Теорія та методика фізичного виховання
Physical Education Theory and Methodology
Teorìâ ta Metodika Fìzičnogo Vihovannâ

ISSN 1993-7989 (print)
ISSN 1993-7997 (online)
ISSN-L 1993-7989

ORIGINAL SCIENTIFIC ARTICLE

CARDIORESPIRATORY FITNESS CUT-POINTS RELATED TO BODY ADIPOSITY PARAMETERS IN MACEDONIAN CHILDREN

Abdulla Elezi[1ABCDE], Valon Kadriu[2ABCDE], Gresa Elezi[3ABCDE], Georgi Georgiev[4ABCDE] and Seryozha Gontarev[4ABCDE]

[1]University of Prishtina
[2]University Clinical Center of Kosovo
[3]American Hospital, Pristina
[4]Ss. Cyril and Methodius University of Skopje

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Valon Kadriu, E-mail: kadriu.valon.md@gmail.com
Accepted for Publication: February 2, 2022
Published: March 25, 2022

DOI: 10.17309/tmfv.2022.1.07

Abstract

Background and Objectives: There is a shortage of criteria referent standards for tests of logistic application meant to estimate the cardiorespiratory fitness (CRF) of children and adolescents in the Republic of North Macedonia. The goal of the research was twofold: (1) To identify the ability of CRF estimated by the 20-m shuttle-run test (20mSRT) to discriminate between "healthy" and "unhealthy" phenotypes (by adiposity measures such as WC and WHR) in children; (2) To determine the correlation between obesity and relatively maximum oxygen consumption (VO_2 peak) tested on a relatively large respondents' sample of Macedonian children. The research was conducted on a sample of 1,863 respondents, 957 (51.4%) of whom were boys, and 906 (48.6%) were girls at the age of 7 to 10 years. All of them were from 19 primary schools in the central and eastern parts of the Republic of North Macedonia.

Materials and Methods: The waist circumference (WC) and waist-to-height ratio (WHtR) were used to identify body adiposity markers. CRF was measured using the 20mSRT (VO_2 peak). Receiver operating characteristic curves and logistic regression were applied in order to establish the discriminative power of CRF in anticipating the parameters of body adiposity markers.

Results: With regard both to the boys and girls, VO_2 peak showed considerable predictive power of identifying the body adiposity (area under the curve [AUC] > 0.66). In boys, when considering the full sample (7-10 years), the best cut-point for VO_2 peak to detect body fat by WC were 48.8 to $mL \cdot kg^{-1} \cdot min^{-1}$ and WHtR were 47.4 to $mL \cdot kg^{-1} \cdot min^{-1}$. For girls, when considering the full sample (7-10 years), the best cut-point to detect body fat by WC were 47.4 to $mL \cdot kg^{-1} \cdot min^{-1}$ and WHtR were 47.1 to $mL \cdot kg^{-1} \cdot min^{-1}$.

Conclusions: According to these cut-points, adolescents with low CRF were more likely to be obese either by WC or WHtR. The border values (cut-points) of CRF can be used as quantitative markers of children of healthier body characteristics from the Republic of North Macedonia.

Keywords: epidemiology, obesity, weight status, children, adolescents.

Introduction

The lack of physical activity, and the low level of cardiorespiratory fitness (CRF) are a huge threat for the public health. Yet their prevailing number is rapidly increasing in countries of development, as is generally the case with Macedonian children and adolescents (Gontarev & Kalac, 2016; Gontarev et al., 2016; Gontarev et al., 2018). Along with that, those of the children suffering from obesity and fat are very likely to remain overweight persons up to their mature age, and there is a greater possibility for them to develop some metabolic risks during their younger age (Sahoo et al., 2015). Although the clinical manifestations of many chronic disease are chiefly displayed in the mature age, it is well known that the long asymptomatic phase of development has its roots early in a person's life, often in their childhood

(Balagopal et al., 2011), which indicates that the initiative of chronic disease prevention should begin within the years of that period of life.

The cardio-respiratory fitness is an equally powerful predicator of a mortal risk, just as the traditional risk factors such as smoking, obesity, hypertension, dyslipidemia and type 2 diabetes mellitus both with children, adolescents and aged population (Kaminsky et al., 2019). A considerable number of research works emphasize the relation between the low level of cardio-respiratory fitness and adiposity with a great risk of cardio-metabolic diseases among the young (Mintjens et al., 2018). In response, the fitness and health outcomes in youth assessment guidelines have called for a better understanding of the close relation between the components of fitness and body composition (Pillsbury, Oria & Pate, 2013). In this sense, the mutual relation of the increased adiposity with a lower level of cardio-respiratory fitness is generally the strongest when adiposity is measured by imagining techniques; it is somewhat weaker when it is assessed by using WC and WHtR, and the weakest when the body mass index (BMI) is used (Lee & Arslanian, 2007).

