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ORIGINAL ARTICLE

Evaluation of left ventricular function in overweight children and teenagers with arterial hypertension and white coat hypertension

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Abstract

Background: *Obesity in childhood is strongly associated with elevated arterial blood pressure and risk of hypertension. The aim of the study was the evaluation of left ventricular (LV) function in hypertensive and white coat hypertensive overweight children and teenagers.*

Methods: *The study group consisted of 74 overweight patients aged 10.3 ± 3.1 years (range: 6–16 years) diagnosed as hypertensive in standard blood pressure measurement. The control group consisted of 31 normotensive and normoweight children. Ambulatory blood pressure monitoring (ABPM) and echocardiographic assessment of the LV mass and function were performed in all participants.*

Results: *Using ABPM hypertension was confirmed in 20 (27%) children. In the 54 (73%) remaining children white coat hypertension was diagnosed. The analysis of echocardiographic parameters revealed higher LV mass index (LVMI) in hypertensive overweight than in normotensive normoweight children (47.5 ± 9.2 g/m$^{2.7}$ vs. 39.8 ± 12.1 g/m$^{2.7}$; $p < 0.05$) and no difference between overweight hypertensive and white coat hypertension-hypertensive groups. The deceleration time of mitral early filling (DCT) was longer in hypertensive normoweight children than in normotensive overweight patients (219.5 ± 110.3 ms vs. 197.8 ± 65.8 ms; $p < 0.05$). A significant correlation between systolic blood pressure load (SBPL) and DCT ($r = 0.57$) and moderate correlation between SBPL and LVMI (r: 0.48) as well as between LVMI and isovolumetric relaxation time ($r = 0.37$) were found.*

Conclusions: *In overweight children the diagnosis of hypertension should be confirmed in ABPM because of the high prevalence of white coat hypertension. Periodic echocardiographic examinations should be recommended in overweight children with increased SBPL and decreased systolic nocturnal deep because of the possibility of LV function impairment.* (Cardiol J 2019; 26, 4: 343–349)

Key words: children, teenagers, overweight, hypertension, white coat hypertension, left ventricular function

Introduction

Obesity in childhood is strongly associated with elevated arterial blood pressure and hypertension, which ranges from 15% to 40% of overweight children [1, 2]. The explanation of hypertension in obesity remains unclear. Overweight children and young adults present some degree of insulin resistance and hyperinsulinemia, which leads to sodium retention.

Hypertension is an important medical issue in obese children and teenagers, while it is unclear if the phenomenon of white coat hypertension (WCH) should be considered as a risk factor in these patients. WCH is defined as a transient blood pressure elevation to hypertensive range

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Table 1. Population characteristics of the study group and control group.

	Hypertensive (n = 20)	WCH-hypertensive (n = 54)	Control group (n = 31)
Gender distribution (male:female)	16:4	36:18	17:14
Age [years]:			
The average ± SD	10.7 ± 3.6	10.1 ± 3.0	10.9 ± 3.6
Range	7–16	6–17	6–17
Body mass index [kg/m^2]:			
The average ± SD	28.4 ± 3.1	25.8 ± 2.9	18.5 ± 2.1
Range	26.9–32.8	25.1–31.9	16.3–24.6
Family history of obesity	8 (40.0%)	25 (46.3%)	2 (6.4%)
Family history of hypertension	7 (35.0%)	19 (35.2%)	–
Family history of diabetes mellitus (type 2)	3 (15.0%)	3 (5.5%)	–

SD — standard deviation; WCH — white coat hypertension

in measurements performed by medical professionals while blood pressure remains normal in out-of-office measurements. The prevalence of WCH in children is 44% to 88%, which is higher than in adults, in whom it ranges from 20% to 60% [3, 4]. The relationship between WCH and future development of persistent hypertension remains controversial, as well as the relationship between WCH and left ventricular (LV) hypertrophy [5].

The aim of the study was the assessment of LV function in overweight hypertensive and WCH children and teenagers.

