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Kardiorespiratorna sposobnost učencev osnovnošolskega izobraževanja: povezava z antropometričnimi značilnostmi

MATEA GAŠPAROVIĆ, VILKO PETRIĆ, VESNA ŠTEMBERGER, MARIJA RAKOVAC & IVA BLAŽEVIĆ

Povzetek Cilj raziskave je bil ugotoviti kardiorespiratorno sposobnost (CRF) učencev in učenk osnovnih šol ter povezavo z njihovimi antropometričnimi značilnostmi. Vzorec je sestavljalo 112 učencev in 136 učenk, starih od 7 do 10 let. Za vrednotenje antropometričnih značilnosti (telesna višina, telesna masa, indeks telesne mase (ITM)) in CRF (test Beep za oceno maksimalne porabe kisika) je bila uporabljena testna baterija Eurofit. Rezultati kažejo stagnacijo CRF v povezavi s kronološko starostjo pri obeh spolih. Statistično značilna povezava (P = 0,001) se je pokazala pri vseh spremenljivkah CRF in antropometričnih spremenljivkah, razen pri telesni višini, ki ni bila značilno povezana s CRF. Povečanje telesne mase in ITM je bilo povezano s pomembnim zmanjšanjem (P = 0,001) CRF učencev in učenk.

Ključne besede: • zdravje • osnovna šola • maksimalna poraba kisika• telesna višina• telesna teža •

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Cardiorespiratory fitness in primary education pupils: the association with anthropometric characteristics

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Abstract The goal of this research was to determine cardiorespiratory fitness (CRF) among primary school male and female pupils and its association with their anthropometric characteristics. The sample consisted of 112 boys and 136 girls, primary school pupils, aged 7 to 10. The Eurofit test battery was used to evaluate anthropometric characteristics (body height, body mass, body mass index (BMI)) and CRF (Beep test to estimate maximal oxygen uptake). The results indicate stagnation in the CRF with chronological age, in both sexes. A statistically significant association ($p = 0.001$) was shown for all CRF variables and anthropometric variables except for body height, which was not significantly associated with CRF. An increase in body mass and BMI was associated with a significant ($p = 0.001$) decrease in male and female pupils' CRF.

Keywords: • health • primary school • maximal oxygen uptake • body height • body weight •

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Introduction

Our contemporary lifestyle, characterized by insufficient physical activity (PA) and various gadgets used to simplify our lives, leads to an increase in body weight and a decrease in motor and functional abilities in children, youth and adults. Inadequate eating habits and insufficient PA lead to an increasing prevalence of overweight and obesity in primary school children, related to an the increased risk of cardiorespiratory disease and diabetes (Guo et al., 2002). An increased body mass index (BMI) influences both present health status and quality of life (WHO, 2016). Overweight children usually have a poor self-image, which causes a decrease in PA and an unhealthy diet (Grogan, 2006). Overweight and obesity are also related to poor motor competencies and poorly developed motor abilities, possibly leading to a poor physical self-image and a decreased engagement in PA.

General PA recommendations have evolved over the years. In 1984 they were still rather loose, recommending that an individual should be active by increasing breathing intensity to the point of sweating at least twice a week, while in 2004 the recommendation was to perform moderate-intensity PA at least 30 minutes a day (Škof, 2010). In 2017 the World Health Organization recommendations are as follows: children and young people between the age of 5 and 17 should be active at least 60 minutes a day, ranging from moderate to high intensity PA. Moreover, exercises to strengthen muscles and bones should be performed at least three times a week (WHO, 2017). Generally, physical education in primary schools is performed in a weekly volume and intensity that is insufficient for significant improvement in physical fitness (Štemberger, 2015). Besides adequately developed motor abilities, well-developed functional abilities are also necessary for children's growth and development. Functional abilities mainly refer to cardiorespiratory fitness (CRF) and/or cardiorespiratory endurance, ability of the cardiovascular and respiratory systems to transport oxygen-enriched blood to all the tissues in the body, and the ability of tissues to use the delivered oxygen to produce energy (Sekulić and Metikoš, 2007).
Previous studies have generally indicated a correlation between low CRF and the occurrence of diseases such as diabetes, metabolic syndrome and arterial hypertension (Carnethon et al., 2009). CRF is related to BMI, and improved CRF diminishes the risk of cardiorespiratory disease. That is why evaluating children's CRF is of utmost importance and considered by many authors the first procedure to be undertaken when health-promoting intervention measures are to be implemented at the population level (Petrić et al., 2016).

