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School children systolic and diastolic blood pressure values: YUSAD study

Research Article

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Abstract: The aim of the study was to analyze changes of systolic and diastolic blood pressure values over five and ten years separately boys and girls and to estimate correlation between them. Three age groups from 8 centers in Serbia were evaluated: Group 1: 10 year old patients, Group 2: 15 year old and Group 3: 20 year old. Group with normal blood pressure values, prehypertensive and hypertensive group were analyzed. Regarding the period of follow-up we analyzed: 10/15 years period-children between 10 and 15 years, 15/20 years period-children between 15 and 20 years, and 10/20 years period-children between 10 and 20 years. Significant increase of diastolic blood pressure was noticed for both genders in 10/15 years period of prehypertensive population, while in hypertensive children, boys showed decline in frequency for systolic and diastolic blood pressure and girls only for diastolic. In 15/20 years period there was significant decrease of prehypertensive and significant increase of hypertensive diastolic blood pressure frequency. In 10/20 years period significant reduction in frequency of prehypertensive systolic blood pressure was noticed, while only hypertensive group of boys showed significant reduction regarding systolic blood pressure frequency. Prehypertensive diastolic and hypertensive systolic blood pressure fluctuations are more related to age.

Keywords: *Blood pressure • Hypertension • School age children • Follow-up*

1. Introduction

Atherosclerosis presents significant causes of all cardiovascular related deaths [1]. It is asymptomatic early in childhood with formation of fatty streaks in the intima of arteries leading to the occlusion and reduction of arterial lumen [1,2].

There are numerous identifiable risk factors for the development of cardiovascular diseases and one among them is blood pressure (BP) [2,3]. The importance of BP evaluation and screening for potential hypertension in childhood is due to its frequency increase usually as the consequence of obesity [4,5]. Also, as modifiable risk factor [1], BP can be controlled and managed in certain degree with therapeutic and behavioral interventions [6,7].

Beside, evaluation of blood pressure in pediatric population, other risk factors should be equally considered. There are studies stressing out that one risk factor can lead to onset of another later in life bringing cumulative effect of more risk factors in the development of atherosclerosis [8-10].

The importance of blood pressure as additional parameter within metabolic syndrome for the cardiovascular mortality was evaluated by Shin et al., stating that BP is shown to be key predictor [11].

Therefore, in our study we analyzed changes of systolic and diastolic blood pressure values over five and

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ten years separately boys and girls and to estimate correlation between them.

2. Material and Methods

YUSAD study (Yugoslav study of atherosclerosis precursors in school children) is prospective multicentric study of atherosclerosis precursors of school children that began in 1998 year. On same population of participants we analyzed blood pressure that is shown to be risk factor for the development of atherosclerotic lesions [12,13]. For the purpose of follow-up we did 3 examinations on randomly chosen school children from 8 centers in Serbia. It is obligatory in Serbia for school children to be regularly evaluated and screened by health care practitioners in health facilities. Informed consent was obtained from parents or legal guardians before inclusion of prospective participants into the study. The study protocol was approved by the Institutional Review Board of the Medical School of the University of Belgrade in Serbia.

Separately systolic and diastolic BP as well as Body mass Index (BMI) were analyzed in both genders. Blood pressure was measured at the right brachial artery with sphygmomanometer when participant was in the sitting position. The first measurement was taken after 30 minutes, while second one was done after an additional 15 minutes of rest. The mean of two consecutive measurements was used for statistical analysis and grouping patients due to the values of systolic and diastolic BP into 3 groups: group with normal BP (normotensive), group that is pre- hypertensive and group with hypertension. The referential values of BP for inclusion in one of above 3 mentioned groups were done according to international standards that were evaluated in previous studie**s.** Normal BP values were defined as systolic and diastolic value below 90th percentile for gender, age and height, prehypertensive values were defined as systolic and diastolic values between ≥90th and <95th percentile for gender, age and height, and hypertension was defined for systolic values and diastolic equal or above 95th percentile for gender, age and height [14]. Body Mass Index was calculated from height and body weight. The value for body weight was taken after triple measurement in the morning before meal. Children with secondary hypertension were excluded from the study. The children from the study included healthy participants that were not been prescribed any medications that could influence BP levels.

First examination was done when children were 10 years of age in 1998 (Group 1). Five years later when children were 15 years of age we re-evaluated same population on second examination (Group 2). Third examination was done when children were 20 years of age (Group 3). There was dissemination of participants between first and second examination (4.1% for boys and 3.6% for girls). Between second and third examination there was no dissemination of participants (0% for both genders).

