

THE RELATIONSHIP OF CARDIORESPIRATORY FITNESS, BIRTH WEIGHT AND PARENTAL BMI ON CHILDREN' OBESITY STATUS

ODNOS IZMEĐU KARDIORESPIRATORNE KONDICIJE, TEŽINE ROĐENJA DETETA I RODITELJSKOG BMI¹, NA STATUS GOJAZNOSTI U DETINJSTVU

ZORICA STANKOVSKA¹, SERJOŽA GONTAREV², ŽARKO KOSTOVSKI², ALEKSANDAR JANKOVIĆ³

¹Ss. Cyril and Methodius University Skopje, St. Kliment Ohridski Faculty of Pedagogy, North Macedonia

²Ss. Cyril and Methodius University Skopje, Faculty of Physical Education, Sport and Health, North Macedonia

³University Novi Sad, Faculty of Pedagogy, Sombor, Serbia

Correspondence:

Žarko Kostovski

Ss. Cyril and Methodius University Skopje, St. Kliment Ohridski Faculty of Pedagogy, North Macedonia
zarkok@ukim.edu.mk

Korespondencija:

Žarko Kostovski

Univerzitet Sv. Kiril i Motodij Skopje, Peadgoški fakultet Sv. Kliment Ohridski
zarkok@ukim.edu.mk

Abstract: The aim of the study was to determine the differences in cardiorespiratory fitness, parents' body mass index, birth weight between a group of children with normal and overweight / obesity and to determine how much the studied variables affect the risk of their biological offspring being overweight. The research was conducted on a sample of 1096 respondents, aged 6 to 10 years, randomly drawn from several primary schools in the Skopje region. The sample is divided into two sub-samples according to gender; 496 male respondents and 600 female respondents. Cardiorespiratory fitness was assessed with the 20m shuttle run test according to the procedures described in FITNESSGRAM. The children were classified into two groups, based on the percentages of the body mass index, according to the IOTF standard. The birth weight of the children was assessed from the pediatric records of each child at birth. The condition of overweight / obese parents was defined according to the classification of the World Health Organization. Data on the education of parents (especially mothers and fathers) were collected through a questionnaire. The prevalence of overweight and obesity in this study was 22.6% and 14.9%, for the entire sample of respondents without statistically significant gender differences. The results of the research indicate the connection between obesity of parents and their children. Furthermore, the results suggest that low cardiorespiratory fitness and high birth weight are predictors of OV / OB in childhood.

Keywords: children; obesity status; cardiorespiratory fitness; birth weight; parental BMI

Sažetak: Cilj istraživanja bio je da se utvrde razlike u kardiorespiratornoj kondiciji, indeksu telesne mase roditelja i rođenoj težini, između grupe dece sa normalnom i prekomernom telesnom težinom/gojaznošću i da se utvrdi koliko proučavane varijable utiču na rizik od prekomerne težine njihovog biološkog potomstva. Istraživanje je sprovedeno na uzorku od 1096 ispitanika, uzrasta od 6 do 11 godina, izabranih po slučajnom izboru iz nekoliko osnovnih škola u regionu Skoplja. Uzorak je podeljen u dva poduzorka prema polu, 496 ispitanika muškog pola i 600 ispitanica. Kardiorespiratorna kondicija je procenjena testom trčanja na 20 metara u skladu sa procedurama opisanim u FITNESSGRAM-u. Deca su klasifikovana u dve grupe, na osnovu procenta indeksa telesne mase, prema IOTF standardu. Rođena težina dece je procenjena iz pedijatrijske dokumentacije svakog deteta pri rođenju. Stanje težina/gojaznih roditelja definisano je prema klasifikaciji Svetske zdravstvene organizacije. Podaci o obrazovanju roditelja (posebno majke i oca) prikupljeni su anketnim upitnikom. Prevalencija prekomerne težine i gojaznosti u ovoj studiji iznosila je 22,6% i 14,9%, za ceo uzorak ispitanika bez statistički značajnih polnih razlika. Rezultati istraživanja ukazuju na vezu između gojaznosti roditelja i njihove dece. Štaviše, rezultati sugerišu da su niska kardiorespiratorna sposobnost i visoka porođajna težina prediktori OV/OB (prekomerne težine/gojaznosti) u detinjstvu.

Ključne reči: deca, gojaznost, kardiorespiratorni fitness, težina na rođenju, roditeljski BMI

INTRODUCTION

Obesity in children has developed since early childhood. The prevalence of childhood obesity has increased significantly in recent decades around the world. The origins of obesity are complex and are influenced by genetic and environmental factors. Obesity and adolescence in childhood persist into adulthood (Simmonds, M., et al. 2016) and are associated with serious cardiovascular disease (Sommer, A. & Twig, G.2018).

Obesity in childhood and later in adolescence is associated with an increased risk of cardiovascular, metabolic and endocrine disorders (Ebbeling, C. B. et al. 2002). Vei et al. (2007), in one of their studies, showed that birth weight is associated with obesity and diabetes in young people. Birth weight (BV) is also present as an important marker of genetic factors associated with increased obesity prevalence.

The results of the study showed that the offsprings of obese parents have an increased risk of obesity due to common genes. (Gordon-Larsen P., in general. 2007). The likely presence of obesity involves changes in the balance between energy intake and energy expenditure. Physical activity, as well as a sedentary lifestyle and diet, appear to play an important role in long-term weight management. According to some studies, obesity in children of early preschool age is associated with other clinical factors that are easily assessed at birth (Baird et al., 2005). While the association between birth weight and obesity risk was found in children aged 4, 8, 10, and 12 (Maffeis et al., 1994), high birth weight was associated with higher BMI at age 7 (Toschke et al., 2004; Hui et al., 2008).

