic fitness (Bovet, Auguste, & Burdette, 2007; Laframboise & deGraauw, 2011; Razak, Maizi, & Muhamad, 2013). Several studies have shown that children with high cardiorespiratory fitness have lower overall and abdominal fatness and a healthier cardiovascular profile by meeting physical activity guidelines (Morrow et al., 2013; Ortega, Ruiz, & Castillo, 2013; Stigman et al., 2009). Acceptable levels of aerobic capacity are associated with a reduced risk of high blood pressure, coronary heart disease, obesity, diabetes, some forms of cancer, and other health problems in adults (Cooper Institute, 2010). Increasing physical fitness in overweight children and adolescents may have many positive effects on health, including lower body fat levels (Ortega et al., 2013). Adequate body composition is relevant in terms of prevention of increased risk of obesity (Miguel-Etayo, 2013; Rauner, Mess, & Woll, 2013). Remarkable and unfavorable changes in body composition and cardiorespiratory performance are caused by continuously decreasing intensity of habitual physical exercise and sedentary lifestyle (Photiou et al., 2008). The growing sedentary lifestyle is reflected by a poor capacity for organic adaptation to physical activity and a deficient capacity for recovery (Hernández-Alvarez, Velásquez-Buendía, Martínez-Gorronno, & Garoz-Puerta, 2009).

Cardiorespiratory fitness profiles of children and adolescents from all over Europe have been studied by several authors (Cuenca-García et al., 2012; Denton et al., 2013; Grassi, Turci, & Sforza, 2006; Guerra, Ribeiro, Costa, Duarte, & Mota, 2002; Ortega et al., 2011; Photiou et al., 2008;

Ruiz et al., 2006; Rychtecký, Pauer, Janouch, Sýkora, & Stejskal, 1995; Stigman et al., 2009). A study by Olds, Tomkinson, Léger and Cazorla (2006) showed that Slovak adolescents placed 17th out of 37 investigated countries worldwide in terms of their level of cardiorespiratory fitness. The most recent nationwide physical fitness testing in Slovak children and adolescents was conducted by Moravec et al. (1996) who reported low level of cardiorespiratory fitness of Slovak youth. However, there is a paucity of information on the relationship between body composition and cardiorespiratory fitness levels of Slovak students.

The purpose of this study was to provide descriptive data on body composition and cardiorespiratory fitness and to examine associations between body composition measures and cardiorespiratory fitness in Slovak high school students.

METHOD

This cross-sectional study was conducted as a part of the research project APVV 0768-11 Somatic, functional and motor development of secondary school students in the reflection of their physical activity. Physical fitness levels and body composition were determined in a total of 576 adolescents. Of these, 289 were boys (mean age 17.5 ± 1.26 years) and 287 were girls (mean age 17.0 ± 1 year). For purpose of analysis, children were divided into 5 age groups: 15-year-olds (n = 132), 16-year-olds (n = 153), 17-year-olds (n = 128), 18-year-olds (n = 130) and 19-year-olds (n = 46). The students tested attended 14 high schools located in Prešov self-governing region in eastern Slovakia. For the purposes of testing, schools and classes were selected randomly. Written informed consent was obtained from children's parents and individual school principals prior to testing. The study was conducted in accordance with the Helsinki declaration and was approved by the university ethics committee.

Assessment of Anthropometric measures and Body composition

Body height (BH) was measured to the nearest mm with participant standing barefoot and upright against a SECA portable stadiometer. Body mass index (BMI) was calculated from the ratio of body mass to body height in meters squared.

Body composition (BC) and body weight (BW) of study participants was determined using portable body composition analyzer InBody 230 (Biospace Co. Ltd., 2006). Body composition analysis included parameters of percent body fat (% BF), visceral fat area (VFA) and waist-to-hip ratio (WHR), which have been reported to be associated with CRF.

Cardiorespiratory fitness (CRF)

Multistage shuttle run described by Léger and Lambert (1982) was administered to estimate CRF level. Ten participants performed the test at the same time. The final test score based on the number of 20-meter distances covered was converted to an estimate of maximal oxygen uptake (VO_2max).