Despite that the physical fitness and body adiposity can be correlated, they are not markers of different diseases' risks. It is established in a certain number of studies, which have been conducted on young population, that those of the youngsters who have a low level of adiposity and low level of cardio-respiratory fitness are subjected to a higher cardiovascular risk than those of the young persons who though have greater adiposity but at the same time have an adequate level of cardio-respiratory fitness, regardless their muscular fitness and body composition (Grøntved et al., 2015; Silva et al., 2018). Recently, Silva et al. (2018) have established that the results obtained from the 20-m shuttle run test, which was applied to Canadian children at the age from 8 to 12 years, were correct so that the sample could be classified according to the fat indicator in relation to the CRF level. In the present study, when using sex-specific cut-points, it was found that regardless of the 20mSRT indicator (laps, VO_2peak or speed), those children having less of the recommended values face a greater possibility to become obese, either by WC, BMI, or both, regardless the factors as the age, the time spent on electronic devises, and the level of physical activity. These results confirm the results obtained in other research works which have established that the cardio-respiratory fitness is independent of the factor of obesity risk and increases the necessity of development of CRF health-related standards in order to predict the cardio-metabolic health of young people. According to that, the comparison of the differences in the criteria referent standards of different predicative equality that are used for assessing the aerobic capacity will help to identify different phenotype risks (optimal and poor health) from the CRF levels estimated by 20mSRT performance and will be of significant public health value. Apart from the fact that there are criterion-referenced cut-points in many countries of high economic development, there is only one study conducted in the R. N. Macedonia (Pireva et al., 2018).

The instructions of estimating the fitness activity of the young population suggest of better understanding of the mutual correlation between the physical fitness and body composition (Pillsbury, Oria & Pate, 2013). Therefore, the defining of the criterion-referenced cut-points connected with the body adiposity parameters in children and adolescents can be useful in identifying the target population for prevention of primary chronic diseases, as well as for creating national politics for promotion of health. The goals of the present research were twofold: (1) To identify the ability of CRF estimated by the 20mSRT to discriminate between "healthy" and "unhealthy" phenotypes (by adiposity measures such as WC and WHR) in children; (2) to establish the connection between the obesity and relative maximum oxygen consumption (VO_2peak) on a relatively big sample of Macedonian children.

Materials and Methods

Participants

The research was conducted on a sample of 1863 children from 19 primary schools in the central and eastern part of the Republic of North Macedonia, of which 8 are located in rural and 11 in urban areas. The sample was divided into two subsamples by gender: 957 respondents were boys and 906 respondents were girls. The average age of the respondents was 8,98±2,37 years. The study included all students whose parents agreed to participate in the study, who were psychophysically healthy, and who regularly attended physical and health education classes. The respondents were treated in accordance with the Helsinki Declaration of 1961 (revision of Edinburgh 2013). The protocols were approved by the Ethics Committee at the University "St. Cyril and Methodius" in Skopje.

The measurements were carried out in March, April and May 2019 in standard school conditions at regular physical and health education classes. The measurements were performed by kinesiology and medicine experts, previously trained in performing functional tests and taking anthropometric measures.

Body Adiposity Parameters

The measurements of weight, height, and WC were carried out at school applying standardized procedures; all the instruments were verified before measuring each subject. Weight was measured in underwear and without shoes with an medical decimal weight scales, to the-nearest 0.1 kg, and height was measured barefoot in the Frankfort horizontal plane with a telescopic height measuring instrument (Martin's anthropometry) to the nearest 0.1 cm. Body mass index was calculated as bodyweight in kilograms divided by the square of height in meters. Waist circumferences were measured twice using inextensible anthropometric tape with the children standing erect and relaxed, with arms at the sides and feet positioned close together. Waist circumference was measured midway between the lowest border of the rib cage and the upper border of the iliac crest, at the end of normal expiration (de Oliveira & Guedes, 2018) WC and height were used to calculate WHtR, with obesity defined as ≥0.50 according to previous reports (Schwandt & Haas, 2016). The 75th percentile of WC according to age and gender were determined based on data collected from the de Ferranti et al. (de Ferranti et al., 2004). WC and WHtR have been used as proxies for central (visceral) adipose tissue which has recently received attention as a marker of 'early health risk' in many populations (Ashwell & Gibson, 2016).

Cardiorespiratory Fitness (CRF)

The 20 meter shuttle run test (Leger et al., 1988) was used to measure fitness. All testing was completed on a firm and level surface (concrete play area at each school). For this test, children were required to run back and forth between two lines placed 20 meters apart. A sound signal was emitted from a pre-recorded tape to dictate running speed. Frequency of the sound signals increased such that running speed increased by 0.5 km/hour each minute from the starting speed of 8.5 km/hour. The test ended when children could no longer keep pace with the sound signal. The last stage that children reached was used to predict maximal oxygen uptake (VO_2max) from the running speed corresponding to that stage (VO_2max = 31.025 + 3.238 X – 3.248 A + 0.1536, where X = the final speed and A = age). This test showed good to very good repeatability and validity (Ramírez-Vélez et al., 2015).

