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ORIGINAL SCIENTIFIC ARTICLE

THE RELATIONS BETWEEN BLOOD PRESSURE AND HANDGRIP STRENGTH IN CHILDREN

Gentiana Beqa Ahmeti[1ABCDE], Besnik Morina[1ABCDE], Georgi Georgiev[2ABCDE] and Seryozha Gontarev[2ABCDE]

[1]University of Pristina "Hasan Pristina"
[2]Ss. Cyril and Methodius University

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Corresponding Author: Besnik Morina, E-mail: besnik.morina@uni-pr.edu
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Abstract

Background. Studies, previously completed, announce that the handgrip strength as a measurement for assessing muscle fitness is associated with cardiovascular risk factors. Yet, the relation of handgrip strength to the blood pressure in children is inconsistent. Therefore, we conducted the present research aiming to establish the relation of the handgrip strength to the blood pressure in Macedonian children from the Skopje region.

Materials and methods. The research was conducted on a sample of 1076 children (534 boys and 542 girls),whereby the following characteristics were measured: blood pressure, handgrip strength, weight, height, body fat percentage, waist circumference and the body mass index (BMI) was calculated. General linear models were used to examine the association between handgrip strength and the outcome variables.

Results. After the adjustment of age, gender, BMI, body fat percentage and waist circumference, the handgrip strength was statistically significantly positively associated to both systolic ($p<0.0001$) and diastolic ($p=0.02$) blood pressure. There was a growing trend of the systolic blood pressure as the handgrip strength increased from the lower quartile to the upper quartile with 3,7 mm Hg difference between the upper and lower quartile (p for trend = 0.03). In this research, it was not established a statistically significant trend of the diastolic blood pressure as the hand grip strength increases from the lower quartile to the upper quartile (p for trend=0.09).

Conclusions. The muscle fitness has a positive correlation with the blood pressure in the respondents. The implications and the basic mechanisms of these results require further research studies.

Keywords: hypertension, children, muscle strength, body mass index.

Introduction

Hypertension is an important challenge public health problem due to the high prevalence and high mortality that is occurring (Mozaffarian et al., 2015). Hypertension in adults originates from childhood (Bao et al., 1995; Chen & Wang, 2008; Juhola et al., 2011; Kagura et al., 2015). Therefore, it is important to identify those factors that provoke the blood pressure variations (BP) in childhood and adolescent period, the aim of which is to design appropriate strategies and state policy for early prevention and intervention. The physical fitness is increasingly recognized as an important predictor of morbidity and mortality (Kodama et al., 2009). The relation between fitness and cardiovascular health is that well recorded in children and adolescents, too (Froberg & Andersen, 2005; Ruiz et al., 2007; Ortega et al., 2008). The muscle fitness, assessed through the handgrip strength, has become an important cardiometabolic marker in children (Ortega et al., 2008; Peterson et al., 2014; Smith et al., 2014). In spite of the fact that muscle fitness is generally related to the cardiometabolic health in children, some people put under question the relation between the muscle strength and cardiometabolic risk (Diez-Fernandez et al., 2015). Regarding the blood pressure, recent studies presented that the high muscle strength correlates with low blood pressure (Ortega et al., 2011; Cohen et al., 2014; Cohen et al., 2017), however there are research studies that have contradictory results (Dong et al., 2016; Demmer et al., 2016; Zhang et al., 2018) in children and adolescents.

The establishment of association between the blood pressure and muscle fitness in children and adolescents can be of help in better understanding the mechanisms for blood pressure regulation and in implementing of early prevention. For that particular intention we conducted the present research, aiming to establish the association between the hand-grip strength and blood pressure in Macedonian children living in the Skopje region.

Materials and methods

Participants

The research was conducted on a sample of 1076 respondents divided into two subsamples of 534 boys and 542 girls aged 6-10. The respondents were chosen at random from a number of schools in the region of the city of Skopje in the Republic of North Macedonia. All the sample consisted of schoolchildren whose parents agreed for their children to be involved in the project. All the children were physically and mentally healthy during the measurements, and no parent reported for their child to have some chronic disease or high blood pressure. The children were treated according to the Principles of the Declaration of Helsinki (Edinburgh revision 2000 year). The project received the Ethics committee approval from Ss. Cyril and Methodius University in Skopje. The measurements were completed in 2019 year.