Ruffier test described by Moravec (1990) was also administered to determine the CRF levels. The test is used to assess body's response capacity and recovery from performing 30 squats in 45 seconds. The final test score is expressed as Ruffier index (RI). The index is calculated using resting pulse rate taken after 20 minutes of sitting still, pulse rate taken after performing 30 squats and pulse rate taken after 1 minute of recovery in a seated position. The pulse rate was measured by palpation on the carotid artery during a 10-second interval.

Data analyses

The raw data on body composition and cardiorespiratory fitness were aggregated by age and gender. Means and standard deviations were calculated by age and gender for anthropometric measures, cardiorespiratory parameters and body composition measures. The cardiorespiratory fitness levels and body composition were compared between genders using Mann-Whitney U test.

The association between body composition measures and cardiorespiratory fitness levels expressed by maximal oxygen uptake and Ruffier index were determined using Spearman's rank order correlation.

RESULTS

Descriptive data on basic anthropometric measures: body height (BH), body weight (BW) and BMI as well as body composition are presented in Table 1. Mean values in BH, BW and BMI were higher in boys across all age groups. All three anthropometric measures increased with age. The greatest difference between genders for BH was found for 19-year-olds; however, the difference in BH and BMI was greatest in 18-year-olds. According to standards for BMI proposed by Stupnicki, Tomaszewski, and Milde (2013), mean BMI values for boys and girls show normal rate of physical development with least risk at most disease.

Descriptive data on body composition for both genders are presented in Table 2. Among body composition parameters analyzed were percent body fat (% BF), visceral fat area (VFA) and waist-hip ratio (WHR).

For both girls and boys, % BF increased with age. Lower % BF mean values were found in boys across all age groups. The greatest gender difference in % BF was found in 19-year-olds. However, this finding may be misleading due to small sample size. According to Fitnessgram performance standards (California Department of Education, 2013) for % BF for males and females, boys and girls achieved Healthy Fitness Zone in all ages. The results showed that boys were taller and heavier than girls and had lower amount of body fat.

Visceral Fat Area is the cross-sectional visceral area obtained from the computed tomography view of the abdominal region (Biospace, 2006). The normal VFA value is under 100 cm^2. Mean VFA values for girls and boys show normal degree of visceral fat area.

Waist-hip ratio is an accurate anthropometric indicator for the prediction of high blood pressure in overweight and obese children and adolescents (González-Jiménez, Montero-Alonso, & Schmidt-Rio Valle, 2013). In recent years, WHR has been suggested to be a more accurate measure of body fat distribution and abdominal obesity compared to BMI and to be more closely associated with subsequent morbidity and mortality (Huxley, Mendis, Zheleznyakov, Reddy, & Chan, 2010). Ratios of waist to hip circumference >0.95 for men and >0.8 for women are associated with the cardiovascular disease risk factors of insulin resistance, high cholesterol, and hypertension (Powers & Howley, 2009). The normal range of WHR is 0.80 to 0.90 for males and 0.75 to 0.85 for females. The results showed that mean values of boys and girls across all ages fell within normal range for WHR.

Descriptive data on cardiorespiratory fitness levels are presented in Table 3. With regard to distance covered, boys ran 471 meters more than girls. The greatest difference in VO_2max mean values was found between 15-year-old boys and girls. For both boys and girls, VO_2max increased with age. VO_2max for boys peaked at 16 years of age and at 17 years of age for girls. There were statistically significant differences between boys and girls for VO_2max ($p < .01$). According to VO_2max classifications for girls and boys aged 13 to 19 years (Cooper, 1982) overall mean values of VO_2max indicate poor level of CRF (see Table 4 and 5). However, according to Cooper's men's and women's aerobics fitness classification, VO_2max of boys was classified as fair, whereas VO_2max of girls was classified as poor. As shown in Table 4 and 5, the highest percentage of boys showed very poor level of CRF, whereas most girls demonstrated poor level of CRF. An interesting finding is that 9.09 percent of 19-year-old girls achieved superior level of CRF. According to Fitnessgram Performance Standards for PACER test (CDE, 2013), boys and girls across all age groups did not achieve Healthy Fitness Zone level.