Statistical Analysis

The basic statistical parameters (arithmetic mean, standard deviation, frequency) were calculated for all variables. The normal distribution of all variables was controlled by Kolmogorov-Smirnov method. None required transformation due to normally distributed. In order to establish the gender differences, the following tests were applied: T-test, Cohen d and $\chi 2$ tests. Pearson's correlations were calculated in order to quantify the connection between CRF and the body adiposity parameters. Diagnosis screening tests (Swets, 1973) (sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio (LR+), and negative likelihood ratio (LR-)) and ROC (receiver operating characteristic) curve analysis have been applied in the determination of cut-off values for analyzed parameters. In addition, the present sample was classified according to the cut-points suggested in the present study and logistic regression analysis with odds ratio (OR) and 95% confidence intervals (CI) was calculated. Univariate and multivariate analysis adjusted for age were used separately for boys and girls. All the analyses were performed using the statistical programs MedCalc 16.8.4® (Ostend, Belgium) and SPSS 24.0® software (SPSS, v. 24.0 for WINDOWS; SPSS Inc., Chicago, IL, USA), and values of $p < 0.05$ were considered statistically significant.

Results

The research was conducted on a sample of 1863 respondents, of whom 957 (51.4%) boys, and 906 (48.6%) girls, all at the age of 7 to 10 years. The average age of the respondents was 8.98 ± 2.37 years.

Table 1 represents the characteristics of the sample. The inspection of Table 1, which represents the values of the arithmetic means, standard deviation, and the level of statistic significance, shows that there are statistically significant differences between the male and female respondents within the variables: BMI (kg/m^2), Waist circumference (cm), Waist-to-height ratio, 20-m shuttle run test (Laps), and 20-m shuttle run test (VO_2 peak). The inspection of the obtained results shows that the boys have a greater body mass index, waist circumference, waist-to-height ratio and achieve better results in the test of assessing the cardio-respiratory fitness, as compared to the girls.

The distribution of the state of obesity, calculated by the body mass index (BMI), WC >75th percentile for age and sex, waist-to-height ratio ≥ 0.50, BMI and waist circumference and BMI and waist-to-height ratio in children regarding their gender, is presented in Table 1. The analysis of Table 1 and inspection of $\chi 2$ tests show that statistically significant differences between the boys and girls exist in the fat calculated by the waist-to-height ratio ≥ 0.50 and BMI

Table 1. Characteristics of the sample

Indicators	Full Sample		Boys		Girls		p Value for Sex	(Cohen d)
	Mean	SD	Mean	SD	Mean	SD		
Age (years)	8.98	2.37	8.90	1.13	9.07	3.20	0.129	0.03
Height (cm)	134.92	9.21	134.89	9.05	134.95	9.37	0.898	0.01
Weight (kg)	34.55	10.44	34.71	10.95	34.39	9.88	0.507	0.03
BMI (kg/m^2)	18.98	3.76	19.18	3.97	18.76	3.52	0.021	0.11
BMI z-score	0.01	0.99	0.01	0.99	0.01	0.99	1.000	0.00
Waist circumference (cm)	61.43	9.05	62.41	9.57	60.41	8.35	0.000	0.22
Waist-to-height ratio	0.45	0.07	0.46	0.07	0.44	0.06	0.000	0.31
Overweight/Obesity[a]	717	38.5%	362	37.8%	355	39.2%	0.290	(N.A)
Obesity (WC >75th percentile for age and sex)[b]	510	23.0%	258	23.3%	252	22.8%	0.414	(N.A)
Obesity (waist-to-height ratio ≥ 0.50)[c]	411	18.4%	253	22.6%	158	14.2%	0.000	(N.A)
BMI and waist circumference	398	21.4%	203	21.2%	195	21.5%	0.457	(N.A)
BMI and waist-to-height ratio	334	17.9%	200	20.9%	134	14.8%	0.000	(N.A)
Stg	3.56	1.45	3.89	1.60	3.21	1.16	0.000	0.49
VO_2max	48.19	3.45	49.04	3.73	47.29	2.86	0.000	0.53

[a] Obesity defined as Cole et al. (2000); [b] >75th percentile waist circumference definition established by De Ferranti et al. (2004); [c] obesity defined as ≥0.50 according to Schwandt and Haas (2016). BMI: body mass index; WHtR, waist-to-height ratio. No applicable (N.A).

Table 2. Diagnostic properties of VO_2 peak (20-m shuttle run test) according to the equation of Léger et al. to detect body fat by age and sex group.

