Nutrición Hospitalaria
ISSN: 0212-1611
nutricion@grupoaran.com
Sociedad Española de Nutrición
Parenteral y Enteral
España

Nutr Hosp. 2017; 34(1):35-40 ISSN 0212-1611 - CODEN NUHOEQ S.V.R. 318

ARÁN

Nutrición Hospitalaria

Trabajo Original

Pediatría

The association between high blood pressure, physical fitness and fatness in adolescents

Asociación entre presión arterial alta, aptitud física y obesidad en los adolescentes

Seryozha Gontarev[1], Ruzdija Kalac[1], Vujica Zivkovic[1], Lence A. Velickovska[1] and Besnik Telai[2]

[1]Faculty of Physical Education, Sport, and Health. Ss. Cyril and Methodius University. Skopje, Macedonia. [2]Faculty of Physical Education. State University of Tetovo. Macedonia

Abstract

Introduction: Hypertension is a health problem that is of national importance. It is a major risk factor for the occurrence of atherosclerosis and cardiovascular, cerebrovascular and renal diseases that are leading or among the leading causes of mortality and morbidity as in ours, as in the most developed and less developed countries.

Objective: The purpose of this study is to analyze the relation of cardiorespiratory fitness and obesity, blood pressure and hypertension for adolescents.

Material and methods: The research was realized on a sample of 4,051 boys and girls at the age of 11 to 14 years. Cardiorespiratory fitness was assessed by using a three minute step test, while the percentage of body fat was determined by bioelectrical impedance method. Blood pressure was measured three times at intervals of 60 seconds, and the result was the median value of the three measurements. The measurements were performed in a separate room with optimum ambient conditions. The relation between hypertension, cardiorespiratory fitness and fat was determined by correlation and multi-nominal logistic regressive analysis.

Results: Boys had higher systolic pressure and lower diastolic pressure compared to girls. The low level of cardiorespiratory fitness and high percentage of body fat were independently associated with an increased risk of blood pressure and hypertension for both boys and girls. The interaction was established between the percentage of body fat and fitness.

Conclusion: The results should be taken into account for building strategies and recommendations for improvement of lifestyle and health for adolescents.

Key words:

Blood pressure. Physical fitness. Fatness. Adolescent.

Resumen

Introducción: la hipertensión es un problema de la salud y es de importancia nacional. Es un factor de riesgo importante para la aparición de la aterosclerosis y enfermedades cardiovasculares, cerebrovasculares y enfermedades renales que están liderando o están entre las principales causas de mortalidad y la morbilidad como en la nuestra, también en los países más desarrollados y menos desarrollados.

Objetivo: el objetivo de este estudio es analizar la relación de la aptitud cardiorrespiratoria y la obesidad, la presión arterial y la hipertensión en los adolescentes.

Material y métodos: la investigación se realizó sobre una muestra de 4.501 niños y niñas de 11 a 14 años. La capacidad cardiorrespiratoria se evalúo con el uso de una prueba de paso que dura tres minutos, mientras que el porcentaje de grasa corporal se determinó con un método de impedancia bioeléctrica. La presión arterial se midió tres veces a intervalos de 60 segundos. El resultado fue el valor medio de las tres mediciones. Las mediciones se realizaron en una habitación separada con condiciones ambientales óptimas. La relación entre la hipertensión, la aptitud cardiorrespiratoria y la grasa se determina con un análisis de correlación y multinominal regresión logística.

Resultados: los niños tenían una mayor presión sistólica y diastólica que las niñas. El nivel bajo de aptitud cardiorrespiratoria y el porcentaje alto de grasa corporal se asociaron independientemente con un mayor riesgo de hipertensión arterial e hipertensión para niños y niñas. La interacción se establece entre el porcentaje de grasa corporal y la forma física.

Conclusión: los resultados obtenidos se deben tener en cuenta para la construcción de estrategias y recomendaciones para la mejora del estilo de vida y la salud de los adolescentes.

Palabras clave:

Presión arterial. Aptitud física. Obesidad. Adolescente.