MATERIAL AND METHODS

Study participants

The survey was conducted on a sample of 1,096 respondents, randomly selected from several primary schools in the Skopje region. The sample was divided into two subsamples by gender, that is 496 male respondents and 600 female respondents. The sample included all students whose parents agreed to participate in the project and who are mentally and physically healthy and regularly attend physical and health education classes. In addition, all students who did not do all the measurements and tests or for some other reason were excluded from the analysis. Respondents were treated in accordance with the Declaration of Helsinki. The protocols were approved by the Ethics Commission of the University of St. Cyril and Methodius "from Skopje. The measurements were realized in March, April and May 2019

Uvod

Gojaznost kod dece uočava se i razvija od ranog detinjstva. Prevalencija gojaznosti kod dece značajno je porasla u poslednjih nekoliko decenija širom sveta. Poreklo gojaznosti je složeno i na njega utiču genetski faktori i faktori životne sredine. Gojaznost i adolescencija u detinjstvu perzistiraju u odraslom dobu (Simmonds, M., et al. 2016) i povezani su sa ozbiljnim kardiovaskularnim oboljenjima (Sommer, A. & Tvig, G.2018).

Gojaznost u detinjstvu i kasnije u adolescenciji je povezana sa povećanim rizikom od kardiovaskularnih, metaboličkih i endokrinih poremećaja (Ebbeling, C. B. et al. 2002). Vei et al. (2007), u jednoj od svojih studija su pokazali da je težina na rođenju povezana sa gojaznošću i dijabetesom kod mladih ljudi. Rođena težina (BV) je takođe prisutna kao važan marker genetskih faktora povezanih sa povećanom prevalencijom gojaznosti.

Rezultati studije su pokazali da potomci gojaznih roditelja imaju povećan rizik od gojaznosti zbog zajedničkih gena. (Gordon-Larsen P., 2007). Verovatno prisustvo gojaznosti uključuje promene u ravnoteži između unosa energije i potrošnje energije. Čini se da fizička aktivnost, kao i sedentarni način života i ishrana igraju važnu ulogu u dugoročnom upravljanju težinom. Prema nekim studijama, gojaznost kod dece ranog predškolskog uzrasta je povezana sa drugim kliničkim faktorima koji se lako procenjuju pri rođenju (Baird et al., 2005). Veza između težina na rođenju i rizika od gojaznosti je pronađena kod dece uzrasta 4, 8, 10 i 12 godina (Maffeis et al., 1994), dok je visoka težina rođenja bila povezana sa višim BMI u dobi od 7 godina (Toschke et al., 2004; Hui et al., 2008).

MATERIAL I METODE

Učesnici studije

Istraživanje je sprovedeno na uzorku od 1096 ispitanika, odabranih po slučajnom izboru iz nekoliko osnovnih škola u Skopskom regionu. Uzorak je podeljen na dva poduzorka prema polu, 496 ispitanika muškog pola i 600 ispitanica. Uzorkom su obuhvaćeni svi učenici za koje su roditelji pristali da učestvuju u projektu i koji su psihički i fizički zdravi i redovno pohađaju nastavu fizičkog i zdravstvenog vaspitanja. Osim toga, iz analize su isključeni svi učenici koji nisu uradili sva merenja i testove ili iz nekog drugog razloga. Ispitanici su tretirani u skladu sa Helsinškom deklaracijom. Protokole je odobrila Etička komisija Univerziteta Sv. Ćirila i Metodija" iz Skoplja. Merenja su realizovana u martu, aprilu i maju 2019. godine u standardnim škol-

in standard school conditions of regular physical education and health education.

Anthropometric measures

Anthropometric measurements were performed according to the standard methodology of the International Biological Program (IBP) and according to the recommendations of the World Health Organization (WHO). When measuring weight and height, the subjects were in underwear without shoes and the weight was measured with a medical decimal scale, with an accuracy of 0.1 kg. The height was measured in the Frankfurt horizontal plane with a telescopic altimeter (Martin Anthropometer) with an accuracy of 0.1 cm. Body mass index (BMI kg / m²) was calculated as weight in kilograms divided by square of height in meters

For this study, participants were classified as NOW or OV / OB according to the International Obesity Working Group (Cole et al., 2000). Parental BMI was calculated based on the weight and height reported by them and was used to assess weight status according to the recommendations of the World Health Organization. BMI is divided into three categories: normal weight ($18.5 \geq \text{BMI} < 25 \text{ kg / m}^2$); overweight ($25 \geq \text{BMI} < 30 \text{ kg / m}^2$) and obesity ($\text{BMI} \geq 30 \text{ kg / m}^2$) (WHO, 1998). Further, to analyze the association between adolescent obesity and parental characteristics, parents were further divided into three groups: (1) both parents with normal weight, (2) one OV / OB parent, and (3) both OV / OB parents. The birth weight (BW) of adolescents was estimated based on the pediatric record of each child at birth. Potential confusers initially used, were selected based on previous reports. Low birth weight and macrosomia are defined as birth weight $< 2500 \text{ g}$ or $\geq 4000 \text{ g}$, respectively.

Cardiorespiratory fitness

Cardiorespiratory fitness (CRF) was measured using a 20-meter shuttle test as previously described in the study by Legera et al. (1988). For this test, the children had to run back and forth between two lines set at a distance of 20 meters. An audible signal is emitted from a pre-recorded tape to dictate the running speed. The frequency of the audible signals increased so that the running speed increased by 0.5 km / h every minute from the initial speed of 8.5 km / h. The test ended when the children could no longer keep up with the sound signal. The last phase that the children reached was used to predict the maximum oxygen intake (VO₂max) from the running speed corresponding to that phase ($\text{VO}_{2\text{max}} = 31.025 + 3.238 \text{ Ks} - 3.248 \text{ A} + 0.1536$, where Ks = final speed and A = age).

skim uslovima redovne nastave fizičkog i zdravstvenog vaspitanja.

Antropometrijske mere

Antropometrijska merenja su vršena prema standardnoj metodologiji Međunarodnog biološkog programa (IBP) i prema preporukama Svetske zdravstvene organizacije (SZO). Pri merenju težine i visine, ispitanici su bili u donjem vešu bez cipela i težina je merena medicinskom decimalnom vagom, sa tačnošću od 0,1 kg. Visina je merena teleskopskim visinomerom (Antropometra po Martin-u) sa tačnost od 0,1 cm. Indeks telesne mase (BMI kg/m²) izračunat je kao težina u kilogramima podeljena sa kvadratom visine u metrima.