Age/Sex	AUC (95% CI)	Cut-Points, $mL \cdot kg^{-1} \cdot min^{-1}$	Sensitivity (%) (95% CI)	Specificity (%) (95% CI)	LR (+) (95% CI)	LR (−) (95% CI)	PPV (%) (95% CI)	NPV (%) (95% CI)
Boys								
Obesity by WC >75th percentile for age and sex								
7-8 years old	0.792 (0.754 to 0.825)	≤49.0	85.12 (77.5-90.9)	65.52 (60.7-70.1)	2.47 (2.1-2.9)	0.23 (0.1-0.3)	42.4 (36.1-48.9)	93.7 (90.2-96.2)
9-10 years old	0.826 (0.787 to 0.861)	≤47.0	83.17 (74.4-89.9)	69.16 (63.8-74.2)	2.70 (2.2-3.2)	0.24 (0.2-0.4)	45.9 (38.5-53.4)	92.9 (88.9-95.8)
7-10 years old	0.796 (0.769 to 0.821)	≤48.8	87.84 (82.8-91.8)	60.25 (56.6-63.8)	2.21 (2.0-2.4)	0.20 (0.1-0.3)	40.3 (35.9-44.8)	94.2 (91.7-96.1)
Obesity by WHtR (≥0.50)								
7-8 years old	0.796 (0.759 to 0.829)	≤48.6	79.35 (69.6-87.1)	68.25 (63.7-72.6)	2.5 (2.1-3.0)	0.30 (0.2-0.5)	34.3 (27.9-41.1)	94.1 (90.9-96.4)
9-10 years old	0.786 (0.744 to 0.824)	≤47.0	77.95 (69.7-84.8)	71.04 (65.5-76.1)	2.69 (2.2-3.3)	0.31 (0.2-0.4)	53.5 (46.0-60.9)	88.3 (83.5-92.1)
7-10 years old	0.802 (0.775 to 0.827)	≤47.4	73.06 (66.7-78.8)	74.66 (71.4-77.8)	2.88 (2.5-3.3)	0.36 (0.3-0.5)	46.1 (40.8-51.5)	90.3 (87.7-92.6)
Girls								
Obesity by WC >75^{th} percentile for age and sex								
7-8 years old	0.664 (0.619 to 0.706)	≤47.7	66.96 (57.4-75.6)	60.96 (55.7-66.1)	1.72 (1.4-2.1)	0.54 (0.4-0.7)	35.0 (28.7-41.8)	85.4 (80.5-89.5)
9-10 years old	0.716 (0.671 to 0.758)	≤44.8	60.00 (49.7-69.7)	73.8 (68.7-78.4)	2.29 (1.8-2.9)	0.54 (0.4-0.7)	40.8 (32.8-49.2)	86.0 (81.4-89.8)
7-10 years old	0.666 (0.634 to 0.697)	≤47.4	75.47 (69.1-81.1)	50.73 (46.9-54.5)	1.53 (1.4-1.7)	0.48 (0.4-0.6)	32.1 (28.0-36.4)	87.0 (83.3-90.2)
Obesity by WHtR (≥0.50)								
7-8 years old	0.703 (0.659 to 0.744)	≤47.3	65.67 (53.1-76.8)	68.08 (63.3-72.6)	2.06 (1.6-2.6)	0.50 (0.4-0.7)	25.6 (19.2-32.8)	92.2 (88.6-95.0)
9-10 years old	0.687 (0.641 to 0.730)	≤45.7	65.67 (53.1-76.8)	68.08 (63.3-72.6)	2.06 (1.6-2.6)	0.50 (0.4-0.7)	25.6 (19.2-32.8)	92.2 (88.6-95.0)
7-10 years old	0.736 (0.715 to 0.756)	≤47.1	71.71 (66.7-76.3)	66.14 (63.7-68.5)	2.12 (1.9-2.3)	0.43 (0.4-0.5)	33.4 (30.1-36.9)	90.8 (88.9-92.4)

AUC: area under the curve; 95% CI: 95% confidence interval; LR+: positive likelihood ratio; LR: negative likelihood ratio; PPV: positive predictive value; NPV: negative predictive value; WC, waist circumference; WHtR: waist-to-height ratio.

and waist-to-height ratio. It is not established statistically significant differences between the boys and girls in the rest of the indexes of assessing the obesity. The percentage values suggest that a greater percentage of the boys are classified in the category of fat ones, calculated by waist-to-height ratio ≥ 0.50 and BMI and waist-to-height ratio.

For boys and girls (Table 2, VO_2 peak showed significant predictive capacity for obesity (area under the curve, AUCs > 0.66). In boys, when considering the full sample (7-10 years), the best cut-point for VO_2 peak estimated by the equation of Léger et al. to detect body fat by WC were 48.8 to $mL \cdot kg^{-1} \cdot min^{-1}$ and WHtR were 47.4 to $mL \cdot kg^{-1} \cdot min^{-1}$. For girls, when considering the full sample (7-10 years), the best cut-point to detect body fat by WC were 47.4 to $mL \cdot kg^{-1} \cdot min^{-1}$ and WHtR were 47.1 to $mL \cdot kg^{-1} \cdot min^{-1}$.

Across all age and sex groups, CRF was weak to moderate negative correlated with WC and WHtR (Table 3).

Finally, according to cut-points suggested (Table 2), adolescents with low CRF were more likely to be obese either by WC or WHtR (Table 4).

Discussion

The basic results of the present study suggest that the cardio-respiratory fitness (estimated by 20-m shuttle run test) presented discriminatory ability in identifying a poor health profile (estimated by body fat parameters) in both girls and boys aged 7-10 years. Additionally, the suggested cut-points for low CRF were associated with obesity in all ages and sexes.