Anthropometric measures and body composition

The anthropometric measurements were performed regarding the methodology of the International biology program (IBP) and regarding the recommendations of the World Health Organization (WHO) and Weiner and Lurie (1981). The weight was taken by a digital scale of 0,1 kg accuracy, and the height was measured with a stadiometer scale with accuracy of 0,1 cm. The waist circumference was measured with a non-elastic scaled tape placed horizontally midway between the bottom of the chest and hipbones. The body mass index was calculated as body weight in kilograms divided by the square of height in meters.

The body composition was established through the method of bioelectrical impedance. The measurements were performed with a monitor of body composition, model "OMRON – BF11". In order to obtain better results' validity, at the beginning of every measuring it was insisted to follow the recommendations of American College of Sports Medicine (2005) and Heyward (2006) was fulfilled.

Blood Pressure Assessment

The blood pressure measuring was taken through an oscillometric method via the calibrated digital device Omron (Kyoto, Japan) model HEM 742, with cuffs of suitable size for the arm circumference of a child. This device has been validated for use with children (Christofaro et al. 2009).

The hypertension was defined as BP ≥ 95th percentage, the prehypertension was defined as BP between ≥ 90th and <95th percentage, the normal blood pressure was defined as BP < 90th percentage. For classifying the respondents, the Update on the Task Force Report on High Blood Pressure in Children and Adolescent was used.

HGS measurement

For assessing the hand-grip strength, the Takei TKK 5101 digital dynamometer was used (range, 1-100 kg). The same was used in measuring the hand-grip strength of both hands. The dynamometer's handle used to be adapted to the hand size of every respondent. The children were instructed to squeezethe dynamometer three consecutive times with each handas tight as possible, and the highest value (maximal value in kilograms) was used for the analyses (Haidar et al., 2004).

Statistical analysis

The sample's characteristics were presented as arithmetic mean and standard deviation of the continuous variables and frequencies and percentages of nominal variables. For establishing the gender differences in continuous variables, the applied analysis was that of covariance with age partialization and chi-square test for nominal variables. For establishing the correlation between the hand-grip strength and blood pressure, the Pearson partial correlation was applied together with its age and gender adjustment. For establishing the relation between the hand-grip strength and measures of the blood pressure, the linear regressive analysis was used together with its adjustment for age, gender, BMI, body fat percentage and waist circumference. All of the analyses were performed using the Statistical Package for Social Sciences software (SPSS, v. 22.0), and the values from $p<0.05$ were considered statistically insignificant.

Table 1. Characteristics of the study sample

Independent variable	Boys		Girls		F	P
	Mean	SD	Mean	SD		
Age (years)	8.62	1.30	8.54	1.33	0.99	0.320
BMI (kg/m^2)	18.84	3.70	18.40	3.33	4.13	0.042
Body fat percentage (%)	24.43	7.78	23.72	8.04	2.02	0.155
Waist circumference (cm)	62.36	9.75	60.19	8.45	15.04	0.000
Handgrip strength (kg)	13.40	3.64	12.14	3.58	32.28	0.000
Systolic blood pressure (mg Hg)	103.92	17.87	101.70	18.75	3.95	0.047
Diastolic blood pressure (mg Hg)	65.99	14.17	65.32	14.84	0.55	0.457

Abbreviations: BMI – body mass index

Table 2. Partial Pearson's correlation to systolic BP and diastolic BP and body mass index, body fat percentage, waist circumference and handgrip strength

Independent variable	Systolic blood pressure (mg Hg)		Diastolic blood pressure (mg Hg)	
	r	P	r	P
BMI (kg/m^2)	0.265	0.000	0.256	0.000
Body fat percentage (%)	0.268	0.000	0.247	0.000
Waist circumference (cm)	0.307	0.000	0.298	0.000
Handgrip strength (kg)	0.186	0.000	0.161	0.000

P values were adjusted for age and sex.