Za ovu studiju, učesnici su klasifikovani kao normalna težina (NOW) ili prekomerna težina/gojaznost (OV/OB) prema Međunarodnoj radnoj grupi za gojaznost (Cole et al., 2000). BMI roditelja je izračunat na osnovu težine i visine koju su sami prijavili i korišćen je za procenu statusa težine prema preporukama Svetske zdravstvene organizacije. BMI je podeljen u tri kategorije: normalna težina ($18,5 \geq \text{BMI} < 25 \text{ kg/m}^2$); prekomerne težine ($25 \geq \text{BMI} < 30 \text{ kg/m}^2$) i gojaznosti ($\text{BMI} \geq 30 \text{ kg/m}^2$) (SZO, 1998). Dalje, za analizu povezanosti između gojaznosti adolescenata i karakteristika roditelja, roditelji su dalje podeljeni u tri grupe: (1) oba roditelja sa normalnom težinom, (2) jedan OV/OB roditelj i (3) oba roditelja OV/OB. Rođenja težina (BW) adolescenata je procenjen na osnovu pedijatrijskog kartona svakog deteta pri rođenju. Prvobitno uključeni potencijalni zbunjujući faktori odabrani su na osnovu prethodnih izveštaja. Mala težina rođenja i makrozomija su definisani kao težina rođenja $< 2500 \text{ g}$ ili $\geq 4000 \text{ g}$, respektivno.

Kardiorespiratorni fitness

Kardiorespiratorni fitness (CRF) je meren korišćenjem trčanja 20m šatl testa kao što je prethodno opisano u studiji Legera et al. (1988). Za ovaj test, deca su morala da trče napred-nazad između dve linije postavljene na udaljenosti od 20 metara. Zvučni signal je emitovan sa unapred snimljene trake da diktira brzinu trčanja. Frekvencija zvučnih signala se povećala tako da se brzina trčanja povećavala za 0,5 km/sat svakog minuta od početne brzine od 8,5 km/h. Test je završen kada deca više nisu mogla da idu u korak sa zvučnim signalom. Poslednja faza koju su deca dostigla korišćena je za predviđanje maksimalnog unosa kiseonika (VO₂max) iz brzine trčanja koja odgovara toj fazi ($\text{VO}_{2\text{max}} = 31,025 + 3,238 \text{ Ks} - 3,248 \text{ A} + 0,1536$, gde je Ks = konačna brzina i A = starost).

Parent education

Data on the education of parents (especially mothers and fathers) were collected through a questionnaire answered by parents of children. Based on the responses of both parents, parental education is coded as 1: two parents with low / secondary education, 2: at least one parent with higher education, 3: two parents with higher education.

Statistics

Arithmetic means and Standard Deviations were calculated to describe participants' characteristics according to gender and obesity status. Comparisons between gender and obesity status were performed by independent t-test for anthropometric variables and χ^2 test for BMI, CRF, parental BMI and parental education categories. For both sexes, the independent group of predictors with BMI as the dependent variable (NOW and OV / OB) was examined using gradual logistic regression analysis with age, body weight, parental obesity status, and parental education as independent variables. Statistical analysis was performed using software SPSS 15 (SPSS, Chicago, IL, USA) and Microsoft Excel 2000 (Microsoft, Redmond, VA, USA). The significance level is set to $P \leq 0.05$.

RESULTS

The characteristics of the examined sample by sex are shown in Table 1. The table shows that male subjects have higher body weight, higher birth weight and show better results in the test to assess cardiorespiratory capacity compared to female subjects ($P \leq 0.01$). Statistically significant differences between male and female respondents were not found in age, body height, BMI, paternal BMI and maternal BMI. The overall prevalence of overweight and obesity was 22.6% and 14.9%, respectively. A review of the χ^2 test shows that no statistically significant differences in the degree of nutrition of boys and girls were found. In total, 51.1% of fathers were classified as overweight, while 22.3% were classified as obese. For mothers, the corresponding figures were 26.4% overweight and 16.5% obese.

Edukacija roditelja

Podaci o obrazovanju roditelja (posebno majke i oca) prikupljeni su putem anketnog upitnika na koji su roditelji dece odgovarali. Na osnovu odgovora oba roditelja, obrazovanje roditelja je šifrirano kao 1: dva roditelja sa niskim/srednjim obrazovanjem, 2: najmanje jedan roditelj sa visokim obrazovanjem, 3: dva roditelja sa visokim obrazovanjem.

Statistika

Aritmetičke sredine i standardne devijacije su izračunate da opišu karakteristike učesnika prema polu i statusu gojaznosti. Poređenja između polova i statusa gojaznosti vršena su nezavisnim t-testom za antropometrijske varijable i χ^2 testom za kategorije BMI, CRF, roditeljski BMI i obrazovanje roditelja. Za oba pola, nezavisna grupa prediktora sa BMI kao zavisna varijabla (NOW i OV/OB) ispitan je korišćenjem postepene logističke regresivne analize sa uzrastom, telesnom masom, statusom gojaznosti roditelja i obrazovanjem roditelja kao nezavisnim varijablama. Statistička analiza je izvršena korišćenjem softvera SPSS 15 (SPSS, Chicago, IL, USA) i Microsoft Excel 2000 (Microsoft, Redmond, VA, USA). Nivo značajnosti je postavljen na $P=0,05$.

REZULTATI

Karakteristike ispitivanog uzorka prema polu prikazane su u tabeli 1. Iz pregleda tabele vidi se da ispitanici muškog pola imaju veću telesnu težinu, veću trudničku težinu i pokazuju bolje rezultate u testu za procenu kardiorespiratorne sposobnosti u odnosu na ispitanice ženskog pola ($P \leq 0,01$). Statistički značajne razlike između ispitanika muškog i ženskog pola nisu nađene u starosti, telesnoj visini, BMI, očevom BMI i BMI kod majke. Ukupna prevalencija prekomerne težine i gojaznosti iznosila je 22,6%, odnosno 14,9%.