Regarding the period of follow-up we analyzed: 10/15 years period – referred to children between 10 and 15 years, 15/20 years period – referred to children between 15 and 20 years, and 10/20 years period – referred to children between 10 and 20 years.

Distribution of participants regarding the BP was presented as whole numbers (N) and percents). Mean values with standard deviation (SD) were also used to describe BP and BMI values in different age groups.

To determine the presence of statistical differences regarding observed parameters during five years of follow-up (10/15 years and 15/20 years period) and ten years of follow-up (10/20 years period) in evaluated population we used chi squared test and results were

Table 1 Distribution of children regarding systolic and diastolic blood pressure values and BMI values

		Boys			Girls		
		Group 1	Group 2	Group 3	Group 1	Group 2	Group 3
		N=468 (%)	N=449 (%)	N=449 (%)	N=579 (%)	N=558 (%)	N=558 (%)
Normal blood pressure	Systolic	345 (73.7)	375 (83.5)	390 (86.9)	456 (78.8)	486 (87.1)	481 (86.4)
	Diastolic	333 (71.2)	266 (59.2)	287 (63.9)	414 (71.5)	374 (67.0)	342 (61.3)
Prehypertension	Systolic	55 (11.8)	41 (9.1)	25 (5.6)	54 (9.3)	29 (5.2)	23 (4.1)
	Diastolic	62 (13.2)	145 (32.3)	86 (19.2)	72 (12.4)	157 (28.2)	91 (16.3)
Hypertension	Systolic	68 (14.5)	33 (7.3)	34 (7.6)	69 (11.9)	43 (7.7)	54 (9.7)
	Diastolic	73 (15.6)	38 (8.5)	76 (16.9)	93 (16.1)	27 (4.8)	125 (22.4)
Blood pressure	Systolic	108.62±11.31	115.83±12.73	118.69±10.87	106.84±10.18	111.48±10.26	110.37±11.14
Mean values ± SD	Diastolic	62.53±10.87	64.31±13.11	72.86±8.34	61.13±9.85	62.84±11.76	68.92±8.29
Body Mass Index (BMI) Mean values ± SD		16.84±2.37	21.18±3.12	22.54±3.02	15.72±2.43	19.86±2.95	20.93±2.68

Table 2 Evaluation of blood pressure and BMI in children age between 10 and 15 years

Blood pressure		10/15 years period					
		Normal blood pressure		Prehypertension		Hypertension	
		χ^2	Δ%	χ^2	Δ%	χ^2	Δ%
Systolic	Boys	1.3	+9.8	0.7	-2.7	5.4*	-7.2
	Girls	0.8	+8.3	2.5	-4.1	1.9	-4.2
Diastolic	Boys	2.2	-12.0	19.5**	+19.1	4.6*	-7.1
	Girls	0.3	-4.5	14.4**	+15.8	17.3**	-11.3
T test Systolic	Boys	9.08**					
	Girls	7.65**					
T test Diastolic	Boys	2.24*					
	Girls	2.66**					
T test BMI	Boys	23.78**					
	Girls	25.87**					

*$p<0.05$
**$p<0.001$

Table 3 Evaluation of blood pressure and BMI in children age between 15 and 20 years

Blood pressure		15/20 years period					
		Normal blood pressure		Prehypertension		Hypertension	
		χ^2	Δ%	χ^2	Δ%	χ^2	Δ%
Systolic	Boys	0.1	+3.4	1.8	-3.5	0.0	+0.3
	Girls	0.0	-0.7	0.3	-1.1	0.5	+2.0
Diastolic	Boys	0.4	+4.7	7.1**	-13.1	6.3*	+8.4
	Girls	0.5	-5.7	6.9**	-11.9	39.2**	+17.6
T test Systolic	Boys	3.62**					
	Girls	1.73					
T test Diastolic	Boys	11.66**					
	Girls	9.98**					
T test BMI	Boys	6.64**					
	Girls	6.34**					

*$p<0.05$
**$p<0.01$

presented as χ^2 values in Tables 1-3. To evaluate the presence of statistical significance between mean values for BP and BMI we used student's t test. The statistical significance was set on $p<0.05$.