Our aim was to determine the level of primary school pupils' CRF and its association with their body height, body weight and BMI.

Methods

The sample (Table 1) consisted of male and female pupils from the 1st to the 4th grade of two primary schools: 'Braća Radić' in Botinec and 'Ivan Cankar' in Zagreb, Croatia. The

participants were then divided into sub-samples according to gender – male and female pupils, and according to age – 7, 8, 9 and 10-year-olds.

Table 1: Sample characteristics

	AGE				
	7 YEARS	8 YEARS	9 YEARS	10 YEARS	TOTAL
GIRLS	49	29	36	22	136
BOYS	39	33	22	18	112
TOTAL	88	62	58	40	248

The measurement was conducted in the period from September to November 2016 during regular Physical Education classes, always at the same time of day (± 2 hours). Data about chronological age were taken before the first measurement. The Eurofit test battery for the school population was used to evaluate the anthropometric characteristics and CRF (Council of Europe, 1988).

Body height and body mass were measured, and body mass index (BMI) was calculated. Body height was measured with an anthropometer with an accuracy of 0.1 cm, the participant standing upright, barefoot on a flat surface. The distance from the base to the scalp was measured and expressed in centimeters. Body mass was measured with a medical scale, the participants standing on the scale wearing only underwear. The results were recorded in kilograms. After measuring the body height and body mass, the BMI was calculated according to the standardized formula: body mass divided by body height expressed in square meters (kg/m^2).

CRF (maximal oxygen uptake - VO_{2max}) was evaluated using the beep test (20m). The beep test is a field test for the evaluation of maximal aerobic capacity. Pupils take a high start position and are required to continuously circle a 20m track (marked by two lines), starting at the recorded sound (beep). Their running speed increases at regular intervals, and the test finishes when the participant is unable to keep up the required pace. The maximal oxygen intake (VO_{2max}) was calculated by a standardized formula, taking into account age, body mass, body height and the beep test results (St Clair Gibson et al., 1998).

The results were presented as mean ± standard deviation (SD). Regression analysis was carried out to test the relation between the anthropometric characteristics (predictors) and CRF (dependent variable) and to predict its further trend. The STATISTICA 12 program (StatSoft, Inc., Tulsa, OK, USA) was used in data analysis. The level of significance was set to 0.05.

Results

Table 2 shows the mean and SD for all the measured variables. Generally, mean values for the morphological variables increased with chronological age for both genders. Boys

were somewhat taller and heavier than girls, while regarding BMI, at the age of 10 both sexes showed a slight decline in the mean BMI of 0.3 unit values.

CRF showed constant average results for both genders. Boys were more successful than girls in the beep test for 0.3 levels, and their VO_{2max} was greater by almost 9 ml/kg/min.

Table 2. Descriptive data (mean ± standard deviation) for male and female pupils according to age

VARIABLES	M	7 YEAR	8 YEAR	9 YEAR	10 YEAR	TOTAL
Height (cm)	B	126.68 ± 4.26	134.61 ± 7.52	137.53 ± 5.07	141.78 ± 6.00	133.48 ± 8.05
	G	124.88 ± 6.30	133.87 ± 6.15	136.51 ± 5.55	141.79 ± 7.33	132.57 ± 8.82
Weight (kg)	B	27.50 ± 6.20	32.22 ± 8.37	34.34 ± 7.12	36.06 ±6.83	31.54 ± 7.81
	G	25.31 ± 4.93	30.69 ± 8.53	33.01 ± 6.41	37.00 ± 10.50	30.30 ± 8.30
BMI (kg/m^2)	B	17.02 ± 2.90	17.60 ± 3.05	18.12 ± 3.41	17.76 ± 2.57	17.51 ± 2.97
	G	16.10 ± 2.26	16.35 ± 4.70	17.68 ± 3.04	17.35 ± 5.54	16.78 ± 3.74
Beep test (level)	B	3.15 ± 1.07	3.28 ± 1.16	3.16 ± 0.93	3.96 ± 1.14	3.31 ± 1.10
	G	2.85 ± 0.61	2.94 ± 0.80	2.93 ± 0.86	3.49 ± 1.00	2.99 ± 0.86
VO_{2max} (ml/kg/min)	B	40.77 ± 4.77	41.23 ± 5.71	41.03 ± 4.89	45.26 ± 5.04	41.69 ± 5.31
	G	32.85 ± 1.59	32.52 ± 2.24	32.44 ± 2.39	33.70 ± 4.01	32.83 ± 2.47

Table 3 shows the relation between BMI and CRF for both genders. A significant negative correlation between BMI and the results of the beep test and VO_{2max} was obtained for both genders. With an increase of one-unit value in boys' BMI, the beep test results decreased by almost 0.3 SDs, while the VO_{2max} decreased by almost 0.5 SDs. For girls, a one-unit increase in BMI was related to an almost 0.3 SD decrease in beep test results, while the VO_{2max} was lower by almost 0.6 SDs.

