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PRACE ORYGINALNE ORIGINAL PAPERS

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Prevalence of arterial hypertension and anthropometrical predictors of elevated blood pressure in 14 years old adolescents

Występowanie nadciśnienia tętniczego i ocena antropometrycznych predyktorów podwyższonego ciśnienia tętniczego u nastolatków w wieku 14 lat

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Keywords

arterial hypertension, prevalence, adolescents, stage 1 hypertension, stage 2 hypertension

Słowa kluczowe

nadciśnienie tętnicze, występowanie, adolescenci, stan przednadciśnieniowy, stadium 2 nadciśnienia tętniczego

S u m m a r y

Introduction. Prevalence of arterial hypertension (AH) based on blood pressure (BP) measurements done on three occasions and assessment of BMI and waist circumference (WC) as predictors of AH was assessed in few studies.

Aim. To assess prevalence of AH and to estimate specificity and sensitivity of BMI and WC in predicting BP status in 416 adolescents (210 males) in mean age 14.5 ± 0.9 yrs.

Material and methods. Recruited subjects represented 90% of local population in this age. BP was measured with auscultatory sphygmomanometer on three different occasions.

Results. Prehypertension was diagnosed in 9% of boys and 7.7% of girls, and AH in 12.3% (11.4% in boys, 13.1% in girls). Stage 1 AH was found in 8.6% of boys and 9.7% of girls and stage 2 AH in 2.9% and 3.4% of boys and girls, respectively. 95th percentile of WC had better sensitivity and specificity over 95th percentile of BMI (0.57 and 0.95 vs 0.25 and 0.96, respectively) in predicting prehypertension and AH. For diagnosis of stage 2 AH 85th percentiles of WC and BMI had sensitivity and specificity of 0.67 and 0.78 vs 0.62 and 0.80, respectively. The same was found when only non-obese children were included to analysis.

Conclusions. The prevalence of AH among 14 years old adolescents was 12.3% and of prehypertension was 8.4%. Both BMI and WC predicted prehypertension and AH but WC had better specificity and sensitivity in predicting stage 2 AH both in general population and among non-obese children.

S t r e s z c z e n i e

Wstęp. Niewiele badań oceniających częstość nadciśnienia tętniczego (NT) opiera się na pomiarach wykonanych w trakcie trzech różnych wizyt. Nadal dyskutowane jest znaczenie wskaźnika masy ciała (BMI) i obwodu talii (OT) jako markerów nadciśnienia, jego ciężkości i ewentualnych powikłań narządowych.

Cel pracy. Oszacowanie występowania NT i czułości oraz swoistości BMI i obwodu talii jako predyktorów ryzyka NT i jego stadiów.

Materiał i metody. W badaniu udział wzięło 416 adolescentów (210 chłopców) w wieku 14,5 ± 0,9 roku, którzy stanowili 90% populacji w tym wieku miejscowości Gniewkowo. Ciśnienie tętnicze mierzono osłuchowo w trakcie trzech różnych wizyt. BMI i OT analizowano jako wartości odchylenia standardowego od mediany normy oraz jako wartości centylowe.

Wyniki. Ciśnienie wysokie prawidłowe/stan przednadciśnieniowy rozpoznano u 9% chłopców i 7,7% dziewczynek, a NT w 12,3% (11,4% chłopców i 13,1% dziewcząt). Stadium 1 NT stwierdzono u 8,6% chłopców i 9,7% dziewcząt, a stadium 2 NT u 2,9% chłopców i 3,4% dziewcząt. OT ≥ 95. centyla miał większą czułość i swoistość niż BMI ≥ 95. centyla (odpowiednio 0,57 i 0,95 vs 0,25 i 0,96) jako predyktor stanu przednadciśnieniowego i NT. 85. centyl OT i BMI miał czułość i swoistość (0,67 i 0,78 vs 0,62 i 0,80) dla rozpoznania stadium 2 NT zarówno dla całej grupy, jak i tylko dzieci nieotyłych.

Wnioski. Częstość NT u nastolatków w wieku 14 lat wyniosła 12,3%, a stanu przednadciśnieniowego 8,4%. BMI i OT są dobrymi predyktorami rozpoznania NT, ale OT ma większą swoistość i czułość w rozpoznawaniu stadium 2 NT zarówno w populacji ogólnej, jak i u dzieci nieotyłych.