Received: 26/05/2016
Accepted: 01/09/2016

Gontarev S, Kalac R, Zivkovic V, Velickovska LA, Telai B. The association between high blood pressure, physical fitness and fatness in adolescents. Nutr Hosp 2017;34:35-40

DOI: http://dx.doi.org/10.20960/nh.973

Correspondence:

Seryozha Gontarev. Faculty of Physical Education, Sport, and Health. Ss. Cyril and Methodius University. Dimce Mircev, 3. 1000 Skopje. R. Macedonia
e-mail: gontarevserjoza@gmail.com

INTRODUCTION

Hypertension is a health problem that is of national importance. It is a major risk factor for the occurrence of atherosclerosis and cardiovascular, cerebrovascular and renal diseases that are leading or among the leading causes of mortality and morbitet as in ours, an in the most developed and less developed countries. Epidemiological studies show a correlation between low physical activity and/or low level of fitness and cardiovascular aliments (1). Biological risk factors for the occurrence of cardiovascular diseases track from childhood and adolescence into adulthood (2-4). The low level of fitness is associated with an increased risk of high blood pressure for middle-aged men and women (5,6). But there are many fewer researches which explain the etiological relationship between fitness and blood pressure for children and adolescents (7-9).

One of the problems of the research is that the increased percentage of body fat (obesity) is associated with blood pressure and fitness. A high physical activity level may influence both fitness and body fatness. There is a consensus that aerobic training reduces blood pressure for adults, but a growing number of studies research the relation of fitness and obesity on blood pressure for children and adolescents, and there were no researches on the interaction of obesity and fitness in terms of blood pressure. Explaining the relationship between blood pressure, physical fitness and obesity is useful for building strategies and recommendations to improve the lifestyle and health of adolescents.

The purpose of this study was to analyze the relation of cardiorespiratory fitness and obesity, blood pressure, as the possible combined effects of cardiorespiratory fitness and body fat.

MATERIALS AND METHODS

SAMPLE OF RESPONDENTS

The research is realized on a sample of 4,051 adolescents with Macedonian nationality, 19 primary school in the central and eastern part of Macedonia, 8 of which are in rural and 11 in urban areas. The sample is divided into two subsamples according to gender and that is 2,078 male respondents and 1,973 female respondents. The average age of the respondents of both gender is 12.4 years. In the study were included all students whose parents gave consent to participate in the research that were psychologically and physically healthy, and who regularly attend classes in physical and health education. The respondents were acted in accordance with the Helsinki Declaration.

The measurements are realized in March, April and May 2013, in standard conditions of regular school classes of physical and health education. The measurements were realized by experts in the field of kinesiology and medicine, previously trained to perform functional tests and taking anthropometric measures.

ANTHROPOMETRIC MEASURES AND BODY COMPOSITION

The measurement of anthropometric measures were implemented by the recommendations of the IBP - International Biological Program (10). For assessment of morphological characteristics were applied the following anthropometric measures: height of the body in a standing position (cm), weight (k), and body mass index (BMI).

The components of the body composition are determined by bioelectrical impedance method (measuring the electrical conductivity -Bioelektrical Impedance Analysis - BIA). The measurement is realized by Body Composition Monitor, model «OMRON - BF511», with whose help the body weight, body fat percentage, and muscle mass percentage is measured. Before starting the measurement in Body Composition Monitor were entered the parameters of gender, age and body height of the respondent. In order to ensure better accuracy of the results obtained from the assessment of body composition, before each measurement were fulfilled prerequisites recommended by ACSM (11) and Heyward (12).

BLOOD PRESSURE

The blood pressure measurement (systolic and diastolic) is realized by experts from the medicine, doctor-specialists pediatrician fields. The measurements were performed in a separate room with optimum ambient conditions in a relaxed state of the respondent, and the relaxation is conducted at least five minutes before the measuring. The measurements were realized on forearm above the wrist on the palm, with clinically tested electronic digital device for measuring blood pressure from the company «Omron». The measurement was conducted on the left hand and before measuring care was taken that the cuff was properly inserted, the hand is at the height of the heart, and the respondent sit properly, not to move or to talk. Blood pressure was measured three times at intervals of 60 seconds, and the result was the median value of the three measurements. In the age group studied, the High Blood Pressure (HBP) was regarded as the average (from three measurements) of systolic and/or diastolic pressure at the 95th percentile for age and gender, adjusted to height percentile. We adopted the methodological recommendations of the Update on the Task Force Report on High Blood Pressure in Children and Adolescent (13).