Table 1. Sample characteristics

Table 1. Karakteristike uzorka

Characteristics	Total (n = 1096)		Boys (n = 496)		Girls (= 600)		P-value
	Mean	SD	Mean	SD	Mean	SD	
Age (years)	8.87	3.10	8.83	1.47	8.90	3.98	NS
Height (sm)	134.63	10.69	134.96	10.51	134.36	10.83	NS
Weight (kg)	34.29	10.29	35.16	10.95	33.57	9.65	0.011
BMI (kg/m ²)	17.55	5.74	17.85	6.01	17.31	5.51	NS
Birth weight (BW) (kg)	3.28	0.59	3.36	0.59	3.21	0.58	0.000
CRF (VO ₂ max)	48.14	3.38	48.87	3.56	47.53	3.09	0.000
CRF (laps)	3.43	1.41	3.78	1.57	3.14	1.19	0.000
Father BMI (kg/m ²)	27.45	3.72	27.46	3.58	27.44	3.84	NS
Mother BMI (kg/m ²)	23.90	3.85	23.95	4.26	23.85	3.45	NS
BMI (%)							
Normal weight	682	62.50%	311	62.80%	371	62.10%	
Overweight	247	22.60%	102	20.60%	145	24.30%	
Obese	163	14.90%	82	16.60%	81	13.60%	NS
P-BMI (%)							
Two parents with normal weight	180	18.70%	83	18.70%	97	18.80%	
At least one parent with OV/OB	547	56.90%	246	55.30%	301	58.30%	
Two parents with OV/OB	234	24.30%	116	26.10%	118	22.90%	NS
P-Edu (%)							
Two parents with Low/Middle education	352	33.20%	209	43.50%	143	24.70%	
At least one parent with High education	322	30.30%	135	28.10%	187	32.20%	
Two parents with High education	387	36.50%	137	28.50%	250	43.10%	0.000

Abbreviations: BMI. body mass index; CRF. cardiorespiratory fitness; NS. not significant; OV/OB. overweight/obese; P-BMI. parental BMI; P-Edu. parental education. NS=P > 0.05

Table 2 shows the differences in the studied variables between the groups of male respondents formed on the basis of the BMI classification. A review of Table 2 shows that the group classified as OV / OB is higher, has a higher body mass index (BMI), and both parents have a higher BMI than their peers classified in the normal body weight group (NOW). CRF values (number of rounds and VO₂ max) were statistically significantly lower in OV / OB than in the NOW group. The body mass index (BMI) of statistical parents differed significantly between the NOW and OV / OB groups (P = 0.001). No statistically significant differences were found between group differences in parent education.

U tabeli 2 prikazane su razlike u proučavanim varijablama između grupa muških ispitanika formiranih na osnovu BMI klasifikacije. Pregled tabele 2 pokazuje da je grupa klasifikovana kao OV / OB viša, teža, ima viši indeks telesne mase (BMI), a oba roditelja imaju veći BMI od svojih vršnjaka klasifikovanih u grupu normalne telesne težine (NOW). CRF vrednosti (broj krugova i VO₂ max) bile su statistički značajno niže u OV/OB nego u grupi NOW. Indeks telesne mase (BMI) roditelja, statistički značajno se razlikovao između grupa NOW i OV/OB (P = 0,001). Nisu nađene statistički značajne razlike između grupnih razlika u obrazovanju roditelja.

Table 2. arithmetic mean and standard deviation of child and parent characteristics according to body mass index in boys

Table 2. Aritmetička sredina i standardna devijacija karakteristika deteta i roditelja prema indeksu telesne mase kod dečaka

Characteristics	Normal weigh		Overweight/obese		P-value
	Mean	SD	Mean	SD	
Age (years)	8.74	1.43	8.98	1.53	NS
Height (sm)	133.35	9.84	137.74	11.04	0.000
Weight (kg)	29.98	6.32	44.00	11.46	0.000
BMI (kg/m ²)	15.31	5.08	22.06	5.00	0.000
Birth weight (BW) (kg)	3.32	0.59	3.42	0.57	NS
CRF (VO2 max)	49.98	3.35	47.01	3.13	0.000
CRF (laps)	4.19	1.59	3.09	1.25	0.000
Father BMI (kg/m ²)	26.84	3.42	28.50	3.61	0.000
Mother BMI (kg/m ²)	23.33	4.28	24.95	4.02	0.000
P-BMI (%)					
Two parents with normal weight	63	22.80%	20	11.90%	
At least one parent with OV/OB	155	56.20%	90	53.60%	
Two parents with OV/OB	58	21.00%	58	34.50%	0.001
P-Edu (%)					
Two parents with Low/Middle education	135	44.90%	74	41.30%	
At least one parent with High educatio	76	25.20%	58	32.40%	
Two parents with High educatio	90	29.90%	47	26.30%	NS
Birth weight					
< 2500 g	28	9.10%	11	6.10%	
2500 – 4000 g	249	80.80%	138	76.20%	
> 4000 g (macrosomia)	31	10.10%	32	17.70%	0.034

Abbreviations: BMI. body mass index; BW. birth weight; NS. not significant; PBMI. parental BMI. NS = $P > 0.05$.

Table 3 shows the differences in the studied variables between the groups of respondents formed on the basis of the BMI classification. From the overview of Table 3 it can be seen that the group classified as OV / OB is higher, the heavier ones have a higher body mass index (BMI), higher birth weight and both parents have a higher BMI compared to their peers classified in the normal weight group). CRF values (number of rounds and VO2 max) were statistically significantly lower in OV / OB than in the NOW group. The parent body mass index (BMI) differed statistically significantly between the NOW and OV / OB groups ($P < 0.001$). Also, the respondents were not statistically significant between the group differences in terms of parent education.

U tabeli 3 prikazane su razlike u proučavanim varijablama između grupa ispitanica formiranih na osnovu BMI klasifikacije. Iz pregleda tabele 3 može se videti da je grupa klasifikovana kao OV/OB veća, teži imaju veći indeks telesne mase (BMI), veću porođajnu težinu i oba roditelja imaju veći BMI u odnosu na svoje vršnjake klasifikovane u grupa sa normalnom telesnom težinom (NOW). CRF vrednosti (broj krugova i VO2 mak) bile su statistički značajno niže u OV/OB nego u grupi NOW. Indeks telesne mase (BMI) roditelja se statistički značajno razlikovao između grupa NOW i OV/OB ($P < 0,001$). Takođe, ispitanice nisu bile statistički značajne između grupnih razlika u pogledu obrazovanja roditelja.