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INTRODUCTION

It is estimated that prevalence of arterial hypertension (AH) in children and adolescents is 3-5% and rises with age from 0 to 18 years (1). However, there are only few data based on triple measurements of BP done on three occasions. Although historically the most prevalent form of AH in childhood was secondary hypertension, it changed in last 2 decades. Now, primary hypertension (PH) starts to dominate as the cause of AH in children older than 6 years and its prevalence is at least the same as of secondary hypertension (2). The recent rise in prevalence of PH in childhood and adolescence is strictly associated with the obesity epidemic and the dominant intermediate phenotype of hypertensive adolescent is overweight and metabolic abnormalities typical of metabolic syndrome. Although the role of visceral fat is of utmost importance in pathogenesis of PH and associated abnormalities it is still debated which anthropometrical parameter has the better predictive value in assessment of cardiovascular risk and blood pressure status (3). Both body mass index (BMI) and waist circumference (WC) are crude markers of adiposity. BMI reflects general relations between mass and height. It is the main marker of overweight and obesity. However, in some cases of excessive muscle mass BMI may falsely indicate adiposity. On the contrary, persons with normal BMI may have increased amount of visceral fat and decreased muscle mass with all metabolic and hemodynamic consequences. WC is the crude marker of visceral fat. However, WC measures also subcutaneous fat. Nevertheless, there is strict relation between WC and metabolic abnormalities both in children and adults (4). In contrast to adults, in childhood and adolescence anthropometrical parameters change with age. Thus, pediatric definitions of overweight and obesity are based on percentile values and not on absolute values.

AIM

The aim of the study was to assess prevalence of AH among 14 years old adolescents and to determine the sensitivity and specificity of BMI and WC as indicators of blood pressure status from prehypertension to stage 2 arterial hypertension.

MATERIAL AND METHODS

418 adolescents (210 males) in mean age 14.5 ± 0.9 yrs were included to the study. Subjects were recruited voluntarily from schools of town Gniewkowo and represented 90% of local population of schoolchildren in this age. The exclusion criteria were body deformities interfering with blood pressure and anthropometrical measurements, chronic disease associated with blood pressure elevation, chronic kidney disease, diabetes and use of antihypertensive medications. All subjects were examined when in good state of health.

Blood pressure (BP) was measured with auscultatory mercury sphygmomanometer. Three measurements were done on right arm on three different occasions. The mean of three BP measurements was analyzed. The cut-off values for diagnosis of high-normal blood pressure/prehypertension, stage 1 and stage 2 of AH were based on referential values for auscultatory measurements from 4th Task Report (5).

During first visit in all subjects height, weight and WC was measured. WC was measured midway between the lowest rib and the superior border of the iliac crest at the end of a normal expiration with a flexible non-elastic anthropometric tape, to the nearest 0.1 cm. Anthropometrical values including BMI and WC were analyzed as absolute and as standard deviation score (SDS) values according to referential normative data for Polish children and adolescents (6). Overweight and obesity were defined according to the International Obesity Task Force cut-off points.

Statistical analysis

Descriptive analyses were used to calculate means and standard deviations. A Mann-Whitney U test and T-test were used to determine differences between the sexes in the case of non-normally distributed data and normally distributed data, respectively. Prevalence of overweight, obesity and blood pressure status was analyzed using chi-square test. The sensitivity and specificity of BMI and WC as predictors of AH and stage 1 and stage 2 of AH was done after calculation of receiver operating curves (ROC). Statistical analysis was performed using SAS 9.3 software. The significance level of all tests was 0.05.

RESULTS

The mean BMI and BMI-SDS was 20.7 and 20.29 in boys and girls, respectively (ns) (tab. 1). The mean WC were 74.4 and 68.1 cm in boys and girls respectively ($p = 0.0001$). Similarly, WC-SDS values were 0.4 ± 0.97 and 0.04 ± 1.12 in boys and girls, respectively ($p = 0.001$). The overall prevalence of overweight (16.1%) and obesity (3.4%) was 19.5%. The prevalence of overweight was higher among boys compared to girls, whereas the prevalence of obesity did not differ between sexes.