EVALUATION OF PHYSICAL FITNESS

3-minute step test. Aerobic capacity is calculated using the 3-minute step test. Respondent was tasked 3 minutes to climb up and climb down from bench on high of 30.5 cm, and that is in four cycles (up, up, down, down) with standardized rhythm of 96 beats per minute (bmp), which enjoyed the metronome. Before the begging of the test the heart rate was measured, wherein children who are in rest condition had submaximal value in terms of age, they were not subjected to loading. The respondents who did not have contraindications to perform step-test immediately after the test (on cue) should sit on the bench to measure heart rate immediately after the burden, and a minute later, the stage of recovery. If the respondent felt dizziness, shortness of breath, nausea, headache or other difficulties, the test is immediately interrupted. The heart rate was measured using a monitor Polar RS800 for registration of the hearth frequency. As a result was taken the heart frequency measured one minute after the test (Postexercise pulse rate) (14).

STATISTICAL ANALYSIS

The data are presented as frequencies (percentage) for categorical variables and mean (SD) for continuous variables. Gender differences in fitness, blood pressure and anthropometric characteristics were analyzed by one-way analysis of variance (ANOVA). Categorical data (weight status and proportion of hypertension) were analyzed using the Chi-square test. Pearson correlation was used to analyse the relationship between blood pressure, anthropometric characteristics and fitness. The univariant and multivariant relation between hypertension, cardiorespiratory fitness and fat tissue is determined by logistic regression analysis, for the needs of the multi-nominal logistic regressive analyze the sample was divided into five categories of postexercise pulse rate and body fat, according to quintile. All the analyses were performed using the Statistical Package for Social Sciences software (SPSS, v. 22.0 for WINDOWS; SPSS Inc., Chicago, IL, USA), and values of $p < 0.05$ were considered statistically significant.

RESULTS

The research was realized on a sample of 4.091 respondents of which 2.116 (51.7%) boys and 1975 (48.3%) girls at the age of 11 to 14 years. The average age of the respondents was 12.4 ± 1.1 years.

In table I are shown the characteristics of a sample. From the review of the table I in which are shown the values of the arithmetical means, standard deviations and the level of statistical significance can be seen that there are statistically significant differences between the male and female gender in the variables Height, Weight, Body fat (%), SBP (mmHg), DBP (mmHg) and Postexercise pulse rate. From the review of the obtained results, can be seen that boys are taller, heavier, have a lower percentage of body fat, higher systolic pressure, and lower diastolic pressure compared to girls. Statistically significant differences were found in the age and BMI variables.

The distribution of the excessive weight/obesity assessed by BMI and hypertension for adolescents in terms of gender are shown in table I. The table I analysis and summary of the Chi-square test (Chi-square = 20.000, p = 0.000) indicate that there are statistically significant differences in the nutrition level among boys and girls. The percentage values show that a higher percentage of boys are overweight/obese. Also, the statistically significant differences were established in the hypertension between boys and girls (Chi-square = 9.449, p = 0.002). The percentage values show that higher percentage of girls (16.5%) have hypertension compared to boys (14.7%).

In the table II are shown the correlation coefficients between the assessment of blood pressure and anthropometric indicators variables and measures to assess cardiorespiratory fitness in the

Table I. Description of the study population means and standard deviation (SD)

	Boys (n = 2,116)		Girls (n = 1,975)		Total (n = 4,091)		p-value
	Mean	SD	Mean	SD	Mean	SD	
Age (years)	12.35	1.10	12.37	1.10	12.36	1.10	0.530
Height (cm)	157.74	10.94	156.13	8.08	156.96	9.70	0.000
Weight (kg)	52.76	14.71	51.12	12.07	51.96	13.52	0.000
BMI	20.95	4.17	20.84	4.07	20.90	4.12	0.414
Body fat (%)	20.60	8.47	25.04	7.73	22.76	8.41	0.000
SBP (mmHg)	115.04	10.87	113.87	10.15	114.47	10.54	0.000
DBP (mmHg)	71.02	8.81	72.22	8.20	71.60	8.54	0.000
Postexercise pulse rate	112.19	18.57	130.03	18.64	120.88	20.63	0.000
Proportion with systolic hypertension n (%)	207	10.1%	194	10.0%	401	10.1%	0.958
Proportion with diastolic hypertension n (%)	169	8.1%	205	10.5%	374	9.3%	0.009
Systolic or/and diastolic hypertension n (%)	302	14.7%	355	18.4%	657	16.5%	0.002
Proportion with overweight and obesity n (%)	386	39.6%	267	29.7%	653	34.9%	0.000