Table 3. Regression coefficients of handgrip strength and other covariates for blood pressure

Independent variable	Systolic blood pressure (mm Hg)			Diastolic blood pressure (mm Hg)		
	β	± SE	P	β	± SE	P
Female sex	0.08	1.16	0.94	0.99	0.92	0.28
Age (per year)	-1.58	0.61	0.01	-1.07	0.48	0.03
BMI (per kg/m^2)	-0.79	0.47	0.09	-0.26	0.37	0.48
Body fat percentage (%)	0.42	0.18	0.02	0.15	0.14	0.30
Waist circumference (cm)	0.56	0.13	0.00	0.46	0.10	0.00
Handgrip strength (kg)	0.74	0.23	0.00	0.42	0.18	0.02

Abbreviations: BMI – body mass index

Results

The examined respondents' characteristics, according to their gender, are presented in Table 1. The Table review shows that the male respondents have greater values of the body mass index (BMI), waist circumference; they demonstrate higher results in the handgrip-strength test and have higher values of the symbolic blood pressure ($p \leq 0.05$). Statistically significant differences between the male and female respondents were not established in the years/age, the percentage of fat tissue and the values of the diastolic blood pressure. Among the participants, the average age was 8.6 ±1.3 years. The prevalence of prehypertension was 8.8% in boys and 5.9% in girls, while the prevalence of hypertension was 20.8% in boys and 18.8% in girls. No statistically significant differences were found between the estimates of prehypertension and hypertension prevalence by sex groups ($p = 0.577$)

Handgrip strength is in a statistically significant positive correlation with the systolic blood pressure ($r = 0.19$, $p < 0.0001$) and with the diastolic blood pressure ($r = 0.16$, $p < 0.0001$) after partializing the age and gender. In addition, the body mass index, the body fat percentage and the waist circumference are in a statistically significant positive correlation with the systolic and diastolic blood pressure ($p < 0.0001$) (Table 2). Handgrip strength was significantly and positively associated with both systolic and diastolic BP, independent of age, sex, BMI, body fat percentage and waist circumference; increase of each kilogram in handgrip strength was associated with 0.74 mm Hg increase in systolic BP ($p < 0.0001$) and 0.42 mm Hg increase in diastolic BP ($p = 0.02$) (Table 3). It was established that there is a statistically significant trend of increasing the systolic blood pressure as the handgrip strength increases from the lower quartile to the upper quartile with 3,7 mm Hg difference between the upper and lower quartile (p for trend = 0.03, Figure 1). It was not established a statistically significant trend of the diastolic blood pressure as the handgrip strength increases from the lower to the upper quartile (p for trend = 0.09, Figure 1).

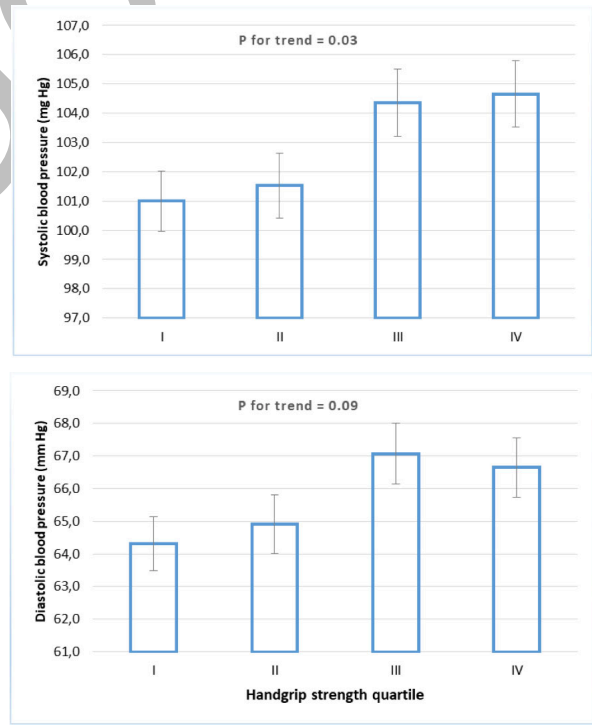

Fig. 1. Least square means of systolic blood pressure (top panel) and diastolic blood pressure (bottom panel) by age- and sex-specific handgrip strength quartile. P values were adjusted for age, sex and body mass index

Discussion

The research results suggest that the hand-grip strength is in a positive correlation with BP in children aged 6-10. This relation was considerably strong, since it was independent of percentages of body fat, waist circumference and BMI. The findings were contrary to the beneficial effects of increased muscular fitness on other cardiometabolic risk factors in both children and adults (Artero et al., 2012; Lin et al., 2015; Kawamoto et al., 2016; Ortega et al., 2003).