Methods

A retrospective study was conducted in a group of 74 consecutive overweight and hypertensive children aged 10.3 ± 3.1 years (range: 6–16 years) admitted to the cardiology clinic. Overweight was defined as body mass index (BMI) above the international cut-off point for overweight by sex and age according to the World Obesity Federation (WOF) [6]. Hypertension was diagnosed based on 3-time standard blood pressure measurements following the criteria presented in the Fourth Report on Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents and the consensus of the European Society of Hypertension (ESH) [7, 8]. The 95th percentile was used for a diagnosis of hypertension. Subjects treated with any medications, suffering from any concomitant disease, with the suspicion of secondary hypertension, or sleep apnoea were excluded from the study. Secondary hypertension was excluded in all children from the study group based on medical history, physical examination, laboratory investigations including blood cell count, plasma glucose, creatinine, urea, uric acid, sodium, potassium, calcium, thyrotropin and thyroxine, urine analysis and urine culture, as well as abdominal ultrasonography, echocardiography and renal scintigraphy in selected patients. The control group consisted of 31 normoweight children aged 10.9 ± 3.6 years (range: 6–17 years). None of the controls had any positive history of hypertension. Population characteristics of the study group and control group are presented in Table 1.

The study was approved by the University Ethics Committee.

Standard blood pressure measurement, ambulatory blood pressure measurement, and echocardiographic examination were performed in children from the study and control groups within a 3 day period.

Standard blood pressure measurements were taken on the right arm in a sitting position using an aneroid sphygmomanometer (Babyphone, Riester) equipped with a set of appropriate cuffs in respect of arm circumference. The clinicians who performed blood pressure measurements were well trained in this procedure and had appropriate experience in blood pressure measurements in children and adolescents.

Ambulatory blood pressure recordings were performed and analysed using an ABP SpaceLab system including report management system and 90207 and 90217 ABP monitors equipped with a set of appropriate cuffs in respect of arm circumference. Analysis of ambulatory blood pressure monitoring (ABPM) data included mean systolic and diastolic blood pressure for a 24-h period (SBP, DBP), the blood pressure load for SBP and DBP (SBPL, DBPL) as the percentage of measurement

Table 2. Results of ambulatory blood pressure monitoring.

Group	SBP [mm Hg]	DBP [mm Hg]	SBPL [%]	DBPL [%]	SBPD [%]	DBPD [%]	HR [bpm]
Hypertensive	134.3 ± 7.9[ab]	67.5 ± 9.2	43.7 ± 10.9[ab]	18.6 ± 8.9[ab]	8.8 ± 6.9[a]	19.1 ± 7.2	88 ± 9
WCH-hypertensive	121.5 ± 8.1[a]	64.7 ± 7.7	23.3 ± 8.2[a]	10.2 ± 8.6	14.9 ± 6.9	18.8 ± 6.7	92 ± 11
Control	112.7 ± 7.6	64.2 ± 5.6	12.8 ± 9.3	9.1 ± 7.6	16.7 ± 6.4	19.4 ± 5.8	85 ± 8

[a]p < 0.05 vs. control group; [b]p < 0.05 vs. WCH-hypertensive group; SBP — systolic blood pressure; DBP — diastolic blood pressure; SBPL — systolic blood pressure load; DBPL — diastolic blood pressure load; SBPD — systolic blood pressure deep; DBPD — diastolic blood pressure deep; HR — mean 24-hour value of heart rate; WCH — white coat hypertension

exceeding the 95[th] percentile and the nocturnal deep for SBP and DBP (SBPD, DBPD) calculated as a percentage of blood pressure decline from wakefulness to sleep periods. White coat hypertension was diagnosed in patients with hypertension diagnosed by standard blood pressure measurement and blood pressure in ABPM.

Echocardiographic examinations were performed using IE33 Philips echocardiographic systems by clinicians with professional experience in the field of pediatric echocardiography. Left ventricular systolic function was assessed by means of ejection fraction (EF) and shortening fraction (SF). Left ventricular mass index (LVMI) was calculated by normalising LV mass to the height to the power of 2.7. The diastolic LV function was analyzed based on the mitral flow profile and LV isovolumetric relaxation time (IVRT). Mitral flow and IVRT were evaluated using a pulsed Doppler in the 4-chamber apical view at the level of mitral valve leaflets. The following parameters of LV diastolic function were computed: velocity of mitral peak early diastolic filling (E), velocity of mitral peak late diastolic filling (A), E/A ratio, and deceleration time of mitral early filling (DCT).

The analysis of correlations between ambulatory blood pressure parameters: SBPL, DBPL, SBPD, and DBPD and echocardiographic parameters: LVMI, SF, EF, E/A, DCT, and IVRT was performed.

Statistical analysis

The results were presented as mean value ± one standard deviation. A p value < 0.05 was considered statistically significant. Analysis of variance (ANOVA) with following post hoc least significant difference test or χ^2 test were used for statistical comparison when appropriate. Correlation between analyzed parameters were assessed using Pearson correlation coefficient.