Data are shown as mean (SD) unless otherwise indicated. Sex differences were analysed by one-way analysis of variance, with sex group as fixed factors, and anthropometric or physical fitness measurements as dependent variables. The respondents were categorized according to the international genderand age-specific BMI (kg/m^2) cut-off points (Cole et al. 2000, 2007) (15,16). $p < 0.010$ for difference between boys and girls (Chi-Square Tests).

Table II. Relationship of systolic and diastolic blood pressure with age, height, weight, body mass index, body fat and physical fitness in Pearson correlation analysis

	Boys		Girls		Total	
	SBP (mm Hg)	DBP (mm Hg)	SBP (mm Hg)	DBP (mm Hg)	SBP (mm Hg)	DBP (mm Hg)
Age (years)	0.310**	0.094*	0.182**	0.144**	0.249**	0.118**
Height (cm)	0.440**	0.196**	0.314**	0.244**	0.390**	0.206**
Weight (kg)	0.477**	0.274**	0.403**	0.294**	0.447**	0.276**
BMI	0.366**	0.257**	0.327**	0.232**	0.348**	0.244**
Body fat (%)	0.144**	0.186**	0.311**	0.233**	0.197**	0.218**
Postexercise pulse rate	0.223**	0.268**	0.256**	0.297**	0.189**	0.282**

$^*p < 0.05$. $^{**}p < 0.01$.

total sample and separately for boys and girls. From the review of table II can be seen that the total sample there is statistically significant correlation between systolic blood pressure, age, body weight, body height, BMI, fat percentage and post-exercise pulse rate. The highest correlation with systolic pressure show the weight, BMI and body height variables. When analyzing the variables separately for boys and girls can be seen that for both gender the statistically significant correlation between systolic pressure, age, body weight, body height, BMI, fat percentage and post-exercise pulse rate. The highest correlation for both gender show again the variables weight, BMI and body height.

In the total sample low statistically significant correlation with diastolic pressure show the age, weight, bogy height, body weight, BMI, fat percentage and post-exercise pulse rate variables. The highest correlation with diastolic pressure shows the post-exercise pulse rate, and weight variables. When analyzing the variables separately for boys and girls can be seen that these variables are statistically correlated with the low diastolic pressure. The highest correlation with the diastolic pressure for both gender shows the post-exercise pulse variable, which estimate the cardiorespiratory fitness.

The relation between hypertension, cardiorespiratory fitness and fat tissue is determined by the multi-nominal logistic regressive analysis, and the results are show in the table III. For the purposes of the multi-nominal logistic regressive analysis the sample was divided into five categories of postexercise pulse rate and body fat, according to quintile. For boys and girls odds ratio (OR) for hypertension is calculated the univariant and multivariant between quintiles of the cardiorespiratory fitness (reference group was the highest quintile) and quintile of body fat compared with respondents who have the smallest percentage of fat (lowest quintile) (Table III).

On the univariant level the independent OR for the lowest quintile of fitness compared to the highest quintile was 3.13 in boys ($p = 0.00$) and 4.44 in girls ($p = 0.00$), respectively. The independent OR for the highest quintile of body fat compared to the lowest quintile was 3.89 ($p = 0.00$) in boys and 2.83 ($p = 0.00$) in girls, respectively.

In order to analyze the independent association of both the cardiorespiratory fitness and the percentage of body fat with the hypertension firstly was done a neutralization of age and body fat and then neutralization of age and cardiorespiratory fitness. The independent OR for the lowest quintile of fitness compared to the highest quintile was 2.18 in boys ($p = 0.00$) and 3.54 in girls ($p = 0.00$), respectively, after adjustment for body fat and age. The independent OR for the highest quintile of body fat compared to the lowest quintile was 3.04 ($p = 0.00$) in boys and 2.28 ($p = 0.00$) girls, respectively, after adjustment for fitness and age.