According to performance standards for Ruffier test for Slovak adolescents (Moravec, 1990), overall mean value of RI showed good level of CRF for boys and average level of CRF for girls. Gender differences in CRF levels expressed by RI were statistically significant ($p < .01$). As shown in Table 3, CRF measured by Ruffier test declined with age for both genders. Girls were found to have higher level of CRF compared to boys at the age of 15 and 17. The greatest gender difference in RI (3.45) across all ages was found between 17-years-olds. According to standards (Moravec, 1990), the highest percentages of boys showed average (15- and 16-year-olds), poor (17-year-olds) and insufficient (18–19-year-olds) level of CRF (see Table 7). Contrary to boys, highest percentages of 15- and 16-year-old girls showed good level of CRF. In older age groups, level of 18- and 19-year-old girls declined to insufficient CRF level (see Table 6).

Spearman's rank order correlation (see Table 9) showed inverse association between % BF ($r = -.24$, $p < .01$), VFA ($r = -.16$, $p < .01$) and WHR ($r = -.18$, $p < .01$) and performance in multi-stage shuttle run for girls, respectively. Body height of girls negatively correlated with performance in Ruffier test ($r = .15$, $p < .01$). There were no statistically significant associations between Ruffier index and body composition measures for boys (see Table 8). For CRF measured by shuttle run, associations for boys were statistically significant between % BF ($r = -.14$, $p < .01$) and WHR ($r = -.17$, $p < .01$) and maximal oxygen uptake.

Table 1: Descriptive statistics of physical characteristics

Parameters	BH		BW		BMI	
	M	*SD*	*M*	*SD*	*M*	*SD*
All participants (n = 576)	170.62	7.90	63.30	7.22	21.60	0.46
Males (n = 289)	176.20	12.23	68.41	12.23	21.92	3.43
Females (n = 310)	165.03	5.89	58.19	10.24	21.27	3.38
15-year-olds (n = 124)	169.70	7.21	60.32	4.14	20.64	0.37
Males (n = 61)	174.79	6.74	63.25	11.28	20.37	3.17
Females (n = 63)	164.60	5.30	57.39	9.32	20.90	3.09
16-year-olds (n = 152)	169.99	8.58	61.86	7.18	21.11	0.35
Males (n = 86)	176.05	6.82	66.94	11.31	21.36	3.27
Females (n = 66)	163.92	5.83	56.78	10.77	20.86	3.71
17-year-olds (n = 132)	171.34	8.20	64.97	8.25	21.78	0.64
Males (n = 63)	177.13	6.25	70.80	12.39	22.23	3.59
Females (n = 69)	165.54	6.15	59.13	10.42	21.32	3.48
18-year-olds (n = 122)	171.60	7.16	65.53	9.64	21.82	1.32
Males (n = 55)	176.66	7.38	72.35	12.72	22.75	3.21
Females (n = 67)	166.53	6.19	58.71	9.38	20.89	2.90
19-year-olds (n = 46)	170.01	10.00	65.75	8.17	21.87	0.28
Males (n = 24)	177.08	6.26	71.53	11.57	22.06	3.60
Females (n = 22)	162.94	4.61	59.97	13.37	21.67	4.27

Note. BH = body height; BW = body weight; BMI = body mass index; *n* = sample size; *M* = mean; *SD* = standard deviation

Table 2: Descriptive statistics of body composition

Parameters	**% BF**		**VFA**		**WHR**	
	M	*SD*	*M*	*SD*	*M*	*SD*
All participants *(n = 576)*	20.60	8.25	53.96	9.26	0.85	0.01
Males (n = 289)	14.76	6.38	47.41	30.76	0.84	0.06
Females (n = 310)	26.43	7.09	60.50	31.51	0.85	0.05
15-year-olds (n = 124)	19.47	8.35	47.87	10.42	0.84	0.02
Males (n = 61)	13.56	6.06	40.50	29.73	0.82	0.05
Females (n = 63)	25.37	7.03	55.23	29.56	0.85	0.05
16-year-olds (n = 152)	20.27	8.84	52.26	12.26	0.84	0.01
Males (n = 86)	14.02	5.99	43.59	29.58	0.83	0.05
Females (n = 66)	26.51	7.18	60.93	31.78	0.85	0.05
17-year-olds (n = 132)	21.21	8.41	57.61	9.86	0.86	0.01
Males (n = 63)	15.26	6.69	50.63	31.98	0.85	0.06
Females (n = 69)	27.16	7.14	64.58	33.30	0.86	0.06
18-year-olds (n = 122)	21.38	6.68	57.46	0.62	0.85	0.01
Males (n = 55)	16.66	6.58	57.02	30.95	0.86	0.05
Females (n = 67)	26.10	6.75	57.89	27.17	0.84	0.05
19-year-olds (n = 46)	21.51	9.40	59.48	15.91	0.85	0.01
Males (n = 24)	14.86	6.56	48.23	29.55	0.84	0.05
Females (n = 22)	28.16	7.96	70.73	41.41	0.86	0.08