Table 3. arithmetic mean and standard deviation of the characteristics of the child and parent according to the body mass index in girls**Table 3.** Aritmetička sredina i standardna devijacija karakteristika deteta i roditelja prema indeksu telesne mase kod devojčica

Characteristics	Normal weigh		Overweight/obese		P-value
	Mean	SD	Mean	SD	
Age (years)	8.79	1.56	9.09	6.17	NS
Height (sm)	133.46	10.53	136.01	11.15	0.005
Weight (kg)	29.51	6.70	40.40	9.90	0.000
BMI (kg/m ²)	15.60	4.20	20.16	6.09	0.000
Birth weight (BW) (kg)	3.17	0.61	3.28	0.54	0.021
CRF (VO ₂ max)	48.28	3.03	46.26	2.77	0.000
CRF (laps)	3.49	1.25	2.57	0.83	0.000
Father BMI (kg/m ²)	26.62	3.36	28.85	4.20	0.000
Mother BMI (kg/m ²)	23.49	3.37	24.47	3.52	0.001
P-BMI (%)					
Two parents with normal weight	71	21.80%	25	13.20%	
At least one parent with OV/OB	198	60.90%	103	54.20%	
Two parents with OV/OB	56	17.20%	62	32.60%	0.000
P-Edu (%)					
Two parents with Low/Middle education	92	25.50%	51	23.60%	
At least one parent with High educatio	123	34.10%	62	28.70%	
Two parents with High educatio	146	40.40%	103	47.70%	NS
Birth weight					
< 2500 g	37	10.10%	16	7.20%	
2500 – 4000 g	301	82.50%	183	82.40%	
> 4000 g (macrosomia)	27	7.40%	23	10.40%	NS

Abbreviations: BMI. body mass index; BW. birth weight; NS. not significant; PBMI. parental BMI. NS = $P > 0.05$.

Table 4. Prevalence of overweight and obesity by gradual multiple logistic regression analysis in boys**Tabela 4.** Prevalencija prekomerne težine i gojaznosti postupnom višestrukom logističkom regresijskom analizom kod dječaka

Explanatory variables	Unstandardized coefficient (B)	Wald statistics	p	OR (95% CI)
Age	-0.38	19.97	0.000	0.68 (0.58-0.81)
Stg	0.72	58.62	0.000	2.06 (1.71-2.47)
P-BMI (%)				
Two parents with normal weight	1.36	14.31	0.000	3.90 (1.92-7.88)
At least one parent with OV/OB	0.62	5.64	0.018	1.86 (1.11-3.09)
Two parents with OV/OB Ref				
Birth weight				
< 2500 g	1.55	9.44	0.002	4.71 (1.75-12.66)
2500 – 4000 g	0.53	2.40	0.122	1.70 (0.87-3.33)
> 4000 g (macrosomia) Ref				

*Dependent variable: overweight and obesity-BMI (Cole at al., 2000, 2007)

Table 5. Prevalence of overweight and obesity by gradual multiple logistic regression analysis in girls

Tabela 5. Prevalencija prekomerne telesne težine i gojaznosti postupnom višestrukom logističkom regresijskom analizom kod djevojčica

Explanatory variables	Unstandardized coefficient (B)	Wald statistics	p	OR (95% CI)
Age	-0.17	5.48	0.019	0.84 (0.73-0.97)
Stg	0.97	61.52	0.000	2.65 (2.07-3.37)
P-BMI (%)				
Two parents with normal weight	1.15	12.76	0.000	3.16 (1.68-5.95)
At least one parent with OV/OB	0.56	5.22	0.022	1.75 (1.08-2.82)
Two parents with OV/OB				
Birth weight				
< 2500 g	0.26	0.30	0.587	1.30 (0.51-3.30)
2500 – 4000 g	0.12	0.12	0.731	1.13 (0.58-2.20)
> 4000 g (macrosomia)				

*Dependent variable: overweight and obesity-BMI (Cole at al.. 2000. 2007)

The relationship between overweight and obesity classified on the basis of BMI in male and female subjects and potential risk factors were determined by multinomial logistic regression analysis, and the results are shown in Tables 4 and 5. From the overview of Table 4 can be seen (OR): 2.06; confidence interval (CI): 1.71–2.47; $P \leq 0.01$), low birth weight (OR: 4.71; CI: 1.75–12.66; $P \leq 0.05$), with both parents with normal body weight (OR: 3.90; CI: 1.92-7.88; $P < 0.01$) or one parent with normal body weight (OR: 1.86; CI: 1.11–3.09; $P \leq 0.05$) were less likely to be classified as OV / OB compared to counterparts classified as NOW. From the overview of Table 5 it can be seen that girls with higher values of cardiorespiratory fitness CRF (OR: 2.64; CI: 2.07–3.37; $P \leq 0.01$), with both parents with normal body weight (OR: 3, 16; CI). Stk #: 1.68- 5.95; $P < 0.01$) or one parent with normal body weight (OR: 1.75; CI: 1.08–2.82; $P \leq 0.05$) are less likely to be classified as OV / OB compared to peers classified as NOW.

DISCUSSION

This paper investigated the relationship between cardiorespiratory fitness and obesity status in children aged 6 to 11 years, taking into account the birth weight of children, body mass index and parental education. The prevalence of overweight and obesity in this study was 22.6% and 14.9% for the entire sample. Although the sample did not represent the entire population of the country, the prevalence of overweight and obesity was similar to the values reported in other studies conducted on samples of Macedonian children and adolescents (Gontarev & Ruždija, 2014; Gontarev, et al., 2018). The results of the study show that children of both sexes clas-