DISCUSSION

The aim of this study was to determine the relation between the cardiorespiratory fitness and obesity (fatness), blood pressure and hypertension for adolescents. The advantage of this study is the relatively large number of respondents who passed the cardiorespiratory test, and they were measured as well as the body composition and the blood pressure. The study results show that there is a connection between the cardiorespiratory fitness and blood pressure/hypertension on the one hand and body fats and blood pressure on the other hand.

On some previous research is it found that the relation between the cardiorespiratory fitness and blood pressure is not linear (17). In this sample for girls and boys it is determined almost linear relation between the blood pressure and the cardiorespiratory fitness. The respondents who belong to the first and second-fifth of the lowest cardiorespiratory fitness have significantly higher blood pressure compared to the remaining three-fifths. The mechanism of the relation between the blood pressure, obesity and fitness are not yet sufficiently explained and it is unknown whether these relations exist a causative relation. It is reasonable to be believed that there is a causative-consequence relation between low levels of physical activity on the one hand and the increased percentage of body fat on the other hand. But also, it is known that both properties have a strong genetic component, and on the other side the nutrition plays an important role at least in

Table III. Odds ratios and 95% confidence intervals for the relationship between hypertension and fitness as well as body fat

Hypertension	Boys OR	95% lower	95% upper	p value	Girls OR	95% lower	95% upper	p value
Crude analyses[a]								
Lowest quintile CRF	3.13	2.08	4.71	0.00	4.44	2.91	6.79	0.00
2nd quintile of CRF	1.74	1.13	2.68	0.01	3.11	2.01	4.80	0.00
3rd quintile of CRF	1.21	0.76	1.93	0.41	1.73	1.09	2.74	0.02
4th quintile of CRF	1.05	0.65	1.69	0.85	1.75	1.09	2.79	0.02
Highest quintile of CRF	1	-	-	-	1	-	-	-
Highest quintile body fat	3.89	2.58	5.86	0.00	2.83	1.95	4.10	0.00
2nd highest quintile body fat	1.75	1.12	2.73	0.01	1.69	1.15	2.50	0.01
3rd highest quintile body fat	1.39	0.88	2.21	0.16	1.22	0.81	1.84	0.34
4th highest quintile body fat	1.39	0.88	2.21	0.16	1.15	0.76	1.75	0.50
Lowest quintile body fat	1	-	-	-	1	-	-	-
Multiple analyses[b]								
Lowest quintile CRF	2.18	1.42	3.36	0.00	3.54	2.28	5.49	0.00
2nd quintile of CRF	1.37	0.88	2.14	0.16	2.71	1.74	4.22	0.00
3rd quintile of CRF	1.02	0.63	1.63	0.95	1.52	0.95	2.42	0.08
4th quintile of CRF	0.97	0.60	1.58	0.91	1.66	1.03	2.66	0.04
Highest quintile of CRF	1	-	-	-	1	-	-	-
Highest quintile body fat	3.04	1.96	4.70	0.00	2.28	1.53	3.38	0.00
2nd highest quintile body fat	1.53	0.96	2.44	0.07	1.53	1.01	2.30	0.04
3rd highest quintile body fat	1.40	0.87	2.25	0.16	1.18	0.77	1.81	0.45
4th highest quintile body fat	1.26	0.78	2.05	0.35	1.17	0.76	1.81	0.47
Lowest quintile body fat	1	-	-	-	1	-	-	-

[a]Univariate age-adjusted OR. [b]Age-adjusted OR for body fat and fitness in the same model.

the etiology of obesity. It is often argued that the physical activity protects against obesity, due to the higher calorific consumption (18), but it can be very simplified explanation. Theoretically is possible as a result of decreased calorie intake to reduce weight, but maintaining it for a longer time of period without increased physical activity is rarely possible. One of the reasons for this may be the function of the enzymes in the metabolism of fats and sensitivity of metabolic hormones, especially insulin which affects the regulation of the appetite, and are not recoverable by a diet. Neither physical activity by itself is not proved successful in reducing body weight but has other benefits provided by exercise, except weight loss (19,20).

