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Health-Related Fitness in Slovak High School Students in Prešov Region

Pavel Ružbarský [1], Martin Zvonař [2,3,4], Peter Kačúr [1], Marek Kokinda [1] and Vincent Anton [2,4,*]

[1] Faculty of Sports, University of Presov, 08001 Presov, Slovakia; pavel.ruzbarsky@unipo.sk (P.R.); peter.kacur@unipo.sk (P.K.); marek.kokinda@unipo.sk (M.K.)
[2] Research Centre for Toxic Compounds in the Environment, Faculty of Science, Masaryk University, Kamenice 753/5, 625 00 Brno, Czech Republic; zvonar@fsps.muni.cz
[3] Faculty of Education, Catholic University, Hrabovska 1, 034 01 Ružomberok, Slovakia
[4] Faculty of Sport Studies, Masaryk University, 625 00 Brno, Czech Republic
* Correspondence: 445055@muni.cz

Abstract: The purpose of this study was to examine the physical characteristics, body composition, and health-related fitness components in Slovak high school students. Data on body composition and health-related fitness were obtained from 848 students attending 14 high schools in the Prešov self-governing region. Health-related fitness levels were determined using the FITNESSGRAM test battery. Body composition was measured using a direct segmental multifrequency bioelectric impedance analyzer InBody 230. The results of the study showed gender differences in anthropometric measures, body composition parameters, and health-related fitness components. Analysis of variance among subgroups with different performance levels in particular tests showed an effect on anthropometric measures and body composition, especially on abdominal strength and endurance and upper body strength and endurance. Regarding gender differences, boys were found to be taller and heavier in all age groups. The BMI values showed a normal rate of physical development in all age groups and both genders. Overall, body composition was more optimal for boys than for girls. Girls were found to have a higher degree of abdominal fat and visceral adiposity. Boys were found to have higher levels of upper body strength and endurance and abdominal strength and endurance. The difference in flexibility level was statistically significant between 16 year-olds.

Keywords: body composition; anthropometry; health-related fitness

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1. Introduction

The adolescent years are characterised by changes in body composition. This period of growth and maturation is also marked by behavioural changes in diet, physical activity, sedentary behavior, and psychological health. Physical activity and participation in sport decline during adolescence, especially in teenage girls, whereas sedentary behavior, the risk of depression, and body-esteem problems increase during teenage years [1]. These physiological and behavioural changes during adolescence warrant the attention of health practitioners to prevent the onset and continuation of obesity throughout the lifespan [2]. Among the main driving forces in evaluating children and young people's health behaviors are increasing levels of childhood obesity, the perception of declining physical fitness levels, reduced physical activity behaviors in children and young people, and reductions in the time available for physical education in school [3]. Research findings support an inverse relationship between body composition and physical fitness of school-aged children [4–8]. Being overweight in childhood and increasing obesity are associated with increased cardiometabolic risk [9]. Higher fitness levels may reduce the hazards of obesity in children [10], as well as mitigate or prevent developing depression and increase self-esteem [11]. Higher BMI is considered as a risk factor for developing musculoskeletal, cardiovascular diseases and cancer [12], whereas other authors claim the amount of abdominal adipose is a more reliable factor for assessing risk [13].

The relationship of body composition and health-related physical fitness deserves more attention in adolescence, especially for better understanding the mortality and morbidity-related approach as adolescents enter adulthood [14]. Schools may play an important role by identifying children with low physical fitness and by promoting positive health behaviours, such as encouraging children to be active with special emphasis on the intensity of activity [11]. Research suggests that consistency also plays a crucial role. Individuals whose physical activity decreases over time are at a significantly higher risk of becoming obese in young adulthood when compared with consistently active counterparts [15].