In order to evaluate the values of systolic and diastolic BP during the follow-up period and separately for boys and girls we calculated difference of participants expressed as percentages and presented as Δ% in Tables 1-3. The positive or negative sign before number in Δ% refers to increase (+) or decrease (-) in the percents of participants during five and ten years of follow-up.

3. Results

We evaluated 1047 children at the initial (first) examination. There were 468 boys on first examination and 579 girls on first examination. On second and third examination there were 449 boys or 95.5% from the boy's population from first examination and 558 girls or 96.4% from the girl's population from first examination. Distribution of participants (boys and girls) in 3 evaluated groups regarding values of systolic and diastolic BP and BMI were presented in Table 1. Our results stress out that majority of evaluated population had normal systolic and diastolic BP values.

In Table 2 and Figure 1, statistical evaluation of observed parameters for first 5 years of follow-up

Figure 1 Evaluation of blood pressure in children age between 10 and 15 years

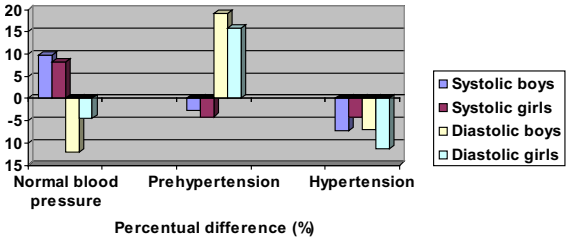
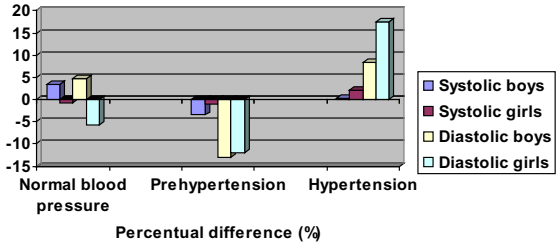
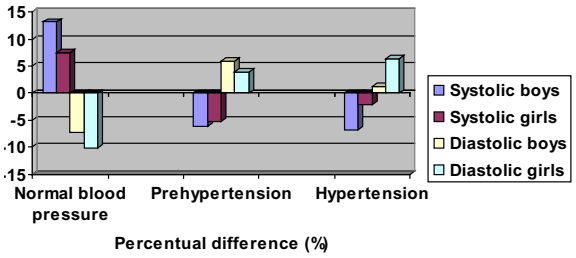


Figure 2 Evaluation of blood pressure in children age between 15 and 20 years



period was presented for the population of school children between 10 and 15 years. There is increase in the proportion of normotensive group for systolic BP, while decrease in proportion regarding normotensive group was observed for diastolic BP. Those changes were found not to be significantly different between two measurements (p>0.05). In the same period, for the group of prehypertensive patients, we found statistically significant increase of participants with prehypertensive diastolic BP (p<0.01). Statistically significant decline in frequency for male gender in hypertensive group for

Figure 3 Evaluation of blood pressure in children age between 10 and 20 years



systolic and diastolic BP was noticed over 5 years of follow-up (p<0.05), and for female gender regarding diastolic BP (p<0.01). There was statistically significant increase for the values of BP (systolic and diastolic) and BMI in this group (p<0.01).

In Table 3 and Figure 2, we presented statistical evaluation of observed parameters for second 5 years period of follow-up, for the population of school children between 15 and 20 years. In the group of normotensive participants it was noticed that male gender showed non significant increase in frequency (p>0.05), while female gender had non significant decrease in frequency (p>0.05), regarding both systolic and diastolic BP. For the group of prehypertensive children between 15 and 20 years of life, there was statistically significant decrease of participants with prehypertensive diastolic BP (p<0.01). Group with hypertension showed statistically significant increase in frequency regarding diastolic BP (p<0.05 for boys; p<0.01 for girls). We found statistically significant increase for the values of BP (systolic and diastolic) was noticed in boys (p<0.01) and for diastolic BP in girls population (p<0.01) and for BMI in both genders (p<0.01).