Table 3. The relation between body mass index and the results of the Beep test and VO_{2max}

	Beep test				VO_{2max}			
Boys	R	R^2	F(1.99)	p	R	R^2	F(1.95)	p
	0.27	0.07	7.84	0.00	0.45	0.21	24.69	0.001
	β	Std. Err. β	t(99)	p	β	Std. Err. β	t(95)	p
	-0.27	0.09	-2.80	0.01	-0.45	0.09	-4.97	0.00
Girls	R	R^2	F(1.127)	p	R	R^2	F(1.116)	P
	0.30	0.09	12.67	0.00	0.57	0.33	57.04	0.00
	β	Std. Err. β	t(127)	p	β	Std. Err. β	t(116)	p
	-0.30	0.08	-3.56	0.00	-0.57	0.08	-7.55	0.00

Table 4 shows the results of the relation between body mass and CRF in both genders. A significant negative correlation between body mass and the results of the beep test and VO_{2max} was obtained for both genders. A one-unit increase in body mass in boys was related to an almost 0.2 SDs in the beep test results, while the VO_{2max} was worse by slightly more than 0.3 SDs. For girls, a one-unit body mass increase was related to an almost 0.2 SDs decrease in the beep test results and an almost 0.5 SDs decrease in VO_{2max}.

Table 4. The relation between body mass and the results of the Beep test and VO_{2max}

	Beep test				VO2 max			
Boys	R	R^2	F(1.100)	p	R	R^2	F(1.95)	p
	0.18	0.04	3.52	0.00	0.33	0.11	11.56	0.001
	β	Std. Err. β	t(100)	p	β	Std. Err. β	t(95)	p
	-0.18	0.09	-1.88	0.03	-0.33	0.10	-3.41	0.00
Girls	R	R^2	F(1.125)	P	R	R^2	F(1.116)	P
	0.20	0.04	5.43	0.00	0.45	0.20	29.57	0.00
	β	Std. Err. β	t(125)	p	β	Std. Err. β	t(116)	p
	-0.20	0.09	-2.33	0.02	-0.45	0.08	-5.44	0.00

Table 5 shows the relation between body height and CRF in both genders. There was no statistically significant correlation between body height and CRF.

Table 5. The relation between body height and the results of the Beep test and VO_{2max}

	Beep test				VO2 max			
Boys	R	R^2	F(1.99)	p	R	R^2	F(1.95)	p
	0.01	0.00	0.01	0.06	0.03	0.00	0.12	0.00
	β	Std. Err. β	t(99)	p	β	Std. Err. β	t(95)	p
	-0.01	0.10	-0.12	0.91	-0.04	0.10	-0.35	0.73
Girls	R	R^2	F(1.127)	p	R	R^2	F(1.116)	p
	0.11	0.01	1.54	0.13	0.07	0.00	0.50	0.00
	β	Std. Err. β	t(127)	p	β	Std. Err. β	t(116)	p
	-0.11	0.09	1.24	0.22	-0.07	0.09	-0.71	0.48

Discussion

The main finding of our study on the relationship between CRF and anthropometric characteristics in primary school pupils aged 7 to 10 was that there was a statistically significant influence of body mass and BMI on CRF in both genders. Regardless of their chronological age, boys were on average somewhat better than girls in all the variables measured. Although a stagnation compared to chronological age was present in CRF variables (beep test results and estimated VO_{2max}), in all age groups and both genders, the average results were almost identical.