The body composition and physical fitness of Slovak children and adolescents were investigated by a variety of authors [16,17]. However, the EUROFIT test battery was used for assessing the level of fitness. There is a lack of information on health-fitness levels of Slovak students according to the FITNESSGRAM performance standards based on the Healthy Fitness Zones [18]. With its lower time and material requirements compared with the EUROFIT, the FITNESSGRAM seems to be the preferable option for assessing health-fitness levels in school settings. Because of that, one of the aims of this study is to provide more information about its practical use.

2. Methods

This cross-sectional study was supported by the Slovak Research and Development Agency according to agreement no. APVV 0768-11 Somatic, functional, and motor development of secondary school students in relation to their physical activity. Data on health-related fitness levels and body composition were collected from 848 adolescents. Of these, 328 were boys (mean age 17.2 $\pm$ 1.22 years) and 520 were girls (mean age 17.19 $\pm$ 1.25 years). For analysis purposes, adolescents were divided into five age groups: 15 year olds (n = 174; m = 174, f = 113), 16 year olds (n = 244; m = 106, f = 138), 17 year olds (n = 172; m = 172, f = 111), and 17+ years old (n = 258; m = 100, f = 158). The students attended 14 high schools located in the Prešov self-governing region in eastern Slovakia. For purposes of testing, schools and classes were selected randomly. One school was selected from each district of the Prešov region except for the Prešov district where, due to its area and population size, two schools were selected. 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 ethics committee of Masaryk University.

2.1. Assessment of Anthropometric Measures and Body Composition

Body height (BH) was measured to the nearest 0.1 cm with the 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 were determined using a portable body composition analyzer InBody 230 [1]. Body composition analysis included the parameters percent body fat (%BF), visceral fat area (VFA) and waist–hip ratio (WHR).

2.2. Components of Health-Related Fitness (HRF)

The FITNESSGRAM test battery as described by the Cooper Institute [18] was administered to estimate the CRF levels. Participants performed four tasks designed to measure each of the selected physical qualities. For abdominal strength and upper body strength and endurance, the curl-up and push-up were selected. To assess the upper body, hamstring, and lower back flexibility, the back-saver sit-and-reach and shoulder stretch were selected. Test scores were classified according to the FITNESSGRAMPerformance Standards of Healthy Fitness Zones [19]. The order of the exercises was in accordance with their metabolic demands. The first exercise was shoulder stretch, followed by back-saver sit-and-reach, curl-up and push-up.

2.3. Data Analysis

The raw data on body composition and health-related fitness components were aggregated by age and gender. Means and standard deviations were calculated by age and gender for body height, body weight, BMI, and body composition measures. Health-related fitness levels and body composition were compared between genders using the Mann–Whitney U test. The associations between body composition measures and HFZ achievement in curl-up, push-up, back-saver sit-and-reach and shoulder stretch were determined using the Kruskal–Wallis analysis of variance. The input data sets for statistical analysis were cleaned of missing values. Therefore, the specific number of participants was different for each variable compared with the total population.

3. Results

3.1. Abdominal Strength and Endurance

Descriptive data for mean curl-up test scores for boys and girls are presented in Tables 1 and 2.

Table 1. Means and standard deviations for health-related fitness test scores for girls.

Girls	Curl-Up		Push-Up		Sit-and-Reach		Shoulder Stretch	
	M	*SD*	*M*	*SD*	*M*	*SD*	*Pass*	*Fail*
15 year-old	29.32	22.26	8.73	7.76	16.69	10.95	109	3
16 year-old	27.53	21.78	9.43	7.71	18.12	10.02	131	7
17 year-old	31.31	21.34	9.03	9.21	18.47	9.80	102	9
17+ year-old	24.35	16.73	8.52	8.12	16.70	9.99	149	8

Note. *M* = mean; *SD* = standard deviation.

Table 2. Means and standard deviations for health-related fitness test scores for boys.