The correlation between the handgrip strength and blood pressure is inconsistent, and in some studies an inverse correlation is established (Ortega et al., 2011; Cohen et al., 2014; Cohen et al., 2017), whereas in other research studies a positive correlation is established (Dong et al., 2016; Demmer et al., 2016; Zhang et al., 2018. Dong et al. (2016) have established in their research that the handgrip strength is positively related to the blood pressure after adjusting or stratifying of BMI in 88.865 Chinese adolescents at the age of 13-17. Demmer et al. (2016) have established similar results in both boys and girls at the age of 10, 14 and 17 years.

All these findings, along with ours, are in contrast to the findings of an inverse association (Ortega et al., 2011; Cohen et al., 2014; Cohen et al., 2017) and by Diez-Fernandez et al. (2015) showing that the inverse associations are mediated by BMI. The positive relationship that we have established between the handgrip strength and blood pressure is in contrast to what would be expected, having in mind the results of previous studies which indicate the associations of muscular fitness with other cardiometabolic risk factors, especially in the adult population (Artero et al., 2012; Lin et al., 2015; Kawamoto et al., 2016). It is well known that the blood pressure in childhood predicts future risks of hypertension and cardiovascular diseases (Bao et al., 1995; Lurbe, 2003; Lawlor & Smith, 2005), and the muscle fitness is inversely correlated to the cardiometabolic risk (Artero et al., 2012; Mainous et al., 2015).

We have many opinions that aerobic exercises have a positive impact on reducing blood pressure in children (García-Hermoso et al., 2013). Also, the 2015 Canadian Hypertension Education Program Recommendations for Blood Pressure Measurement, Diagnosis, Assessment of Risk, Prevention and Treatment of Hypertension just makes mention of the fact that the applied resistance training does not have a negative influence on the blood pressure with a weak strength of evidence (Grade D) (Daskalopoulou et al., 2015), and the instruction developed by European Society of Hypertension gives no specific recommendations related to the resistance training (Lurbe et al., 2009).

Finally, some advantages as well as certain limitations of the present study should be pointed. The study was conducted on a relatively big sample of 1076 respondents. Measurements were performed by professionally trained persons using a proper methodology and procedures, which provided quality and control. One of the study's limitations is the fact that its nature was transversal and monitoring. Therefore, it is not possible to establish the causality of the observed associations. It is necessary to conduct longitudinal research works and clinical examinations in order to elucidate the relation between the muscle strength and blood pressure. Several studies despite the fact that the grip strength is readily employed and has been shown to be highly correlated with total muscle strength in adolescents, (Wind, et al., 2010), it is not necessarily effective for assessing the strength change with resistance training interventions. In addition, we had no information about how often children do exercises for muscle strengthening, and it is advisable for that type of data to be included in future research studies.

In addition, there were no data about the cardiorespiratory fitness and physical activity that would be significant determinants of the blood pressure in children (Kim et al., 2016). Finally, our research did not cover all of the eight regions into which the Republic of North Macedonia is divided. Nevertheless, our goal was to establish the relationships in the available sample, and not to assess the population parameters of the whole Macedonian population in total.

Conclusion

So far, a given number of studies have had their focus on the relation between the muscle strength and specific health outcomes in children and adolescents, obscuring relevant interventions and treatments. The research results show that the greater hand-grip strength is associated with a greater blood pressure in children. This correlation is independent of the body mass index, waist circumference and body fat percentage.