The study results are in accordance with the research conducted on a sample of 8740 Canadian children at the age of 8.0-12.9 years, and these results show the negative connection between the 20-m shuttle run test and and cardiometabolic risk (as assessed by adiposity measures), and that CRF cut-points obtained by ROC analysis have a good discriminative power of predicting the obesity (Silva et al., 2018). In the present research, the offered optimum CRF cut-points for children of 8 to 12 years were 41 $mL \cdot kg^{-1} \cdot min^{-1}$ for the boys and 39 $mL \cdot kg^{-1} \cdot min^{-1}$ for the girls. In another similar research which has been conducted on a sample of 16.619 British children at the age of 11-13.9 years from Liverpool (Boddy et al., 2012), the offered values for identification of children exposed to the risk of obesity were 41.9 $mL \cdot kg^{-1} \cdot min^{-1}$ for girls, and 46.96 $mL \cdot kg^{-1} \cdot min^{-1}$ for boys. In research conducted on a sample of 72.505 adolescents from Chille and Columbia, at the age of 13 and 15 years (Prieto-Benavides et al., 2019), the offered values of children exposed to obesity risk were 43.77 $mL \cdot kg^{-1} \cdot min^{-1}$ for boys and 38.53 $mL \cdot kg^{-1} \cdot min^{-1}$ for girls. In our research, regarding the whole sample of the male respondents, the optimal cut-points for WC was 48.8 $mL \cdot kg^{-1} \cdot min^{-1}$ while for WHtR it was 47.4 $mL \cdot kg^{-1} \cdot min^{-1}$. The whole sample of female respondents has the optimal cut-points' value for WC of 47.4 $mL \cdot kg^{-1} \cdot min^{-1}$, while those of WHtR were 47.1 $mL \cdot kg^{-1} \cdot min^{-1}$.

Two studies of research (Lang et al., 2019; Ruiz et al., 2016) regarding CRF cut-points to identify red flags for healthy and unhealthy phenotypes in children and adolescents, offer two temporary international referent criterion standards of 42 $mL \cdot kg^{-1} \cdot min^{-1}$ и 35 $mL \cdot kg^{-1} \cdot min^{-1}$ for boys and girls at the age of 8-18 years, respectively.

Table 3. Pearson correlation coefficient of association between cardiorespiratory fitness and body fat parameters by sex

Indicators	Boys			Girls		
	7-8 years old	9-10 years old	7-10 years old	7-8 years old	9-10 years old	7-10 years old
WC (cm)	-0,376*	-0,486*	-0,462*	-0,320*	-0,438*	-0,301*
WHtR	-0,276*	-0,359*	-0,341*	-0,227*	-0,300*	-0,248*

WC, waist circumference; WHtR, waist-to-height ratio. * $p < 0.001$ (r, Pearson correlation coefficient).

Table 4. Association between unhealthy level of cardiorespiratory fitness and obesity by sex

Indicators	Boys		Girls	
	Crude Analysis (OR (95% CI)	Adjusted Analysis (OR (95% CI) †	Crude Analysis (OR (95% CI)	Adjusted Analysis (OR (95% CI) †
Obesity by WC >75th percentile for age and sex				
Low cardiorespiratory fitness				
Sex-age-specific cut-points	9,76 (6,68-14,26)*	9,77 (6,69-14,28)*	3,39 (2,47-4,67)*	3,40 (2,46-4,69)*
Sex-specific cut-points	8,12 (5,54-11,92)*	8,53 (5,78-12,61)*	4,12 (3,27-5,19)*	4,95 (3,84-6,37)*
Obesity by WHtR (≥0.50)				
Low cardiorespiratory fitness				
Sex-age-specific cut-points	7,21 (5,03-10,32)*	7,21 (5,02-10,35)*	3,25 (2,23-4,74)*	3,26 (2,23-4,76)*
Sex-specific cut-points	8,35 (5,65-12,35)*	7,89 (5,33-11,70)*	4,98 (3,84-6,44)*	5,21 (3,96-6,86)*

OR: odds ratio; 95% CI: 95% confidence interval; WC, waist circumference; WHtR, waist-to-height ratio. † Adjusted analyses for age; * Logistic regression ($p < 0.001$).

The cut-points offered in our study are higher than those offered by Lang et al. (2019) and Ruiz et al. (2016). The reason for these differences might lie in the fact that our study makes use only of indexes of assessing the excessive body weight and obesity in order to define the poor health profile, whereas whereas the Ruiz and Lang cut-points used different cardiometabolic factors of risk. In addition, most of those studies have been conducted on a local sample of respondents who might not have the necessary representativity with regard to the whole population level. Further, both studies showed cut-points for CRF for many high-income countries, and, so far, there are very few studies conducted on a large sample of children and adolescents from the West Balkan, and especially from the Republic of North Macedonia (Pireva et al., 2018).

In general, these studies suggest the existence of significant connection between CRF and the indexes of assessing the obesity which is detectable as early as in the childhood and adolescent period, and which can be used in creating strategies and prevention measures for reducing the cardiometabolic factors of risk. The harmful results that are ascribed to the obesity can be reduced to a certain degree by maintaining the suitable levels of CRF (Mintjens et al., 2018; Lang et al., 2018a). In our research, we have also tested the connection between CRF and indexes of assessing obesity as well as the proposed cut-points of low CRF and obesity. The connection between our cut-points for low CRF and obesity give a clear insight of the connections between the unfavourable CRF and the lower health status, and emphasizes the necessity of the public-health intervention for raising the level of physical fitness of young population.