Results

All of the 74 overweight children from the study group were found to be hypertensive in standard blood pressure measurement. In 20 (27%) of them hypertension was confirmed in ABPM (hypertensive group). In the remaining 54 (73%) with the proper result of ABPM white coat hypertension was diagnosed (WCH-hypertensive group).

All of the 31 normoweight children were found to be normotensive in standard measurement and ABPM (controls).

Isolated systolic hypertension was found in 19 cases (26% of all overweight children) among patients of the hypertensive group. The overall results of ABPM are presented in Table 2, Figures 1 and 2. SBP was significantly higher in the hypertensive group (p < 0.01) and the WCH-hypertensive group (p < 0.05) than in controls. SBP in the hypertensive group was significantly higher in comparison to the WCH-hypertensive

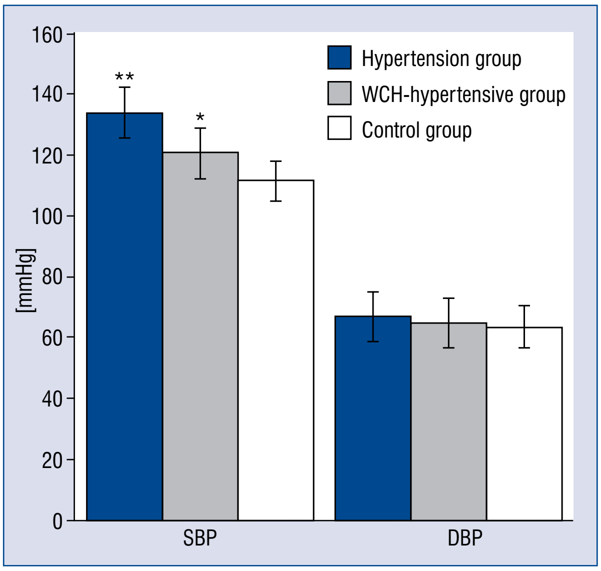

Figure 1. Results of ambulatory blood pressure monitoring: systolic blood pressure (SBP) and diastolic blood pressure (DBP) in hypertensive, white coat hypertension (WCH)-hypertensive and control groups; *p < 0.05 vs. control group; **p < 0.05 vs. WCH-hypertensive group and vs. control group.

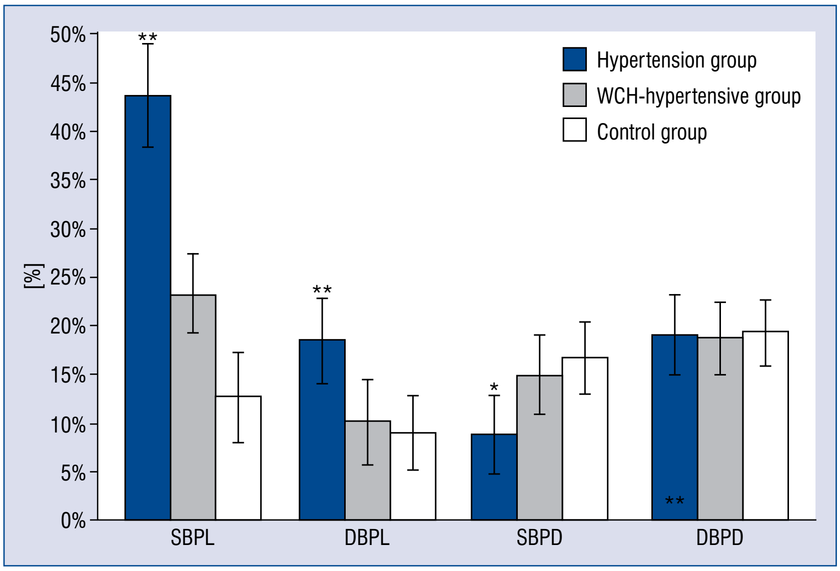

Figure 2. Results of ambulatory blood pressure monitoring: systolic blood pressure load (SBPL), diastolic blood pressure load (DBPL), systolic blood pressure deep (SBPD) and diastolic blood pressure deep (DBPD) in hypertensive, white coat hypertension (WCH)-hypertensive and control group; *p < 0.05 vs. control group; **p < 0.05 vs. WCH-hypertensive group and vs. control group.

Table 3. Results of echocardiographic examination.