Boys	Curl-Up		Push-Up		Sit-and-Reach		Shoulder Stretch	
	M	*SD*	*M*	*SD*	*M*	*SD*	*Pass*	*Fail*
15 year-old	45.42	22.71	32.35	14.48	15.22	10.30	51	9
16 year-old	38.74	22.81	36.04	16.90	14.81	9.78	97	7
17 year-old	34.02	22.50	39.33	15.56	16.60	9.25	55	3
17+ year-old	36.69	20.70	36.23	14.22	15.26	10.82	83	17

Note. *M* = mean; *SD* = standard deviation.

The results show that both boys and girls had superior levels of abdominal strength compared with the standards for the American population. The highest mean score for curl-up was found for 17-year-old girls and 15-year-old boys. The comparison of curl-up test scores across all age groups with performance standards showed that the highest %HFZ achievement was found for 17-year-old girls and 15-year-old boys (see Tables 3 and 4).

Table 3. The percentage for HFZ achievement for health-related fitness tests: girls.

Girls	15 Years Old		16 Years Old		17 Years Old		17+ Years Old	
	Yes	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*
	%		%		%		%	
Curl-Up	65.50	34.50	62.31	37.69	70.27	29.73	66.66	33.33
90° Push-Up	55.36	44.64	55.80	44.20	50.45	49.55	49.68	50.32
Back-Saver Sit-and-Reach	13.27	86.73	10.87	89.13	9.00	91.00	12.03	87.97
Shoulder Stretch	97.32	2.68	94.93	5.07	91.90	8.10	94.90	5.10

Table 4. The percentage for HFZ achievement for health-related fitness tests: boys.

Boys	15 Years Old		16 Years Old		17 Years Old		17+ Years Old	
	Yes	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*
	%		%		%		%	
Curl-Up	79.66	20.34	70.19	29.81	62.71	37.29	61.86	38.14
90° Push-Up	86.66	13.34	89.32	10.68	93.10	6.90	94.00	6.00
Back-Saver Sit-and-Reach	11.48	88.52	9.38	90.62	16.40	83.60	17.82	82.18
Shoulder Stretch	85.00	15.00	93.27	6.73	94.83	5.17	83.00	17.00

The percentage of HFZ achievement decreased with age for boys, but not for girls. The mean HFZ achievement percentages for boys and girls differed only by 2.41%. The gender difference in HFZ achievement for curl-ups decreased with age. The greatest difference in %HFZ achievement was found between 15 year olds. Differences in abdominal strength and endurance by age and gender were statistically significant for 15 year olds, 16 year olds and 17+ year olds ($p < 0.05$).

3.2. Upper Body Strength and Endurance

The most important advantage of push-ups is that they require no equipment and very few zero scores occur [20]. Descriptive data on mean push-up scores for boys and girls are presented in Tables 1 and 2. Girls and boys across all age groups met the push-up HFZ standard. For the push-up, the highest %HFZ achievement was found for 17+-year-old boys and 16-year-old girls (see Tables 3 and 4). The level of upper body strength declined with age in girls but increased with age in boys. An interesting finding is that the mean %HFZ achievement for boys exceeded 90%. The gender difference between mean values of %HFZ achievement for the push-up test was 37.95%. The gender difference in HFZ achievement for push-ups increased with age. The greatest difference in %HFZ achievement for push-ups was found between 17+ year olds (44.32%). Differences in upper body strength and endurance by age and gender were statistically significant for all age groups ($p < 0.05$).

3.3. Hamstring, Lower Back, and Shoulder Girth Flexibility

Descriptive data on mean back-saver sit-and-reach and shoulder stretch test scores for boys and girls are presented in Tables 1 and 2. Girls and boys across all age groups did not meet HFZ performance standards for the back-saver sit-and-reach test. The highest level of hamstring and lower back flexibility was found for 17-year-old boys and girls. Comparison of back savers sit-and-reach test scores across all age groups with performance standards showed that the highest %HFZ achievement was found for 15 year-old girls and 17+ year-old boys (see Tables 3 and 4). The %HFZ achievement for both girls and boys was poor. The gender difference between mean values for this flexibility test was 2.48%. The greatest difference in %HFZ between genders was found for 17-year-olds (7.4%).