sdos gojaznosti i gojaznosti klasifikovanih na osnovu BMI kod muških i ženskih ispitanika i potencijalnih faktora rizika utvrđen je multinomijalnom logističkom regresionom analizom, a rezultati su prikazani u tabelama 4 i 5. Iz pregleda tabele 4 može se videti dečaci sa višom kardiorespiratornom kondicijom CRF (OR): 2,06; interval poverenja (CI): 1,71–2,47; $P \leq 0,01$), niska porođajna težina (OR: 4,71; CI: 1,75–12,66; $P \leq 0,05$), sa oba roditelja sa normalnom telesnom težinom (OR: 3,90; CI: 1,92-7,88; $P < 0,01$) ili jedan roditelj sa normalnom telesnom težinom (OR: 1,86; CI: 1,11–3,09; $P \leq 0,05$) su manje verovatno bili klasifikovani kao OV / OB u poređenju sa kolegama klasifikovanim kao normalna težina (NOW). Iz pregleda tabele 5 može se videti da devojčice sa višim vrednostima kardiorespiratornog fitnesa CRF (OR: 2,64; CI: 2,07–3,37; $P \leq 0,01$), sa oba roditelja sa normalnom telesnom težinom (OR: 3,16; CI). : 1,68- 5,95; $P < 0,01$) ili jedan roditelj sa normalnom telesnom težinom (OR: 1,75; CI: 1,08–2,82; $P \leq 0,05$), manje je verovatno da će biti klasifikovani kao OV / OB u poređenju sa vršnjacima klasifikovanim kao normalna težina (NOW).

DISKUSIJA

Ovaj rad je istraživao vezu između kardiorespiratorne kondicije i gojaznog statusa kod dece uzrasta od 6 do 11 godina, uzimajući u obzir porođajnu težinu dece, indeks telesne mase i obrazovanje roditelja. Prevalencija prekomerne težine i gojaznosti u ovoj studiji iznosila je 22,6% i 14,9% za ceo uzorak ispitanika. Iako uzorak nije predstavljao celokupnu populaciju zemlje, prevalencija prekomerne težine i gojaznosti bila je slična vrednostima prijavljenim u drugim studijama sprovedenim na uzorcima makedonske dece i adolescenata (Gontarev &

sified as OV / OB show lower results in cardiorespiratory condition (number of laps and VO₂ max) compared to their peers classified as normal body weight (NOW). The results are consistent with previous studies that used a sophisticated methodology to assess body composition in children aged 8 to 11 years (Gutin, et al., 2004). Lee and Arslanian (2007) found that cardiorespiratory fitness was associated with lower visceral and abdominal subcutaneous fat levels measured by DEXA in 113 American adolescents aged 8 to 17 years. These findings were similar when anthropometric methods were used to assess total and central adiposity (Ortega, et al., 2007). Ruiz et al. (2006) found that cardiorespiratory condition was inversely related to total body fat estimated through the sum of five skin folds in Swedish and Estonian children aged 9 to 10 years.

Our results may have some significance from a preventive point of view, as they have potentially indicated some future negative health implications. Previous research suggests that low levels of cardiorespiratory fitness, excess body fat, and a sedentary lifestyle are predictors of certain cardiovascular and metabolic disorders (Janssen et al., 2005). Longitudinal studies also suggest that, regardless of the initial level of cardiorespiratory fitness, improvements in it are associated with a lower risk of developing obesity / obesity during puberty (Ortega, et al., 2011).

Moreover, the results of this study indicate that parental obesity is a strong predictor of overweight / obesity in children. The results are consistent with previous research suggesting a link between parents' obesity levels and their children's obesity status (Whitaker et al., 1997; Maffeis et al., 1998; Treuth et al., 2003). Moreover, our data clearly showed that the association was even stronger when obesity was detected in both, not just one parent, according to other studies (Davison and Birch, 2001; Herbert et al., 2006). For example, maternal obesity has been associated with obesity in younger children (Gordon-Larsen et al., 2007). This is particularly important because some data suggest that an overweight child living in a family where one or both parents are overweight is likely to remain obese during childhood, adolescence, and adulthood (Magarei et al., 2003). Namely, the results of the research suggest that obesity / childhood obesity occurs in the family circle, where in addition to the genetic factor, environmental factors also play an important role. Therefore, our data indicate the need to take into account the family environment when designing intervention programs to prevent or reduce obesity.

Numerous studies have examined the association

Ruždija, 2014; Gontarev, et al., 2018). Rezultati studije pokazuju da deca oba pola klasifikovana kao OV/OB pokazuju niže rezultate u kardiorespiratornoj kondiciji (broj krugova i VO₂ max) u poređenju sa svojim vršnjacima klasifikovanim kao normalna telesna težina (NOW). Rezultati su u skladu sa prethodnim studijama koje su koristile sofisticiranu metodologiju za procenu telesne kompozicije kod dece uzrasta od 8 do 11 godina (Gutin, et al., 2004). Lee i Arslanian (2007) su otkrili da je kardiorespiratorna kondicija povezana sa nižim vrednostima visceralne i abdominalne potkožne masti merene DEK-SA kod 113 američkih adolescenata starosti od 8 do 17 godina. Ovi nalazi su bili slični kada su antropometrijske metode korišćene za procenu ukupne i centralne adipoznosti (Ortega, et al., 2007). Ruiz i dr. (2006) su otkrili da je kardiorespiratorna kondicija obrnuto povezana sa ukupnom telesnom masnoćom procenjenom kroz zbir od pet kožnih nabora kod Švedske i Estonske dece uzrasta od 9 do 10 godina.

Naši rezultati mogu imati određeni značaj sa preventivne tačke gledišta, jer su potencijalno ukazali na neke buduće negativne implikacije po zdravlje. Prethodna istraživanja sugerišu da su nizak nivo kardiorespiratorne kondicije, višak telesne masti i sedentarni način života prediktori određenih kardiovaskularnih i metaboličkih poremećaja (Janssen et al., 2005). Longitudinalne studije takođe sugerišu da su, bez obzira na početni nivo kardiorespiratorne kondicije, poboljšanja u njoj povezana sa manjim rizikom od razvoja gojaznosti/gojaznosti tokom puberteta (Ortega, et al., 2011).