Group	LVMI [g/h$^{2.7}$]	SF [%]	EF [%]	E/A	DCT [ms]	IVRT [ms]
Hypertensives	47.5 ± 9.2[a]	36.8 ± 5.1	66.4 ± 4.6	1.42 ± 0.29[a]	219.5 ± 110.3[ab]	79.4 ± 12.4[a]
WCH-hypertensives	44.1 ± 12.7	35.4 ± 3.9	65.3 ± 3.8	1.48 ± 0.34	208.3 ± 92.3[a]	66.8 ± 9.7
Controls	39.8 ± 12.1	35.2 ± 4.7	64.1 ± 4.1	1.69 ± 0.75	197.8 ± 65.8	64.3 ± 11.2

[a]p < 0.05 vs. control group; [b]p < 0.05 vs. WCH-hypertensive group; LVMI — left ventricular mass index; SF — shortening fraction; EF — ejection fraction; E — velocity of mitral peak early diastolic filling; A — velocity of mitral peak late diastolic filling; DCT — deceleration time of mitral early filing; IVRT — left ventricular isovolumetric relaxation time; WCH — white coat hypertension

group ($p < 0.01$). SBPL was significantly higher in the hypertensive group ($p < 0.001$) and the WCH-hypertensive group ($p < 0.01$) than in controls, and SBPL in the hypertensive group was significantly higher in comparison to the WCH-hypertensive group ($p < 0.001$). There were no significant differences between the study group and controls for DBP. DBPL was significantly higher in the hypertensive group than in the WCH-hypertensive group and controls ($p < 0.01$). SBPD was significantly lower in the hypertensive group in comparison to control group ($p < 0.01$). No differences in DBP were found.

The results of echocardiographic examination are shown in Table 3. The E/A ratio was significantly lower in the hypertensive group than in the control group ($p < 0.05$). DCT was significantly longer in the hypertensive group in comparison to the WCH-hypertensive group ($p < 0.05$) and controls ($p < 0.01$). IVRT was significantly longer in the hypertensive group than in the control group ($p < 0.05$). LVMI in the hypertensive group was significantly higher in comparison to the control group, and no differences were found between hypertensive and WCH-hypertensive groups as well as between WCH-hypertensive patients and controls. Because of the heterogeneous distribution of sex between the groups of hypertensive, WCH-hypertensive, and controls, additional separate evaluation of LVMI in subgroups of hypertensive, WCH-hypertensive, and normotensive boys was performed with respective results as follows: 48.8 ± 8.8 g/m$^{2.7}$, 45.7 ± 9.6 g/m$^{2.7}$ and 41.7 ± 8.5 g/m$^{2.7}$. LVMI in the subgroups of hypertensive boys was significantly higher in comparison to the subgroup of normotensive boys ($p < 0.05$). There was no significant difference in LVMI between subgroups of WCH-hypertensive and normotensive boys. Respective analysis between girls was not performed because of the low number of girls in potential subgroups. The obtained mean values of EF and FS in the hypertensive group were higher vs. the WCH-hypertensive group and controls, but the differences were not statistically significant.

High significant correlation between SBPL and DCT ($r = 0.57$, $p < 0.05$) and moderate correlation between SBPL and LVMI ($r = 0.48$, $p < 0.05$), SBPL and IVRT ($r = 0.37$, $p < 0.05$), and SBPD and DCT ($r = 0.35$, $p < 0.05$) were found.

Discussion

Obesity is known as an important factor in determining blood pressure, the prevalence of hypertension, and its complications. The prevalence of obesity is rising, especially in developed countries. The association between overweight and hypertension has been reported in numerous studies [9, 10].

In this study hypertension was diagnosed in 27% of overweight children. Sorof et al. [9] reported a higher prevalence of hypertension in obese children, which was estimated at 33%. The lower occurrence of hypertension in our patients may be explained by the higher prevalence of WCH, which was 73%. It is higher than was reported in a previous study in healthy, normoweight children in whom the prevalence of WCH was 52.3% [11]. The present study group consisted of patients with BMI above the international cut-off point for overweight by sex and age according the WOF, while in the study of Sorof et al. [9] only strictly obese children were included. In the review of the literature we could not find any studies concerning WCH occurrence in overweight children. The explanation of high prevalence of WCH in overweight patients remains unclear. Obesity may be a stressful factor during the medical examination which could influence casual blood pressure measurement and lead to over diagnosis of hypertension.

In the present study, isolated systolic hypertension was diagnosed in 19 children among patients from the hypertensive group, i.e. 26% of all overweights. Sorof et al. [9] evaluated the prevalence of systolic hypertension in obese children at 50%.