It is known that insulin sensitivity increases with aerobic. The training effect is from local character only for the trained muscles. In the study of Acts and al. it is applied an experiment which was loaded only one leg, it showed greater sensitivity on insulin, while for the untrained leg there were no changes (21). Insulin is a hormone with many functions, and the post-serum level of the insulin is increased for people with low level of fitness as well as people with a large percentage of body fat. Besides its impact on the transport of glucose it has anabolic effect in the storage of fat in fat cells. Insulin influences the regulation of the appetite by changes in substrate levels in the blood, and the Ferranini indicates the impact on blood pressure (22). The sensitivity to insulin can be one of the key mechanisms that cause the relation between blood pressure, body fat and cardiorespiratory fitness.

The relation between obesity and blood pressure is consistent with the previous researches (23-28). Farah and the collaborators (29) have made systematic review of randomized clinical trials in which the physical training effects of blood pressure in obese adolescents were researched. In two studies were applied exercises for strength in combination with aerobic exercises, while in six studies only aerobic exercises. Five studies used complementary intervention, especially nutritional. In four studies is determined the reduction of the systolic pressure for experimental group, and at the same time by reducing the percentage of body fat. In all studies in which was determined reduction of the systolic blood pressure were applied aerobic (cardiorespiratory) exercises from 12 to 24 weeks with a frequency of three to six times a week, with a duration of 50 to 90 minutes and intensity of burden between 55 to 75% of the maximum heart rate. Our research also confirmed the results of these studies in which the cardiorespiratory fitness and blood pressure in preadolescents and adolescents were researched. The results of our study indicate that the change in cardiorespiratory fitness is associated with the changes in blood pressure adds to the existing evidence in adults of an association between physical fitness and blood pressure. To confirm the results, further research is needed, especially through experimental and interventional studies. In short, the results indicate that there is a relation between the level of cardiorespiratory fitness and blood pressure and probably the change in cardiorespiratory fitness and reducing body fat is associated with blood pressure for adolescents.

CONCLUSION

On the basis of the obtained results it can be concluded that a higher percentage of boys are overweight/obese, have a higher systolic pressure, and lower diastolic pressure compared to girls. The low level of cardiorespiratory fitness and high percentage of body fat are independently associated with an increased risk of blood pressure and hypertension for both boys and girls. The interaction is established between the percentage of body fat and fitness. The results should be taken into account in building strategies and recommendations to improve the lifestyle and health for adolescents.

ACKNOWLEDGEMENTS

We hereby express our most heartfelt gratitude to the adolescents who took part in this study, as well as to their parents and teachers. We are deeply grateful to the Municipal Councils of Strumica and Kisela Voda, and for the funding support of the Faculty of Physical Education, Sport and Health in Skopje.