Štaviše, rezultati ove studije ukazuju da je gojaznost roditelja snažan prediktor prekomerne težine/gojaznosti kod dece. Rezultati su u skladu sa prethodnim istraživanjima koja sugerišu vezu između nivoa gojaznosti roditelja i statusa gojaznosti njihove dece (Whitaker et al., 1997; Maffeis et al., 1998; Treuth et al., 2003). Naši podaci su jasno pokazali da je povezanost bila još jača kada je gojaznost otkrivena kod oba, a ne samo kod jednog roditelja, u skladu sa drugim studijama (Davison i Birch, 2001; Herbert et al., 2006). Na primer, gojaznost majki je bila povezana sa gojaznošću kod mlađe dece (Gordon-Larsen et al., 2007). Ovo je posebno važno jer neki podaci sugerišu da će dete sa viškom kilograma koje živi u porodici u kojoj jedan ili oba roditelja imaju višak kilograma verovatno ostati gojazno tokom detinjstva, adolescencije i odraslog doba (Magarei et al., 2003). Naime, rezultati istraživanja sugerišu da se gojaznost/gojaznost u detinjstvu javlja u krugu porodice, gde pored genetskog faktora važnu ulogu imaju i faktori sredine. Dakle, naši podaci ukazuju na potrebu da se pri osmišljavanju inter-

between maternal weight and the later development of cardiovascular disease (Karter et al., 1999; Vei et al., 2007) and obesity (Stettler et al., 2002). Our data show that boys with low birth weight are 4.71 less likely to be OV / OB. No association was found between girls and birth weight and the likelihood of being OV / OB. Some previous research has found a link between BW and the continued prevalence of obesity in children and adolescents (Curhan et al., 1996; Dubois and Girard, 2006; Vei et al., 2007). The results of our research showed that the mother's body weight, especially in boys, is a strong predictor of OV / OB in childhood and therefore intrauterine factors should be considered as a strategic option when creating an intervention program.

The advantages of this study are the size of the sample of children and the responses of parents to the nutritional status, education and birth weight of their children. This study also has some limitations that should be noted. First, the parent body mass index was determined based on self-reported data, which may affect the true prevalence of overweight and obesity (Treuth et al., 2003). However, BMI from self-reported data has been shown to be sufficiently accurate and widely used in epidemiological studies; on the other hand, objective measurements of the weight and height of large specimens can be difficult and unattainable due to organizational constraints. Second, the study did not consider the impact of diet on energy regulation. Future studies should include dietary factors that may be associated with obesity.

CONCLUSION

The prevalence of overweight and obesity in this study was 22.6% and 14.9%, respectively, for the entire sample of respondents without a statistically significant gender difference. Furthermore, the results of the research indicate the connection between obesity of parents and their children. The results suggest that low cardiorespiratory fitness and high birth weight are predictors of childhood OV / OB. Thus, the implementation of programs that promote active behavior in primary school children should not focus only on the suggestion of structured activities in or outside the school environment, but should take into account environmental aspects, such as parental awareness and counseling. Combining direct effort with indirect action (ie aimed at increasing the role of parents in promoting their children's physical activity, especially free outdoor play) can lead to stronger immediate results, as well as to structuring and maintaining healthy behavioral assets in later life.

ventnih programa za prevenciju ili smanjenje gojaznosti vodi računa o porodičnom okruženju.

Brojne studije su ispitivale povezanost između težine majke i kasnijeg razvoja kardiovaskularnih bolesti (Karter et al., 1999; Vei et al., 2007) i gojaznosti (Stettler et al., 2002). Naši podaci pokazuju da dečaci sa malom porođajnom težinom imaju 4,71 manje šanse da budu OV/OB. Nije pronađena povezanost između devojčica i težine rođenja i verovatnoće da budu OV/OB. Neka ranija istraživanja su otkrila vezu između BW i dalje prevalencije gojaznosti kod dece i adolescenata (Curhan et al., 1996; Dubois i Girard, 2006; Vei et al., 2007). Rezultati našeg istraživanja su pokazali da je telesna težina majke, posebno kod dečaka, snažan prediktor OV/OB u detinjstvu i zato intrauterine faktore treba posmatrati kao stratešku opciju pri kreiranju programa intervencije.

Prednosti ove studije su veličina uzorka dece i odgovori roditelja na status uhranjenosti, obrazovanje i porođajnu težinu njihove dece. Ova studija takođe ima neka ograničenja koja treba napomenuti. Prvo, indeks telesne mase roditelja određen je na osnovu podataka koji su sami prijavili, što može uticati na pravu prevalenciju prekomerne težine i gojaznosti (Treuth et al., 2003). Međutim, pokazalo se da je BMI iz podataka samoprijavljenih dovoljno tačan i da se široko koristi u epidemiološkim studijama; s druge strane, objektivna merenja težine i visine velikih uzoraka mogu biti teška i nedostižna zbog organizacionih ograničenja. Drugo, studija nije uzela u obzir uticaj ishrane na regulaciju energije. Buduće studije bi trebalo da uključuju i faktore ishrane koji mogu biti povezani sa gojaznošću.

ZAKLJUČAK

Prevalencija prekomerne težine i gojaznosti u ovoj studiji iznosila je 22,6% i 14,9%, za ceo uzorak ispitanika bez statistički značajne polne razlike. Nadalje, rezultati istraživanja ukazuju na povezanost gojaznost roditelja i njihove dece. Rezultati sugeriraju da su niska kardiorespiratorna kondicija i visoka porođajna težina, prediktori OV/OB iz djetinjstva. Dakle, implementacija programa koji promovišu aktivno ponašanje dece u osnovnoj školi, ne bi trebalo da ih fokusiraju samo na sugestiju strukturirane aktivnosti u ili izvan školskog okruženja, nego treba uzeti u obzir okolne aspekte, kao što su svest roditelja i savetovanja. Kombinovanje direktnog napora sa indirektnim delovanjem (tj. usmerenim na povećati ulogu roditelja u promicanju fizičke aktivnosti njihove dece, posebno slobodna igra na otvorenom) može dovesti do jačih trenutnih rezultata, kao i na strukturiranje i održavanje zdravog načina života i ponašanja u kasnijim periodima života.