Such kind of interventions – for example in the school environment – should include promotion of physical activity in order to increase the CRF levels (Pozuelo-Carrascosa et al., 2018), which were alluded to in the most recent guidelines for physical activity (Physical Activity Guidelines Advisory Committee, 2018). Having in mind the results obtained in our research and comparing them with 142 studies (Lang et al., 2018b), which have examined the correlation between 20mSRT and different health indicators in children and adolescents, it can be concluded that 20mSRT is positively connected to the physical, physiologic and psycho-social and cognitive health of young persons, and it can be used as a holistic indicator of health which can help to identify the young persons running the risk of developing poor health.

Our research has several limits which should be taken into consideration when interpreting the results. In the first place, the pattern of a vertical zonation of our study does not allow us to explain the causality. Secondly, if the study had covered some other cardiometabolic factors of risk (e.g., dyslipidemia, blood pressure and insulin resistance), some additional information might have been obtained about the prognosticated assessment values. And finally, VO_2peak was established by the formula of results obtained from 20mSRT, but standard methods of testing by direct measuring of oxygen consumption are required to be applied in order to confirm out cut-points.

The chief advantage of the present study is its potential usefulness of the cut-points, which can be used in the training research by the teachers in the subject of Physical Education as well as the health workers in the countries of the West Balkan, and especially in the Republic of North Macedonia. Since 20mSRT is a simple, practical and cheap method of assessing CRF, it can be used in examining the connection between the physical activity and health of children and adolescents with regard to the population level (Lang et al., 2018). Finally, the significance of the present study is the relatively great sample of respondents, which makes it possible

to have a sensible examination of different indicators of the excessive weight and obesity on the level of a whole population in order to have better profile of Macedonian children.

Conclusions

Though a transversal research was conducted, AUC demonstrated moderate discriminative power, and our results confirm the ability and usefulness of CRF (assessed by 20mSRT) in detecting fat in children. Our findings also suggest that the proposed cut-points for low CRF are associated with obesity, in both genders. Therefore, teachers of Physical Education and health workers can use locally the obtained cut-points values for VO_2 as a cheap and practical method which can help to identify children and adolescents under the threat of poor health.

Conflict of interest

Authors have no conflict of interest to disclose.

References

Gontarev, S. & Kalac, R. (2016). Prediction of physical activity factors in macedonian adolescents. *Journal of Physical Education and Sport.*

Gontarev, S., Kalac, R., Ameti, V., & Redjepi, A. (2016). Factors associated with physical activity among Macedonian adolescents in albanian ethnic community. *Iranian journal of public health, 45*(4), 474.

Gontarev, S., Kalac, R., Velickovska, L. A., & Zivkovic, V. (2018). Physical Fitness Reference Standards in Macedonian Children And Adolescent: The Makfit Study. *Nutricion hospitalaria, 35*(6),1275-128. https://doi.org/10.20960/nh.1881

Sahoo, K., Sahoo, B., Choudhury, A. K., Sofi, N. Y., Kumar, R., & Bhadoria, A. S. (2015). Childhood obesity: causes and consequences. *Journal of family medicine and primary care, 4*(2), 187. https://doi.org/10.4103/2249-4863.154628

Balagopal, P., De Ferranti, S. D., Cook, S., Daniels, S. R., Gidding, S. S., Hayman, L. L., ... & Steinberger, J. (2011). Nontraditional risk factors and biomarkers for cardiovascular disease: mechanistic, research, and clinical considerations for youth: a scientific statement from the American Heart Association. *Circulation, 123*(23), 2749-2769. https://doi.org/10.1161/cir.0b013e31821c7c64

Kaminsky, L. A., Arena, R., Ellingsen, Ø., Harber, M. P., Myers, J., Ozemek, C., & Ross, R. (2019). Cardiorespiratory fitness and cardiovascular disease-The past, present, and future. *Progress in cardiovascular diseases, 62*(2), 86-93. https://doi.org/10.1016/j.pcad.2019.01.002

Mintjens, S., Menting, M. D., Daams, J. G., van Poppel, M. N., Roseboom, T. J., & Gemke, R. J. (2018). Cardiorespiratory fitness in childhood and adolescence affects future cardiovascular risk factors: a systematic review of longitudinal studies. *Sports Medicine, 48*(11), 2577-2605. https://doi.org/10.1007/s40279-018-0974-5

Pillsbury, L., Oria, M., & Pate, R. (Eds.). (2013). *Fitness measures and health outcomes in youth.*

Lee, S. J., & Arslanian, S. A. (2007). Cardiorespiratory fitness and abdominal adiposity in youth. *European journal of clinical nutrition, 61*(4), 561-565. https://doi.org/10.1038/sj.ejcn.1602541

Grøntved, A., Ried-Larsen, M., Møller, N. C., Kristensen, P. L., Froberg, K., Brage, S., & Andersen, L. B. (2015). Muscle strength in youth and cardiovascular risk in young adulthood (the European Youth Heart Study). *British journal of sports medicine, 49*(2), 90-94. https://doi.org/10.1136/bjsports-2012-091907

Silva, D. A. S., Lang, J. J., Barnes, J. D., Tomkinson, G. R., & Tremblay, M. S. (2018). Cardiorespiratory fitness in children: evidence for criterion-referenced cut-points. *PLoS One, 13*(8), e0201048. https://doi.org/10.1371/journal.pone.0201048

Pireva, A., Selimi, M., Gontarev, S., & Georgiev, G. (2018). Association between aerobic fitness and high blood pressure in adolescents in Macedonia evidence for criterion-referenced cut-points. *Journal of Physical Education and Sport 18*(2), 853-861.