According to the norms, the results for 9-year-old male and female pupils were in the 'poor' category (test values between 2/2 and 3/1 for male pupils and 2/2 and 3/4 for female pupils). Pupils who were one year older were in the 'fair' category, with average values for male pupils between 3/2 and 3/8 and for female pupils between 3/6 and 4/5. First and second graders (7-8-year olds) also showed unsatisfactory results in terms of poor CRF. The reasons for this may vary, but we can assume that insufficient PA (both in leisure

time and during physical education classes) might play a significant role. Results showed a significant relation between BMI and body mass and CRF for male and female pupils ($p = 0.001$ for all), while the relation between body height and CRF was not significant. Consequently, the higher the body mass and BMI, the poorer the CRF results—to a significant extent. Male and female pupils who took part in this research were on average somewhat taller and heavier than their peers, but still in the normal BMI category.

Previous studies showed that a low CRF was related to various diseases, the most common being arteriosclerosis, osteoporosis, diabetes and depression (Salzer et al., 2006). Unfortunately, these diseases are leading causes of morbidity in both Europe and the world. It has been estimated that cardiorespiratory diseases take 4 million lives in Europe every year (Kraljić and Marković, 2013). Anderssen et al. (2007) investigated the correlation between CRF and the risk of cardiorespiratory diseases in a sample of 2,845 children aged 9 to 15 from Portugal (n=944), Denmark (n=849) and Estonia (n=1052). After accounting for the influence of country of provenance, age, gender, socio-economic status, family history and diabetes, the results showed that low CRF represented an individual high-risk factor for the occurrence of cardiovascular disease. Mastrangelo and associates found that obese children had poorer results in VO_{2max} and cardiorespiratory endurance than children who were not obese (Mastrangelo et al., 2008), a finding in line with our results. The occurrence of overweight and obesity in children is usually related to a decrease in PA, which in turn has a negative impact on the development of CRF.

Regular PA is very important for the maintenance and improvement of health status, while at the same time preventing the occurrence of various diseases, such as arteriosclerosis, coronary heart disease, diabetes, arterial hypertension, colon and breast cancer, osteoporosis and depression (Ayler et al., 2003; Capiro and Weiss, 2005; Ischander et al., 2007). Parikh and Stratton (2011) showed that although age, gender, body constitution and health condition significantly influenced CRF, the most influential factor was PA. According to the World Health Organization, a daily period of 60 minutes of PA is necessary for school-aged children, while they were found to actually spend only 90 to 135 minutes per week in PA (Petrić et al., 2016). This amount of time is insufficient even for education about PA during physical education classes, let alone for transformation of and a positive change in body characteristics.

Along with an increase in regular physical education classes, which are irreplaceable for every child and the foundation for the population's health when it comes to regular PA, it is necessary to conduct regular intervention kinesiological programmes (Petrić et al., 2016). In their research on third- and fourth-grade pupils, Kamenjaš and Samaržija (2016) found that the level of PA contributed to an increase in CRF. The authors encouraged pupils to engage in extracurricular activities which directly and significantly influenced and increased their CRF. Games of moderate aerobic intensity can elicit a significant increase in CRF and a decrease in BMI and body fat percentage (Mathisen et al., 2016; Ten et al., 2016).

It is necessary to increase children's PA during the time spent at school, but also in their free time. It is an increase not only in the number of physical education classes that would be needed, but also in their quality, consistent implementation and, last but not least, changes in the curriculum in the direction of more content on health promotion. In Croatia's school system, the present physical education curriculum is oriented towards children's sports result. The situation is similar in Slovenia, where the standard of knowledge that pupils should achieve after completion of each semester determine the student's knowledge of a particular sports field (as, for instance, "*Pupils can successfully choose the basic technical and tactical elements according to the playing situation. They know the tasks of players in individual gaming positions. They know the sport games' basic rules. They respect the rules of a sport behaviour. They use appropriate terminology and concepts linked to sports games*"(Kovač et al., 2011, p.36)). Each year in April, children's morphological characteristics and motor abilities are tested. However, there is too little emphasis on exercise meant to improve children's health. The authors believe the battery tests employed should primarily be directed toward the evaluation of health-related physical fitness, and only afterwards to the evaluation of motor abilities important for sports performance (Petrić et al., 2016).

Conclusion

The results indicate a stagnation in 7-to-10 year-old boys' and girls' CRF and a statistically significant relation between body mass and BMI and CRF. It can be predicted that, along with the increase in body mass and BMI, CRF in both sexes will decrease, thus increasing their health risk. Adequate measures to promote PA in school-aged children should be undertaken. Further research should be directed toward the design and evaluation of intervention programs in the education system which will contribute to a decrease in body mass and BMI and an increase in CRF.

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