As shown in Tables 1 and 2, the highest percentage of adolescents who did not achieve the HFZ for shoulder stretch was found for 17+-year-old girls and 17-year-old boys. For the shoulder stretch test, the highest %HFZ achievement was found for 15-year-old girls and 17-year-old boys (see Tables 3 and 4). The difference in the highest %HFZ achievement between means for both genders in this test was 5.74%. For boys, the %HFZ achievement for shoulder stretch increased up to the age of 17 years. However, for girls the %HFZ achievement for shoulder stretch decreased up to the age of 17 years. The difference between genders in the back-saver sit-and-reach test was statistically significant for 16 year-olds ($p < 0.05$).

3.4. Anthropometric Measures and Body Composition

Descriptive data on body height, body weight, BMI, and body composition parameters for boys and girls are presented in Tables 5 and 6.

Table 5. Means and standard deviations for anthropometric measures.

Parameters	*BH*		*BW*		*BMI*	
All Participants (n = 848)	***M***	***SD***	***M***	***SD***	***M***	***SD***
15 year olds (*n = 174*)	168.63	8.16	60.51	11.58	21.10	3.20
Males (*n* = 61)	176.33	6.32	66.14	12.51	21.42	3.64
Females (*n* = 113)	164.41	5.56	57.42	9.41	20.93	2.94
16 year olds (*n = 244*)	169.53	10.65	61.71	12.17	21.63	6.25
Males (*n* = 106)	176.52	11.48	67.11	11.62	22.43	8.57
Females (*n* = 138)	164.05	5.57	59.49	10.88	21.00	3.42
17 year olds (*n = 172*)	169.96	8.43	62.93	11.71	21.68	3.37
Males (*n* = 61)	177.81	6.42	67.29	11.21	21.57	3.11
Females (*n* = 111)	165.57	5.84	60.49	11.32	21.72	3.53
17+ year olds (*n = 258*)	170.17	8.82	63.37	12.10	21.82	3.37
Males (*n* = 100)	177.92	6.72	69.62	11.53	22.17	3.16
Females (*n* = 158)	165.17	5.93	59.38	10.72	21.59	3.48

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

Table 6. Means and standard deviations for body composition parameters.

	%BF		*VFA*		*WHR*	
All Participants (*n = 848*)	***M***	***SD***	***M***	***SD***	***M***	***SD***
15 year olds (*n = 174*)	20.01	6.18	53.05	31.55	0.837	0.051
Males (*n* = 61)	15.64	8.43	48.50	36.15	0.833	0.058
Females (*n* = 113)	24.38	7.89	55.54	28.58	0.840	0.047
16 year olds (*n = 244*)	20.05	6.57	52.73	32.06	0.836	0.060
Males (*n* = 106)	15.40	8.54	46.74	35.40	0.825	0.072
Females (*n* = 138)	24.69	7.20	57.42	28.44	0.846	0.047
17 year olds (*n = 172*)	20.73	7.79	57.31	33.27	0.842	0.058
Males (*n* = 61)	15.22	7.07	43.71	27.91	0.823	0.054
Females (*n* = 111)	26.23	8.15	64.91	33.70	0.853	0.057
17+ year olds (*n = 258*)	21.33	7.20	57.97	32.24	0.845	0.055
Males (*n* = 100)	16.24	6.97	49.37	29.07	0.840	0.050
Females (*n* = 158)	26.42	7.80	63.46	33.04	0.848	0.058

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

Boys were taller and heavier across all age groups. For boys, body height and body weight increased with age. The greatest difference in body height between boys and girls was found for 17+ year olds. Differences in body height were statistically significant across all age groups ($p < 0.05$). An interesting finding is that the highest mean body weight was found for 16-year-old boys. This may be attributed to the fact that several 16-year-old boys were obese and overweight. For girls, body weight increased with age. Mean BMI values for both boys and girls across all age groups were in the HFZ range for BMI. The greatest difference in BMI was found between 16 year olds. The differences in body weight and BMI were statistically significant and were found across all age groups ($p < 0.05$).