Taking into consideration the multiple benefits of the muscle fitness, it is necessary to be very precautious in interpreting the findings of this study. Additional clinical trials and cohort studies are needed on a bigger sample of respondents in order to confirm the results and explain the possible mechanisms of this correlation. The present study can be of significant importance in hypertension intervention.

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ЗВ'ЯЗОК МІЖ АРТЕРІАЛЬНИМ ТИСКОМ І ДИНАМІЧНОЮ СИЛОЮ КИСТІ В ДІТЕЙ

Гентіана Бека Ахметі[1ABCDE], Беснік Моріна[1ABCDE], Георгі Георгієв[2ABCDE], Серьожа Гонтарев[2ABCDE]

Приштинський університет
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., 3 табл., 1 рис., 35 джерел.

Історія питання. У дослідженнях, які були завершені раніше, було заявлено, що динамічна сила кисті як вимірювання для оцінки підготовленості м'язів пов'язана з факторами ризику серцево-судинних захворювань. Проте зв'язок динамічної сили кисті з артеріальним тиском у дітей суперечливий. Тому ми провели це дослідження з метою встановити зв'язок динамічної сили кисті з артеріальним тиском у македонських дітей із регіону Скоп'є.

Матеріали та методи. Дослідження проводили на вибірці з 1076 дітей (534 хлопчики та 542 дівчинки), за допомогою яких вимірювали такі характеристики: артеріальний тиск, динамічна сила кисті, вага, зріст, відсоток жиру в організмі, окружність талії та розраховували індекс маси тіла (ІМТ). Для вивчення зв'язку між динамічною силою кисті та вихідними змінними використовували загальні лінійні моделі.

Результати. Після узгодження віку, статі, ІМТ, відсотка жиру в організмі та окружності талії динамічна сила кисті була статистично значущо позитивно пов'язана як із систолічним ($p<0,0001$), так і з діастолічним ($p=0,02$) артеріальним тиском. Спостерігався тренд до зростання систолічного артеріального тиску, оскільки динамічна сила кисті збільшувалася від нижнього квартиля до верхнього квартиля з різницею 3,7 мм рт.ст. між верхнім і нижнім квартилем (p для тренда = 0,03). У цьому дослідженні не було встановлено статистично значущого тренда діастолічного артеріального тиску, оскільки динамічна сила кисті зростає від нижнього квартиля до верхнього квартиля (p для тренда = 0,09).

Висновки. Підготовленість м'язів позитивно корелює з артеріальним тиском в учасників. Наслідки та основні механізми цих результатів потребують подальших досліджень.

Ключові слова: гіпертонія, діти, сила м'язів, індекс маси тіла.

Information about the authors:

Ahmeti, Gentiana Beqa: gentiana.beqa@uni-pr.edu; https://orcid.org/0000-0001-7727-1827; Faculty of Physical Education and Sport, University of Pristina, Industrial Zone, Pristina, 10000, Kosovo

Morina, Besnik: besnik.morina@uni-pr.edu; https://orcid.org/0000-0001-7554-799X; Faculty of Physical Education and Sport, University of Pristina, 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 in Skopje, Dimce Mircev, 3, Skopje, 1000, Republic of North Macedonia

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

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Retraction Note

The Editors have retracted the following article:

Ahmeti, G. B., Morina, B., Georgiev, G., & Gontarev, S. (2023). The Relations Between Blood Pressure and Handgrip Strength in Children. Physical Education Theory and Methodology, 23(2), 207–213. https://doi.org/10.17309/tmfv.2023.2.08

Following the publication of the article, the Organizata për Rritjen e Tälätsë në Arsim – ORCA contacted the journal. Upon editorial follow-up, similarities were noted between this article and a previous publication by another group ("Handgrip Strength and Blood Pressure in Children and Adolescents: Evidence From NHANES 2011 to 2014", published in the American Journal of Hypertension in 2018, by Zhang, R., Li, C., Liu, T., Zheng, L., & Li, S.). Considering these issues, the Editors retract this article. The authors don't agree with the retraction.

We have been informed in our decision-making by our policy on publishing ethics and COPE guidelines.

The retracted article will remain online to maintain the scholarly record, but it will be digitally watermarked on each page as "Retracted".