REFERENCES

- Baird J, Fisher D, Lucas P, Kleijnen J, Roberts H, Law C (2005). Being big or growing fast: systematic review of size and growth in infancy and later obesity. *BMJ* 331, 929.
- Cole T, Bellizzi M, Flegal K, Dietz W (2000). Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* 320, 1240–1243.
- Curhan GC, Chertow GM, Willett WC, Spiegelman D, Colditz GA, Manson JE et al. (1996). Birth weight and adult hypertension and obesity in women. *Circulation* 94, 1310–1315.
- Davison KK, Birch LL (2001). Child and parent characteristics as predictors of change in girls' body mass index. *Int J Obes Relat Metab Disord* 25, 1834–1842.
- Dubois L, Girard M (2006). Early determinants of overweight at 4.5 years in a population-based longitudinal study. *Int J Obes (Lond)* 30, 610–617.
- Ebbeling, C. B., Pawlak, D. B. & Ludwig, D. S. Childhood obesity: public-health crisis, common sense cure. *Lancet*. 360, 473–482 (2002).
- Gordon-Larsen P, Adair LS, Suchindran CM (2007). Maternal obesity is associated with younger age at obesity onset in U.S. adolescent offspring followed into adulthood. *Obesity (Silver Spring)* 15, 2790–2796.
- Gordon-Larsen P, McMurray RG, Popkin BM (2000). Determinants of adolescent physical activity and inactivity patterns. *Pediatrics* 105, E83.
- Gutin, B., Yin, Z., Humphries, M. C., Hoffman, W. H., Gower, B., & Barbeau, P. (2004). Relations of fatness and fitness to fasting insulin in black and white adolescents. *The Journal of pediatrics*, 145(6), 737-743.
- Herbert A, Gerry NP, McQueen MB, Heid IM, Pfeufer A, Illig T et al. (2006). A common genetic variant is associated with adult and childhood obesity. *Science* 312, 279–283.
- Janssen I, Katzmarzyk PT, Boyce WF, Vereecken C, Mulvihill C, Roberts C et al. (2005). Comparison of overweight and obesity prevalence in school-aged youth from 34 countries and their relationships with physical activity and dietary patterns. *Obes Rev* 6, 123–132.
- Karter AJ, Rowell SE, Ackerson LM, Mitchell BD, Ferrara A, Selby JV et al. (1999). Excess maternal transmission of type 2 diabetes. The Northern California Kaiser Permanente Diabetes Registry. *Diabetes Care* 22, 938–943.
- Leger LA, Mercier D, Gadoury C, Lambert J (1988). The multistage 20 meter shuttle run test for aerobic fitness. *J Sports Sci* 6, 93–101.
- Lee, S.J., Arslanian, S.A. (2007) Cardiorespiratory fitness and abdominal adiposity in youth. *Eur J Clin Nutr*, doi: 10.1038/sj.ejcn.1602541.
- Maffei C, Micciolo R, Must A, Zaffanello M, Pinelli L (1994). Parental and perinatal factors associated with childhood obesity in north-east Italy. *Int J Obes Relat Metab Disord* 18, 301–305.
- Maffei C, Talamini G, Tato L (1998). Influence of diet, physical activity and parents' obesity on children's adiposity: a four-year longitudinal study. *Int J Obes Relat Metab Disord* 22, 758–764.
- Magarey AM, Daniels LA, Boulton TJ, Cockington RA (2003). Predicting obesity in early adulthood from childhood and parental obesity. *Int J Obes Relat Metab Disord* 27, 505–513.
- Ortega, F. B., Tresaco, B., Ruiz, J. R., Moreno, L. A., Martin-Matillas, M., Mesa, J. L., ... & Castillo, M. J. (2007). Cardiorespiratory fitness and sedentary activities are associated with adiposity in adolescents. *Obesity*, 15(6), 1589-1599.
- Ortega, F. B., Artero, E. G., Ruiz, J. R., Jiménez-Pavón D. (2011) Physical fitness levels among European adolescents: the HELENA study. *Br J Sports Med* 2011;45:20–29. doi:10.1136/bjism.2009.062679
- Ruiz, J. R., Rizzo, N. S., Hurtig-Wennlöf, A., Ortega, F. B., Wärnberg, J., & Sjöström, M. (2006). Relations of total physical activity and intensity to fitness and fatness in children: the European Youth Heart Study-. *The American journal of clinical nutrition*, 84(2), 299-303.
- Gontarev, S., Kalac, R. (2014) The relationship between overweight, obesity and physical fitness among eleven and twelve-year-old Macedonian adolescents. *Journal of Physical Education and Sport* 14(2):178-185
- Gontarev S, Kalack R, Velickovska LA, Stojmanovska DS, Misovski A, Milenkovski J. (2018) Health-related physical fitness of normal, stunted and overweight children aged 6-14 years in Macedonia. *Nutr Hosp* 2018;35(5):1208-1214
- Stettler N, Zemel BS, Kumanyika S, Stallings VA (2002). Infant weight gain and childhood overweight status in a multicenter, cohort study. *Pediatrics* 109, 194–199.
- Simmonds, M., Llewellyn, A., Owen, C. G. & Woolacott, N. Predicting adult obesity from childhood obesity: a systematic review and meta-analysis. *Obes Rev*. 17, 95–107 (2016).
- Sommer, A. & Twig, G. The Impact of Childhood and Adolescent Obesity on Cardiovascular Risk in Adulthood: a Systematic Review. *Curr Diab Rep*. 18, 91, <https://doi.org/10.1007/s11892-018-1062-9> (2018).
- Toschke AM, Grote V, Koletzko B, Von Kries R (2004). Identifying children at high risk for overweight at school entry by weight gain during the first 2 years. *Arch Pediatr Adolesc Med* 158, 449–452.
- Treuth MS, Butte NF, Sorkin JD (2003). Predictors of body fat gain in nonobese girls with a familial predisposition to obesity. *Am J Clin Nutr* 78, 1212–1218.
- Wei JN, Li HY, Sung FC, Lin CC, Chiang CC, Li CY et al. (2007). Birth weight correlates differently with cardiovascular risk factors in youth. *Obesity (Silver Spring)* 15, 1609–1616.
- Whitaker RC, Wright JA, Pepe MS, Seidel KD, Dietz WH (1997). Predicting obesity in young adulthood from childhood and parental obesity. *N Engl J Med* 337, 869–873.

Primljen: 08. mart 2022. / Received: March 08, 2022
 Prihvaćen: 30. april 2022. / Accepted: April 30, 2022