3.5. Body Composition

The descriptive statistics for the measures of body composition are presented in Table 6. For boys, the %BF decreased with age up to 17 years of age. The greatest difference in %BF was found for 17 year olds. For girls, the amount of body fat increased with age.

According to Powers and Howley [21], 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 age groups fell within the normal range for WHR except for the 16-year-old boys. Gender differences in WHR were statistically significant ($p < 0.05$) for 16- and 17-year-old boys and girls.

VFA is the cross-sectional visceral area [22] used to express the degree of abdominal visceral fat. The normal VFA value is under 100 cm^2. Mean VFA values for girls and boys show a normal degree of visceral fat area. The greatest difference between mean VFA values across age groups was found for 17 year-olds. Differences in VFA by gender were found to be statistically significant across all age groups ($p < 0.05$).

To determine the relationship of anthropometric measures and body composition parameters with HFZ achievement for four Fitnessgram tests, a Kruskal–Wallis analysis of variance was used. To compare medians for the curl-up test and push-up test, participants were grouped into three HFZ zones according to performance standards: "Needs Improvement" (NI group), "Healthy Fitness Zone" (HFZ group), and above the "Healthy Fitness Zone" (AHFZ) [20]. Flexibility levels between groups were compared between two groups (pass/fail) by age for both genders.

For boys, performance in the curl-up test was not associated with anthropometric measures or body composition. However, for girls, curl-up performance was associated with body height, and a difference in body height was found between the NI group and the AHFZ group (H = 9.24, $p < 0.01$). This indicates the effect of body height on curl-up performance in girls. Another parameter that was found to be associated with curl-up performance was WHR. A difference in WHR for girls was found between the NI group and the HFZ group (H = 9.24, $p < 0.01$).

For boys, push-up performance was found to be associated with body height. The effect of body height on push-up performance was found for girls only. The difference in body height in girls was found between NI and HFZ (H = 32.0, $p < 0.05$), between NI and AHFZ (H = 32.0, $p < 0.01$) and between HFZ and AHFZ (H = 32.0, $p < 0.05$). Body weight was found to be associated with HFZ achievement zones for both boys and girls. A difference in body weight for girls was found between the NI group and HFZ group (H = 28.24, $p < 0.01$) and between the NI group and AHFZ group (H = 28.24, $p < 0.01$). Push-up performance of boys was found to be associated with body weight as well. The difference in body weight was found between the NI group and the AHFZ group (H = 6.7, $p < 0.05$). Besides body weight, another parameter found to be associated with HFZ achievement for the push-up test was percent body fat (%BF). A difference in %BF was found between the NI group and HFZ group (H = 26.81, $p < 0.01$) and between the NI group and AHFZ group (H = 26.81, $p < 0.01$). For girls, differences in %BF were found among all groups. There was a difference between the NI group and HFZ group (H = 23.2, $p < 0.01$), between the NI group and AHFZ group (H = 23.2, $p < 0.01$) and between the HFZ group and AHFZ group (H = 23.2, $p < 0.05$). Another parameter that affected push-up performance for girls and boys was the waist–hip ratio. We found that WHR differed for girls between the NI group and HFZ group (H = 21.7, $p < 0.01$) and between the NI group and AHFZ group (H = 21.7, $p < 0.01$). For boys, WHR medians among groups differed between the NI group and HFZ group (H = 15.09, $p < 0.01$) and between the NI group and AHFZ group (H = 15.09 $p < 0.01$). Push-up performance of girls was affected by BMI. Differences in BMI were found between the NI group and HFZ group (H = 16.6, $p < 0.01$) and between the NI group and the AHFZ group (H = 16.6, $p < 0.05$). VFA was found to affect push-up performance for both girls and boys. For girls, a difference in VFA was found between the NI group and HFZ group (H = 29.19, $p < 0.01$) and between the NI group and AHFZ group (H = 29.19, $p < 0.01$). Similar to girls, differences in VFA in boys were found between the NI group and HFZ group (H = 13.6, $p < 0.05$) and between the NI group and AHFZ group (H = 13.6, $p < 0.01$).