REFERENCES

1. Centers for Disease Control and Prevention. (2015). US Department of Health and Human Services Physical activity guidelines for Americans 2008. Washington, DC; 2008.
2. Andersen LB. Tracking of risk factors for coronary heart disease from adolescence to young adulthood with special emphasis on physical activity and fitness. Dan Med Bul 1996;43:407-18.
3. Twisk JWR, Kemper HCG, Mechelen Wv, et al. Tracking of risk factors for coronary heart disease over a 14-year period: a comparison between lifestyle and biologic risk factors with data from the Amsterdam Growth and Health Study. Am J Epidemiol 1997;145:888-98.
4. Ortega FB, Ruiz JR, Castillo MJ, et al. Physical fitness in childhood and adolescence: a powerful marker of health. International Journal of Obesity 2008;32(1):1-11.
5. Barengo NC, Hu G, Lakka TA, et al. Low physical activity as a predictor for total and cardiovascular disease mortality in middle-aged men and women in Finland. European Heart Journal 2004;25(24):2204-11.
6. Blair SN, Goodyear NN, Gibbons LW, et al. Physical fitness and incidence of hypertension in healthy normotensive men and women. JAMA 1984;252:487-90.
7. Parkhad SB, Palve SB. Association of physical activity and physical fitness with blood pressure profile in Maharashtrian adolescent boys and girls. Internet Journal of Medical Update-EJOURNAL 2014;9(1):4-9.
8. Gaya A, Aires L, Mello J, et al. Incidence of hypertension in schoolchildren and adolescents: relationship with physical activity, cardiorespiratory fitness and obesity. Pensar a Prática 2015;18(3):557-70.
9. Santos Silva DA, Tremblay M, Pelegrini A, et al. Association Between Aerobic Fitness And High Blood Pressure in Adolescents in Brazil: Evidence for Criterion-Referenced Cut-Points. Pediatric Exercise Science 2016;28(2): 312-20.
10. Lohman TG, Roche AF, Martorell R. Anthropometric standardization reference manual. Human Kinetics Books; 1988.
11. ACSM (American College of Sports Medicine) Health-Related physical Fitness Assessment Manual. Baltimore: Lippincott Williams and Wilkins; 2005.
12. Heyward VH. Advanced fitness assessment and exercise prescription. 5th edition. Champaign: Human Kinetics Publishers; 2006.
13. Grupo de Trabajo del Programa Nacional de Educación sobre Hipertensión en Niños y Adolescentes de los EE. UU. The Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents. Pediatrics 2004;114(2):555-76.
14. Jacks DE, Topp R, Moore JB. Prediction of VO2 peak using a sub-maximal bench step test in children. Clinical Kinesiology 2011;65(4):68-75.
15. Cole TJ, Bellizzi MC, Flegal KM, et al. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ 2000;320:1240-3.
16. Cole TJ, Flegal KM, Nicholls D, et al. Body mass index cut offs to define thinness in children and adolescents international survey. BMJ 2007;335:194.
17. Andersen LB. Blood pressure, physical fitness and physical activity in 17-year-old Danish adolescents. Journal of Internal Medicine 1994;236(3):323-30.
18. Fogelholm M, Kukkonen-Harjula K. Does physical activity prevent weight gain a systematic review. Obesity Reviews 2000;1:95-111.
19. Wood PD, Stefanick ML, Williams PT, et al. The effects on plasma lipoproteins of a prudent weight-reducing diet, with or without exercise, in overweight men and women. New England Journal of Medicine 1991;325:461-6.
20. Wood PD, Haskell WL, Blair SN, et al. Increased exercise level and plasma lipoprotein concentrations: a one year, randomized, controlled study in sedentary middle-aged men. Metabolism 1983;32:31-9.
21. Dela F. On the influence of physical training on glucose homeostasis. Acta Physiologica Scandinavica. Supplementum 1996;635:1.
22. Ferrannini E. Insulin resistance and blood pressure. In: Reaven GM, Laws A, editors. Insulin resistance. The metabolic syndrome X. Contemporary endocrinology. Totowa NJ: Humana Press; 1999;15:281-308.
23. Silva AO, Silva MV, Pereira LK, et al. Association between general and abdominal obesity with high blood pressure: difference between genders. Jornal de Pediatria 2016;92(2):174-80.
24. Devonshire AL, Hager ER, Black MM, et al. Elevated blood pressure in adolescent girls: correlation to body size and composition. BMC Public Health 2016;16(1):1.
25. Gaskin PS, Hall RV, Chami P, et al. Associations of blood pressure with body composition among Afro-Caribbean children in Barbados. PloS one 2015;10(3):e0121107.
26. Bohn B, Müller MJ, Simic-Schleicher G, et al. BMI or BIA: Is body mass index or body fat mass a better predictor of cardiovascular risk in overweight or obese children and adolescents? Obesity Facts 2015;8(2):156-65.
27. Dong B, Wang Z, Wang HJ, et al. Associations between adiposity indicators and elevated blood pressure among Chinese children and adolescents. Journal of Human Hypertension 2015;29(4):236-40.
28. Kelly RK, Magnussen CG, Sabin MA, et al. Development of hypertension in overweight adolescents: a review. Adolescent Health, Medicine and Therapeutics 2015;6:171.
29. Farah BQ, Berenguer MD, Prado WL, et al. Effect of physical training on the blood pressure of adolescents with obesity. Revista Paulista de Pediatria 2012;30(4):600-7.