High-normal blood pressure was diagnosed in 9% of boys and 7.7% of girls, and arterial hypertension in 12.3% of cases (11.4% in boys and 13.1% in girls). Stage 1 AH was found in 8.6% of boys and 9.7% of girls and stage 2 AH in 2.9% and 3.4% of boys and girls, respectively. Systolic AH dominated in nearly 80% of all cases of AH.

Analysis of specificity and sensitivity of BMI and WC in diagnosis of elevated BP revealed that for diagnosis of prehypertension and AH 95th percentile of WC had slightly better sensitivity and specificity over 95th percentile of BMI (0.57 and 0.95 vs 0.25 and 0.96, respectively) (tab. 2). For diagnosis of stage 2 of AH 85th percentiles of WC and BMI had sensitivity and specificity of 0.67 and 0.78 vs 0.62 and 0.80, respectively (tab. 3). The same was found when only non-obese children were included to analysis.

Table 1. Description of basic anthropometrical and blood pressures data (mean (SD)) and body weight and blood pressure status (%).

Variable	Boys	Girls	p
Age (years)	14.4 (1.0)	14.5 (1.0)	ns
BMI (kg/m^2)	20.7 (4.2)	20.3 (3.4)	ns
BMI-SDS	0.15 (1.06)	0.00 (1.09)	ns
Waist (cm)	74.4 (9.3)	68.1 (7.2)	0.0001
Waist-SDS	0.42 (0.97)	0.04 (1.12)	0.001
SBP (mmHg)	120.7 (11.01)	117.1 (10.69)	0.0009
DBP (mmHg)	68.7 (6.57)	67.2 (7.26)	0.027
Overweight (overall prevalence 16.1%)	20.0%	12.1%	0.03
Obesity (overall prevalence 3.4%)	3.8%	2.9%	ns
High-normal blood pressure (overall prevalence 8.4%)	9%	7.7%	ns
Arterial hypertension (overall prevalence 12.3%)	11.4%	13.1%	ns
Stage 1 (overall prevalence 9.2%)	8.6%	9.7%	ns
Stage 2 (overall prevalence 3.1%)	2.9%	3.4%	ns

BMI – body mass index; BMI-SDS – body mass index-standard deviation score; SBP – systolic blood pressure; DBP – diastolic blood pressure

DISCUSSION

The main result of our study is description of blood pressure status in a large group of 14 years old adolescents and estimation of value of basic anthropometrical indices as predictors of AH and severity of AH. In contrast to many epidemiological studies where blood pressure was measured on one occasion, we diagnosed AH according to definition, i.e. when blood pressure values were elevated on three independent visits.

We found that prevalence of AH diagnosed according to current pediatric definition in 14 years old adolescents is 12.3%, does not differ between girls and boys and equals the prevalence of AH in young adults. The second finding is that stage 2 AH was found in 3.1%. Because there are basic differences between pediatric definition and classification of AH severity with definition of AH and its classification in adults, it is difficult to compare prevalence of specific stages of AH found in our study with prevalence of AH and its stages in adults. Notwithstanding, we are not aware of any study describing prevalence of different stages of AH in young adults. When interpreting our finding of general prevalence of AH in adolescents one must underline two points. First, primary hypertension is dominating form of AH in adolescents and is strictly associated with visceral obesity and low physical activity (7). Thus, according to guidelines, stage 1 AH in the adolescent is an indication to basic diagnostic tests and to non-pharmacological treatment. However, in subjects with stage 2 AH more diagnostic tests should be performed and pharmacological treatment should be started (5, 8). Therefore, our findings indicate that 12% of adolescents may require first step of diagnostic evaluation of elevated blood pressure and one quarter of them, i.e. adolescents with stage 2 AH, require more sophisticated diagnostic tests usually not available for general practitioners. In Poland, these diagnostics steps are done in hospital setting. The second issue is different diagnosis of AH in adolescents based on pediatric or adult blood pressure cut-off values (9). One must underline, that pediatric definition of AH is based on statistical distribution of blood pressure values and arbitrarily chosen cut-off of 95th percentile. In case of 18 years old boys 95th percentile for systolic blood pressure equals 140 mmHg what is the same as cut-off value for normal and elevated blood pressure in adults. In contrast, in case of 18 years old girls, 95th percentile vale for systolic blood pressure is far below 140 mmHg and the difference may reach even 9 mmHg. However, according to guidelines, diagnosis of AH obligates to start treatment. In case of primary hypertension it is non-pharmacological treatment in subjects with stage 1 AH and both non-pharmacological and pharmacological in case of stage 2 AH and lack of effect of non-pharmacological therapy in subjects with stage 1 AH. On the other side there is some uncertainty regarding treatment of adolescents with mild elevation AH, i.e. with stage 1 AH. Thus, it is important to focus on group of subjects who are at risk for more severe AH, i.e. with stage 2 AH. Because the dominant intermediate phenotype of primary hypertension in adolescents is overweight and metabolic syndrome (7) we tried to determine usefulness of simple anthropometrical variables to predict probability of diagnosis of AH and stage 2 AH. We found that BMI has similar