Note. % BF = percent body fat; VFA = visceral fat area; WHR = waist-hip ratio; *n* = sample size; *M* = mean; *SD* = standard deviation

Table 3: Means and standard deviations of cardirespiratory fitness measures

	Multistage shuttle run		**Ruffier test**	
	VO_2max		*Ruffier index*	
	M	*SD*	*M*	*SD*
All participants (N = 576)	33.57	6.09	12.48	1.07
Males (*n* = 289)	37.87	7.91	11.72	5.97
Females (*n* = 310)	29.26	5.44	13.23	4.88
15-year-olds (n = 124)	32.31	7.45	11.80	0.04
Males (*n* = 61)	37.58	8.89	11.82	9.43
Females (*n* = 63)	27.04	4.67	11.77	3.35
16-year-olds (n = 152)	34.16	7.31	11.73	2.10
Males (*n* = 86)	39.33	8.30	10.24	4.48
Females (*n* = 66)	28.99	5.64	13.22	4.66
17-year-olds (n = 132)	34.12	5.06	13.37	2.44
Males (*n* = 63)	37.70	6.32	11.64	4.09
Females (n = 69)	30.54	5.75	15.09	5.19
18-year-olds (n = 122)	31.79	5.87	13.13	0.91
Males (*n* = 55)	35.94	7.38	13.77	4.73
Females (*n* = 67)	27.64	5.03	12.48	4.59
19-year-olds (n = 46)	34.37	5.46	13.22	1.34
Males (*n* = 24)	38.23	8.38	12.27	4.84
Females (*n* = 22)	30.51	6.12	14.17	7.09

Note. n = sample size*; M* = mean*; SD* = standard deviation

Table 4: Descriptive statistics of percentages achieving norm-referenced standards for VO_{2max} for girls

VO_{2max}	*Range*	15-year-olds	16-year-olds	17-year-olds	18-year-olds	19-year-olds
Girls		%	%	%	%	%
1. Very poor	<25.0	15.87	25.76	13.04	32.84	22.73
2. Poor	25.0–30.9	47.62	40.91	37.68	40.30	36.36
3. Fair	31.0–34.9	23.81	18.18	33.33	16.41	18.18
4. Good	35.0–38.9	11.11	10.61	5.80	7.46	9.09
5. Excellent	39.0–41.9	1.59	1.51	7.25	2.99	4.55
6. Superior	>42.0	0.00	3.03	2.90	0.00	9.09

Note. VO_{2max} = maximal oxygen uptake

Table 5: Descriptive statistics of percentages achieving norm-referenced standards for VO_{2max} for boys

VO_{2max}	*Range*	15-year-olds	16-year-olds	17-year-olds	18-year-olds	19-year-olds
Boys		%	%	%	%	%
1. Very poor	<35.0	39.34	32.56	38.10	43.64	37.5
2. Poor	35.0–38.3	14.75	24.42	15.87	14.55	16.67
3. Fair	38.4–45.1	19.67	20.93	36.51	30.91	25.00
4. Good	45.2–50.9	21.31	13.95	6.35	9.09	12.50
5. Excellent	51.0–55.9	3.29	4.65	3.17	1.81	8.33
6. Superior	>56.0	1.64	3.49	0.00	0.00	0.00

Note. VO_{2max} = maximal oxygen uptake

Table 6: Descriptive statistics of percentages achieving norm-referenced standards for Ruffier index for girls