Schwandt, P., & Haas, G. M. (2016). Is the ratio waist circumference to height (WHtR) of 0.5 a universal measure for abdominal adiposity in children and adolescents? *International Journal of Obesity, 40*(7), 1141-1142.

de Oliveira, R. G., & Guedes, D. P. (2018). Performance of anthropometric indicators as predictors of metabolic syndrome in Brazilian adolescents. *BMC pediatrics, 18*(1), 1-9. https://doi.org/10.1186/s12887-018-1030-1

de Ferranti, S. D., Gauvreau, K., Ludwig, D. S., Neufeld, E. J., Newburger, J. W., & Rifai, N. (2004). Prevalence of the metabolic syndrome in American adolescents: findings from the Third National Health and Nutrition Examination Survey. *Circulation, 110*(16), 2494-2497. https://doi.org/10.1161/01.cir.0000145117.40114.c7

Ashwell, M., & Gibson, S. (2016). Waist-to-height ratio as an indicator of 'early health risk': simpler and more predictive than using a 'matrix'based on BMI and waist circumference. *BMJ open, 6*(3), e010159. https://doi.org/10.1136/bmjopen-2015-010159

Leger, L. A., Mercier, D., Gadoury, C., & Lambert, J. (1988). The multistage 20 metre shuttle run test for aerobic fitness. *Journal of sports sciences, 6*(2), 93-101. https://doi.org/10.1080/02640418808729800

Ramírez-Vélez, R., Rodrigues-Bezerra, D., Correa-Bautista, J. E., Izquierdo, M., & Lobelo, F. (2015). Reliability of health-related physical fitness tests among Colombian children and adolescents: the FUPRECOL study. *PloS one, 10*(10), e0140875. https://doi.org/10.1371/journal.pone.0140875

Swets, J. A. (1973). The relative operating characteristic in psychology: a technique for isolating effects of response bias finds wide use in the study of perception and cognition. *Science, 182*(4116), 990-1000. https://doi.org/10.1126/science.182.4116.990

Boddy, L. M., Thomas, N. E., Fairclough, S. J., Tolfrey, K., Brophy, S., Rees, A., Knox, G., Baker, J. S., & Stratton, G. (2012). ROC Generated Thresholds for Field-Assessed Aerobic Fitness Related to Body Size and Cardiometabolic Risk in Schoolchildren. *PLoS ONE, 7*(9), e45755. https://doi.org/10.1371/journal.pone.0045755

Prieto-Benavides, D. H., García-Hermoso, A., Izquierdo, M., Alonso-Martínez, A. M., Agostinis-Sobrinho, C.,

Correa-Bautista, J. E., & Ramírez-Vélez, R. (2019). Cardiorespiratory fitness Cut-Points are related to body adiposity parameters in Latin American adolescents. *Medicina, 55*(9), 508. https://doi.org/10.3390/medicina55090508

Lang, J. J., Tremblay, M. S., Ortega, F. B., Ruiz, J. R., & Tomkinson, G. R. (2019). Review of criterion-referenced standards for cardiorespiratory fitness: what percentage of 1 142 026 international children and youth are apparently healthy?. *British Journal of Sports Medicine, 53*(15), 953-958. https://doi.org/10.1136/bjsports-2016-096955

Ruiz, J. R., Cavero-Redondo, I., Ortega, F. B., Welk, G. J., Andersen, L. B., & Martinez-Vizcaino, V. (2016). Cardiorespiratory fitness cut points to avoid cardiovascular disease risk in children and adolescents; what level of fitness should raise a red flag? A systematic review and meta-analysis. *British journal of sports medicine, 50*(23), 1451-1458. https://doi.org/10.1136/bjsports-2015-095903

Lang, J. J., Belanger, K., Poitras, V., Janssen, I., Tomkinson, G. R., & Tremblay, M. S. (2018a). Systematic review of the relationship between 20 m shuttle run performance and health indicators among children and youth. *Journal of Science and Medicine in Sport, 21*(4), 383-397. https://doi.org/10.1016/j.jsams.2017.08.002

Pozuelo-Carrascosa, D. P., García-Hermoso, A., Álvarez-Bueno, C., Sánchez-López, M., & Martinez-Vizcaino, V. (2018). Effectiveness of school-based physical activity programmes on cardiorespiratory fitness in children: a meta-analysis of randomised controlled trials. *British journal of sports medicine, 52*(19), 1234-1240. https://doi.org/10.1136/bjsports-2017-097600

Physical Activity Guidelines Advisory Committee (2018). 2018 physical activity guidelines advisory committee scientific report.