Table 2. Specificity and sensitivity of WC and BMI measurements in predicting prehypertension and arterial hypertension.

	2 SD		95th percentile		90th percentile		85th percentile	
	Waist	BMI	Waist	BMI	Waist	BMI	Waist	BMI
Sensitivity	0.20	0.16	0.57	0.25	0.42	0.35	0.58	0.49
Specificity	0.99	0.99	0.95	0.96	0.90	0.91	0.84	0.85

Table 3. Specificity and sensitivity of waist and BMI measurements in predicting diagnosis of stage 2 hypertension.

	2 SD		95th percentile		90th percentile		85th percentile	
	Waist	BMI	Waist	BMI	Waist	BMI	Waist	BMI
Sensitivity	0.33	0.08	0.11	0.38	0.58	0.54	0.67	0.62
Specificity	0.96	0.97	0.92	0.93	0.85	0.88	0.78	0.80

specificity but was less sensitive than WC in diagnosis of high-normal blood pressure and AH in comparison with measurement of WC. However, WC had slightly better sensitivity and specificity than BMI in predicting stage 2 hypertension. Nevertheless, the differences were small. BMI is regarded as the main determinant of blood pressure in general population and decrease of BMI correlates with decrease of blood pressure in hypertensive children (4,10,11). However, it is visceral obesity what determines target organ damage in children with primary hypertension and decrease of WC and visceral fat assessed by nuclear magnetic imaging determined regression of left ventricular mass index and subclinical arterial injury expressed as carotid artery wall cross sectional area (11). Our findings are partly in line with results obtained by Bloetzer et al. who found that limiting prophylactic blood pressure measurements to obese children with positive familial history of AH may increase sensitivity and specificity of diagnosis of AH and may be alternative to universal screening (12). However, our results indicate that it is not only BMI, but rather WC what should be taken as the risk factor of elevated blood pressure.

The other finding of our study is that the dominant form of AH in adolescents is isolated systolic blood pressure. It is the same as found in other studies of hypertensive adolescents (13). However, in this study we did not measure other components of hyperdynamic circulation such as heart rate and peripheral arterial resistance. Moreover, diagnosis of isolated systolic hypertension in adolescent or young adult must be differentiated from spurious hypertension what needs to determine central blood pressure (14, 15).

CONCLUSIONS

Concluding, we found that the prevalence of AH among 14 years old adolescents is 12.3% and of prehypertension is 8.4%. Both BMI and WC are good predictors of elevated BP and of AH but visceral obesity measured as WC has better specificity and sensitivity as a predictor of stage 2 AH both in general population and among non-obese children and may serve as an alternative indication to blood pressure screening in contrast to universal screening.

LIMITATIONS AND STRENGTHS OF THE STUDY

The main limitation of the study is lack of data from 24 hour ambulatory blood pressure measurements what may confirm or exclude diagnosis of AH. Thus, we can not firmly state that all subjects in whom blood pressure was elevated were truly hypertensive. Secondly, we do not have any data on target organ damage and we did not assess central blood pressure to exclude spurious hypertension. On the other side, we determined blood pressure on three independent visits and we diagnosed AH according to definition and guidelines. The other strength of the study is that our subjects were from general pediatric population and represented almost all members of that area.

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