In the study of Lurbe et al. [12] the SBP and DBP in ABPM as well as SBPL and DBPL were found to be significantly higher in overweight in comparison to normoweight children. In the same study no significant differences in systolic and diastolic nocturnal deep were found. In our recent study the SBP and SBPL in the ABPM were significantly higher in the hypertensive group and WCH-hypertensive group than in normotensive normoweight children; furthermore, SBP and SBPL in the WCH-hypertensive overweight patients were significantly higher in comparison to healthy controls. The DBPL in overweight hypertensive patients was significantly higher than in WCH-hypertensive overweight and normoweight children. Systolic nocturnal deep in hypertensive overweight patients was significantly lower than in normoweights. No significant differences between the investigated groups were found in DBP and diastolic nocturnal deep. In the study by Sorof et al. [4], where ABPM results in normoweight patients with WCH and healthy controls were compared, the SBP and SBPL and DBPL were higher in patients with WCH, and there were no differences in DBP, and systolic and diastolic nocturnal deep between the analyzed groups. The results of this study are consistent with the results of the cited authors except for systolic nocturnal deep. In contrast to results herein, Di Salvo et al. [13] did not find any significant difference of SBP and DBP in ABPM between overweight and normoweight children.

Left ventricular hypertrophy is known to be an independent risk factor of cardiovascular morbidity and mortality. In the present study LVMI was significantly higher in hypertensive boys than in normotensive ones, while no differences were found between hypertensive and WCH-hypertensive male subgroups as well as between WCH-hypertensive boys and normotensive ones. These results are consistent with data presented in the literature on condition that their authors analyzed groups consisting of males and females [13–15]. Daniels et al. [16] reported that body mass was a strong determinant of LV hypertrophy. The impact of WCH on LV function remains controversial. In some studies, increased LV mass in patients with WCH in comparison to healthy controls was reported [5]. In this study no significant differences of SF and EF, describing LV systolic function, between analyzed groups were found, which is consistent with the majority of reports [13, 14, 17–19]. According to Lee at al. [20] the alteration of LV diastolic function in hypertensive children and teenagers is mostly related to elevated LV mass. In the present study DCT in hypertensive overweight patients was significantly longer than in the WCH-hypertensive group; moreover, mean values of this parameter obtained in hypertensive and WCH-hypertensive overweight patients were significantly higher vs. healthy normoweight children. The results of the E/A ratio and IVRT in the group of hypertensive overweight patients did not differ from those obtained in WCH-hypertensive overweight children, whereas the E/A ratio obtained in the present hypertensive patients was lower and IVRT was longer than in normotensive normoweight children. These results of E/A ratio, DCT, and IVRT suggest an impaired LV diastolic function in overweight patients, which is consistent with data presented in the literature [21].

In this study significant correlations between SBPL load in ABPM and early filling deceleration time, LVMI, and LV relaxation time as well as between systolic blood pressure nocturnal deep and DCT were found. It should be considered that increased SBPL and decreased SBPD may reflect LV alteration due to increased blood pressure in overweight children.

In summary, it should be emphasised that the combination of overweight and hypertension presents a particularly adverse profile for satisfactory cardiovascular outcomes. It is still difficult to answer the question of whether overweight children are more exposed and sensitive to arterial hypertension and related LV hypertrophy in comparison to overweight adults, because the explanation of hypertension in obesity remains unclear. The age range of this study group was wide, so some children were enrolled to the study during puberty while others were enrolled before such a period. It is a documented fact that a significant rise in blood pressure, mostly systolic, associated with physical growth is observed during the period of puberty and is more prominent in boys than in girls. The rise of blood pressure in puberty is connected with increased secretion of gonadal hormones like oestrogens and testosterone as well as other hormones like growth hormone. The relationship between the rate of blood pressure increase in puberty and development of hypertension is unclear. Family history of hypertension increasing the risk of early hypertension was not found as a significant factor of the rate of blood pressure increase in puberty [22].

Limitations of the study

Limitations of the study include a dependency of echocardiography on the angle and difficulty in providing a good quality of echocardiographic window due to obesity as well as heterogeneous distribution of sex between hypertensive, WCH--hypertensive, and control groups. The pubertal status and echocardiographic analysis of the profile of pulmonary vein flow were not assessed in the study groups. The results obtained in hypertensive overweight patients were not compared with a cohort of overweight normotensive controls.

Conclusions

1. In overweight children the diagnosis of hypertension should be confirmed by ABPM because of a high prevalence of WCH.
2. Periodic echocardiographic examinations are recommended in overweight children with an increased SBPL load and decreased systolic nocturnal deep because of the risk of LV function impairment.

Conflict of interest: None declared

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