Girls	*Range*	*15-year-olds*	*Range*	*16-year-olds*	*Range*	*17-year-olds*	*Range*	*18–19-year-olds*
		%		%		%		%
1. Insufficient	19.5 and >	5.63	20.2 and >	17.91	18.9 and >	25.33	17.1 and >	24.74
2. Very poor	19.4–17.5	0.00	20.1–17.9	0.00	18.8–16.8	12.00	17.0–15.3	8.25
3. Poor	17.4–15.6	4.23	17.8–15.9	14.93	16.7–14.6	12.00	15.2–13.6	15.46
4. Below average	15.5–13.6	14.08	15.8–13.8	13.43	14.5–12.5	17.33	13.5–11.9	13.40
5. Average	13.5–11.7	18.31	13.7–11.8	13.43	12.4–10.4	13.34	11.8–10.2	9.28
6. Good	11.6–9.7	33.80	11.7–9.7	20.90	10.3–8.2	5.33	10.1–8.3	10.31
7. Very good	9.6–7.8	12.68	9.6–7.5	8.96	8.1–6.1	10.67	8.2–6.7	7.22
8. Excellent	7.7–5.8	8.45	7.4–5.6	7.46	6.0–4.0	1.33	6.6–5.0	3.09
9. Superior	5.7 and <	2.82	5.5 and <	2.98	3.9 and <	2.67	4.9 and <	8.25

Table 7: Descriptive statistics of percentages achieving norm-referenced standards for Ruffier index for boys

Boys	*Range*	*15-year-olds*	*Range*	*16-year-olds*	*Range*	*17-year-olds*	*Range*	*18–19-year-olds*
		%		%		%		%
1. Insufficient	16.2 and >	14.75	16.2 and >	10.47	16.2 and >	12.70	15.5 and >	30.38
2. Very poor	16.1–14.4	4.92	16.1–14.8	4.65	16.1–14.4	9.53	15.4–13.9	18.99
3. Poor	14.3–12.6	6.56	14.7–12.8	8.14	14.3–12.5	20.63	13.8–12.3	8.86
4. Below average	12.5–10.7	19.67	12.7–10.8	15.11	12.4–10.7	15.87	12.2–10.7	10.13
5. Average	10.6–8.9	22.95	10.7–8.9	20.93	10.6–8.8	11.11	10.6–9.1	7.59
6. Good	8.8–7.1	14.75	8.8–6.9	19.77	8.7–6.9	17.46	9.0–7.5	15.19
7. Very good	7.0–5.3	9.84	6.8–4.9	9.30	6.8–5.0	7.94	7.4–5.9	5.06
8. Excellent	5.2–3.5	0.00	4.8–2.9	6.98	4.9–3.2	3.17	5.8–4.3	1.27
9. Superior	3.4 and <	6.56	2.8 and <	4.65	3.1 and <	1.59	4.2 and <	2.53

Table 8: Correlation between Ruffier index and multistage shuttle run scores for boys

Boys	*15-year-old*		*16-year-old*		*17-year-old*		*18-year-old*		*19-year-old*		*Total*	
	Ruffier	*MSR*	*Ruffier*	*MSR*	*Ruffier*	*MSR*	*Ruffier*	*MSR*	*Ruffier*	*MSR*	*Ruffier*	*MSR*
BH	0.05	0.03	0.13	0.01	0.14	0.14	−0.07	0.180	−0.38	0.07	0.07	0.07
BW	−0.04	0.08	−0.08	−0.02	0.02	0.13	−0.05	0.035	−0.29	0.29	0.01	0.05
BMI	−0.05	0.14	−0.15	−0.02	−0.04	0.09	−0.02	−0.062	−0.06	0.29	−0.003	0.04
% BF	−0.11	0.14	−0.10	−0.10	−0.08	0.19	−0.15	−0.172	−0.20	0.15	0.09	−0.14
VFA	0.02	0.01	−0.12	−0.12	−0.13	0.18	−0.15	−0.104	−0.02	0.01	0.08	−0.10
WHR	−0.06	−0.08	−0.11	−0.05	−0.19	0.14	−0.16	−0.103	0.14	0.05	0.11	−0.17

Note. BH = body height; *BW* = body weight; *BMI* = body mass index; % BF = percent body fat; VFA = visceral fat area; WHR = waist-hip ratio; *MSR* = multistage shuttle run test

Table 9: Correlation between Ruffier index and multistage shuttle run scores for girls