Lang, J. J., Tomkinson, G. R., Janssen, I., Ruiz, J. R., Ortega, F. B., Léger, L., & Tremblay, M. S. (2018b). Making a case for cardiorespiratory fitness surveillance among children and youth. *Exercise and sport sciences reviews, 46*(2), 66-75. https://doi.org/10.1249/jes.0000000000000138

ПОРОГОВІ ТОЧКИ КАРДІОРЕСПІРАТОРНОЇ ПІДГОТОВЛЕНОСТІ, ПОВ'ЯЗАНІ З ПАРАМЕТРАМИ ОЖИРІННЯ ТІЛА У МАКЕДОНСЬКИХ ДІТЕЙ

Абдулла Елезі[1ABCDE], Валон Кадріу[2ABCDE], Греса Елезі[3ABCDE], Георгій Георгієв[4ABCDE], Серьожа Гонтарєв[4ABCDE]

[1]Університет в Приштині
[2]Університетський клінічний центр Косова
[3]Американська лікарня, Приштина
[4]Кирило-Мефодіївський університет в Скоп'є

Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 7 с., 4 табл., 27 джерел.

Проблематика та цілі. У Республіці Північна Македонія не вистачає критеріїв та стандартів для тестів логістичного застосування, призначених для оцінки кардіореспіраторної придатності (КРП) у дітей та підлітків. Мета дослідження була двоякою: 1) Визначити здатність КРП, що оцінюється за допомогою тесту «20-метровий човниковий біг», розрізняти «здорові» та «нездорові» фенотипи (за показниками ожиріння, такими як ОТ та СТЗ) у дітей; 2) Визначити взаємозв'язок між ожирінням та відносно максимальним споживанням кисню (VO_2peak), перевіреним на відносно великій вибірці македонських дітей. Дослідження проведено на вибірці з 1863 респондентів, з яких 957 (51,4%) були хлопчики та 906 (48,6%) – дівчата віком від 7 до 10 років. Усі вони були учнями 19 початкових шкіл центральної та східної частин Республіки Північна Македонія.

Матеріали і методи. Окружність талії (ОТ) та співвідношення талії та зросту (СТЗ) використовувалися для визначення маркерів ожиріння тіла. КРП вимірювали за допомогою тесту "20-метровий човниковий біг" (VO_2peak). Криві операційних характеристик приймача та логістична регресія були застосовані для встановлення розрізняючої здатності КРП у прогнозуванні параметрів маркерів ожиріння тіла.

Результати. Як для хлопчиків, так і для дівчат, VO_2peak показав значну прогностичну здатність для визначення ожиріння (площа під кривою [AUC] > 0,66). У хлопчиків, при розгляді повної вибірки (7–10 років), найкраща порогова точка для VO_2 peak для визначення жирової маси тіла за допомогою ОТ була до 48,8 мл·кг$^{-1}$·хв$^{-1}$, а СТЗ – до 47,4 мл·кг$^{-1}$·хв$^{-1}$. У дівчат, при розгляді повної вибірки (7-10 років), найкращою точкою для визначення жирової маси тіла за допомогою ОТ була до 47,4 мл·кг$^{-1}$·хв$^{-1}$, а СТЗ – до 47,1 мл·кг$^{-1}$·хв$^{-1}$.

Висновки. Згідно з цими пороговими точками, підлітки з низькою КРП частіше мали ожиріння за ОТ або СТЗ. Граничні значення (порогові точки) КРП можуть бути використані як кількісні маркери для дітей з більш здоровими характеристиками тіла з Республіки Північна Македонія.

Ключові слова: епідеміологія, ожиріння, маса тіла, діти, підлітки.

Information about the authors:

Elezi Abdulla: abdulla.elezi@uni-pr.edu; https://orcid.org/0000-0003-0225-7494; Faculty of Physical Education and Sport, University of Pristina, Kosovo, Industrial Zone, Pristina, 10000, Kosovo.

Kadriu Valon: kadriu.valon.md@gmail.com; https://orcid.org/0000-0003-0201-3561; University Clinical Center of Kosovo, 10000, Kosovo.

Elezi Gresa: gresaelezi@hotmail.com; https://orcid.org/0000-0002-1937-4294; American Hospital, Industrial Zone, Pristina, 10000, Kosovo.

Georgiev Georgi: georgigeorgiev63@yahoo.com; https://orcid.org/0000-0002-1748-9477; Faculty of Physical Education, Sport and Health, Ss. Cyril and Methodius University of Skopje, Dimce Mircev, 3, Skopje, 1000, Republic of North Macedonia.

Gontarev Seryozha: gontarevserjozal@gmail.com; https://orcid.org/0000-0001-5873-2974; Faculty of Physical Education, Sport, and Health, Ss. Cyril and Methodius University of Skopje, Dimce Mircev, 3, Skopje, 1000, Republic of North Macedonia.

Cite this article as: Elezi, A., Kadriu, V., Elezi, G., Georgiev, G., & Gontarev, S. (2022). Cardiorespiratory Fitness Cut-Points Related to Body Adiposity Parameters in Macedonian Children. *Teoriâ ta Metodika Fizičnogo Vihovannâ, 22*(1), 48-55. https://doi.org/10.17309/tmfv.2022.1.07

Received: 16.11.2021. Accepted: 2.02.2022. Published: 25.03.2022