Performance in the sit-and-reach test was found to be associated with body weight for both genders. There was a difference in body weight between groups for girls (H = 5.540, $p < 0.05$) and for boys (H = 6.47, $p < 0.01$). The BMI index was also found to be associated with sit-and-reach performance in boys only (H = 4.77, $p < 0.05$). Shoulder stretch performance was found to be associated with body weight and BMI for boys only. There was a statistically significant difference in body weight and BMI between groups, respectively (H = 4.1, $p < 0.05$; H = 5.94, $p < 0.05$).

4. Discussion and Conclusions

The results of the study showed that there were gender differences in anthropometric measures, body composition parameters, and health-related fitness components. The analysis of variance among subgroups with different performance levels in particular tests revealed an effect on anthropometric measures and body composition, especially on abdominal strength and endurance and upper body strength and endurance.

The findings of this study are consistent with results reported by other studies. According to Kyröläinen, Santilla, Nindl, and Vasankari [23], body composition is strongly related to physical fitness. The impact of body weight and body composition on upper body extremity test scores has long been recognized and reconfirmed [24]. As reported by Lloyd et al. [8], curl-up and push-up scores were significantly correlated with the sum of skinfolds, body weight, and BMI as body size and composition were shown to influence the achievement of criterion-referenced standards. According to Plowman [20], an improvement in body composition will generally result in improved performance in aerobic capacity and also muscle strength and endurance, especially in the upper body, due to a reduction in excess weight and having to lift less weight. Underperformance in strength tests may be attributed to excess body weight and visceral fat.

Research has shown that abdominal adiposity is as important in children as it is in adults. Excess abdominal fat in children results in metabolic alterations associated with the risk of cardiovascular disease later in life [25]. In sedentary obese children and adolescents, abdominal obesity is negatively related to bone mineral density, suggesting a potential link between abdominal obesity and osteoporosis [26]. Regarding obesity, the assessment of body composition is useful for the screening of excess body fat and its related metabolic complications. This emphasizes the importance of effective prevention of weight gain in individuals with a tendency to accumulate visceral fat at an early age [27].

The purpose of this study was to evaluate the actual status of physical characteristics and body composition in Slovak high school children and compare the results obtained with health-related fitness recommendations. With respect to gender differences, boys were found to be taller and heavier across all age groups. BMI values showed the normal rate of physical development in all age groups and both genders. Overall, body composition was more optimal for boys than for girls. Girls were found to have a higher degree of abdominal fat and visceral adiposity. Boys were found to have a higher level of upper body strength and endurance and abdominal strength and endurance. The differences in flexibility level were statistically significant among 16 year olds.

Anthropometric measures and body composition parameters were found to affect performance in tests of abdominal strength and upper body strength. The analysis of variance revealed the effect of body height and waist–hip ratio on abdominal strength and endurance for girls. Upper body strength and endurance were inversely associated with all anthropometric and body composition parameters. Flexibility was inversely associated with body weight and BMI values.

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Institutional Review Board Statement: A participant's legal guardian (in the cases where a participant was younger than 18 years) or participants (in the cases where a participant was older than 18 years) received a verbal description of the study procedures before testing, agreed with publishing of the collected data and completed a written informed consent that was approved by the ethical committee of the Faculty of Sports Studies of Masaryk University. Measurements were taken according to the ethical standards of the Declaration of Helsinki.

Informed Consent Statement: Informed consent was obtained from all the subjects involved in the study.

Data Availability Statement: The datasets generated and analyzed for this study can be requested by correspondence authors.

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Conflicts of Interest: The authors declare that they have no conflict of interest.

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