Table 4 Evaluation of blood pressure and BMI in children age between 10 and 20 years

Blood pressure		10/20 years period					
		Normal blood pressure		Prehypertension		Hypertension	
		χ^2	Δ%	χ^2	Δ%	χ^2	Δ%
Systolic	Boys	2.2	+13.2	5.0*	-6.2	5.0*	-6.9
	Girls	0.7	+7.6	4.8*	-5.2	0.5	-2.2
Diastolic	Boys	0.8	-7.3	2.3	+6.0	0.1	+1.3
	Girls	1.6	-10.2	1.1	+3.9	2.2	+6.3
T test Systolic	Boys	13.74**					
	Girls	5.58**					
T test Diastolic	Boys	16.10**					
	Girls	14.40**					
T test BMI	Boys	31.87**					
	Girls	34.36**					

*$p<0.05$
**$p<0.01$

In Table 4 and Figure 3, we presented statistical evaluation of observed parameters for 10 years period of follow-up for the population of school children between 10 and 20 years. When first and third check-ups compared, we found non statistical difference in the number of school children for both genders in group with normal either systolic or diastolic BP ($p>0.05$). Opposite to the previous observations regarding statistical difference of the number of participants during 5 years period, we found that over 10 years of follow-up, there is statistically significant decrease ($p<0.05$) regarding proportion of participants for both genders in the prehypertensive group for systolic BP. In the group of hypertensive children, only boys showed statistically significant decline ($p<0.05$) in the proportion for systolic BP over 10 years of follow-up. There was statistically significant increase for the values of BP (systolic and diastolic) and BMI for both genders ($p<0.01$).

4. Discussion

There are numerous epidemiological and longitudinal studies describing correlation of elevated blood pressure and cardiovascular diseases both in young and adult population [11,12,15]. In the study of Fujitsu et al, group of authors evaluated correlation of other risk factors on blood pressure in school children as well [16].

Atherosclerosis, a proces leading to cardiovascular disease, begins in childhood with long evolution and silent period of clinical expression [17]. Absence of clinical manifestations during silent period can be explained by fact that critical narrowing of blood vessel leading to ischemic event lasts for years and in some cases for decades.

Importance of BP evaluation and influence of interventions in individuals with established prehypertension or hypertension on frequency of cardiovascular diseases was studied by Maruthur et al., stating that reduction of cardiovascular events can be more than 10% for persons involved in antihypertensive treatment [7].

Blood pressure is usually not single risk factor for cardiovascular disease, instead it is often strongly associated with body weight, physical inactivity and others [18,19]. In pediatric population BP values correlate with growth and development [20].

Even though, majority of children are normotensive, 15.9% of 10 years population was hypertensive, while this proportion declined to 6.5% of 15 years population. These findings point out higher values of hypertension than for children in the USA (5%) and Japan (3%) [21].

In our study we have demonstrated that from the results referring to the group of children between age of 10 and 15 years, in certain degree it can be stated that age for both genders more closely correlates with changes in diastolic rather then systolic BP. Since we found that there is inversion (increase versus decrease) in the proportion for diastolic BP in the prehypertensive group of children between 10 and 15 years and prehypertensive group of children between 15 and 20 years, it can be concluded that younger children tend to develop prehypertensive diastolic BP, while as they get older, they are more stabilized with reduction in diastolic BP values. Regarding the hypertensive group we found that there is inversion (decrease versus increase) in the proportion for diastolic BP in the hypertensive group of children between 10 and 15 years and hypertensive group of children between 15 and 20 years indicating that older children are more vulnerable to develop hypertensive diastolic BP. Also it is noticed that changes in systolic BP values are far less sensitive regarding the age in school children.

Opposite to the findings from both 5 years periods of follow-up, in the group that was included in 10 years of follow-up was shown that frequency of children with prehypertensive diastolic BP values is more likely to fluctuate over their growth period, while frequency of children with prehypertensive systolic BP values tends to decrease gradually over the time implicating that systolic BP values are more stable and less influenced by age of school children.

We have noticed during ten years period that hypertensive group of boys showed significant reduction in population frequency regarding systolic BP. As for the group of prehypertensive children, there were opposite findings but for diastolic BP frequencies, implicating that on longer term fluctuations in frequency of population regarding diastolic BP tend not to be significant, while frequency fluctuations for male gender regarding systolic BP tend to be significantly decreased.

For all groups regarding 5 and 10 years of follow-up it was shown that diastolic BP and BMI values significantly increased in both genders as well as systolic BP except for the group of girls in the period between 15 and 20 years of life.

Our findings regarding the changes in BP values during 5 years period over 10 years of follow-up, given all the facts, stress out that BP tend to have fluctuations during child's growth and development implicating possible involvement of other potential factors that can influence BP values. There are studies stressing out different proportions of hypertensive adolescents and young adults in different areas implicating the role of other factors as well [22]. Therefore, further studies

should address their potential role on systolic and diastolic BP values in childhood.

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