Girls	*15-year-old*		*16-year-old*		*17-year-old*		*18-year-old*		*19-year-old*		*Total*	
	Ruffier	*MSR*	*Ruffier*	*MSR*	*Ruffier*	*MSR*	*Ruffier*	*MSR*	*Ruffier*	*MSR*	*MSR*	*Léger*
TV	−0.14	−0.15	0.04	0.17	−0.28	0.16	−0.16	−0.005	−0.27	−0.12	−0.15	0.01
TH	−0.11	−0.07	−0.16	0.18	−0.004	0.04	−0.04	0.08	0.98	−0.03	−0.06	0.04
BMI	−0.05	−0.04	−0.18	0.10	0.17	0.003	0.02	0.11	0.04	−0.10	0.01	0.05
%BF	−0.09	−0.05	−0.15	0.01	0.11	0.06	0.07	0.21	0.23	−0.27	0.10	−0.24
VFA	−0.08	−0.02	−0.12	0.04	0.17	0.04	0.01	0.21	0.21	−0.37	0.04	−0.16
WHR	0.06	−0.03	−0.11	0.02	0.02	0.01	−0.003	0.12	0.03	−0.13	0.07	−0.18

Note. BH = body height; *BW* = body weight; *BMI* = body mass index; % BF = percent body fat; VFA = visceral fat area; WHR = waist-hip ratio; *MSR* = multistage shuttle run test

DISCUSSION

Similar findings on CRF measured by Ruffier test have been reported by Hernández-Alvarez et al. (2009) who found that boys obtained better results in Ruffier test than girls. Authors reported deficient level of cardiorespiratory adapting capacity in half of the studied population of Spanish boys and girls between 9 to 17 years of age. According to reference values for Ruffier test reported by Moravec (1990) CRF level increased with age for girls and remained stable during adolescence for boys. Our results have revealed lower CRF level for both boys and girls compared to their age-matched counterparts tested almost 25 years ago. Rychtecký et al. (1995) reported significant positive effect of high physical activity levels on cardiorespiratory fitness in pupils aged 11 to 14 years. The differences between Ruffier indexes for boys and girls performing low volumes and high volumes of physical activity reported by authors were statistically significant.

Inverse relationship between body composition and physical performance has been reported by a variety of studies (Bovet et al., 2007; González-Gross et al., 2003; Stigman et al., 2009; Grassi et al., 2006). The level of physical fitness in children and adolescents, especially aerobic capacity, is inversely related to current and body future body fat levels (Ortega et al., 2013). Grassi et al. (2006) reported that predicted VO_2max was significantly related to BMI and to body mass. No relationship was found with standing height and a negative relationship between BMI and VO_2max was found also in the overweight adolescents. Lloyd et al. (2003) found that sum of skinfolds, body weight and BMI were significantly negatively correlated with the PACER test results.

CONCLUSIONS

Present study deals with the association of body composition with cardiorespiratory fitness of adolescents from eastern Slovakia. The results showed that boys had higher level of cardiorespiratory fitness indicated by VO_2max and Ruffier index than girls across all age groups. Overall, cardiorespiratory fitness of both boys and girls increased with age. According to VO_2max the level of cardiorespiratory fitness was poor for boys and girls. The physical development was found to be normal as expressed by BMI. Mean values of WHR and VFA showed normal degree of abdominal obesity and visceral fatness. Correlation analysis showed inverse association of percent body fat and waist-hip ratio with performance in multistage shuttle run for both genders. Body height of girls negatively correlated with performance in Ruffier test. There were no statistically significant associations between Ruffier index and body composition measures for boys.

What does this article add?

Present study deals with the association of physical characteristics, body composition and cardiorespiratory fitness of Slovak adolescents. The study was conducted due to the fact that the physical activity levels and physical fitness levels of Slovak children and adolescents are declining. The results of this study have theoretical implications for health professionals, school physical education teachers and state legislators, who have the highest degree of practical and legal competence to change the behavioral, nutritional and activity tendencies of present youth. The data provided are aggregated by age and gender. Therefore, competent authorities have cross-sectional gender-specific data for age groups that are at the highest risk of disease associated with low cardiorespiratory fitness levels. Observations from this study highlight the importance of health promotion in children to decrease incidence of overweight and abdominal obesity across childhood and adolescence. The negative association between body fat and cardiorespiratory fitness levels suggests there is a need to allocate time for performing physical activity to reduce the degree of fatness.

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