

Arterial hypertension and pulse pressure in school-age children

Yu. M. Nechytailo, N. I. Kovtyuk, D. Yu. Nechytailo

HSEE "Bukovinian state medical university", Chernivtsi, Ukraine

Childhood arterial hypertension (AH) has become a global problem not only for pediatrics, but also for public health in general.

Objective. The aim of this study was to determine the prevalence of arterial hypertension among school-age children and diagnostic value of pulse pressure.

Materials and methods. In total 848 children in 10–17 years of age (mean age – 13.9 ± 0.06 years, 45.4 % boys and 54.6 % girls) from urban and rural areas of Chernivtsi region were examined in schools during screening for elevated blood pressure (BP). School-based ambulatory seated BP was measured by oscillometric automated recording devices with the age selection of cuffs. Elevated systolic (SAP) or diastolic (DAP) pressure was diagnosed in those children with indicators above the 95th percentile of age norms in accordance with the national normative values. In cases of elevated BP the measurements were verified by aneroid device.

Results. It has been established that the frequency of high blood pressure in the examined school students was 25.2 %, including 17.7 % of arterial hypertension (BP above 95 percentile) and 7.5 % – pre-hypertension (90–95 percentile). The prevalence of hypertension varied with age subgroups and the highest level was in 16 years of age – 29.9 % with high blood pressure (21.9 % above 95 percentile and 8.0 % between the 90th and 95th percentiles). Increased SAP was combined with an increased DAP in 47.3 % of cases and in the study had a positive correlation with overweight ($r=0.27$, $p<0.05$) and negative with physical performance ($r=-0.21$, $p<0.05$). The pulse pressure had significant correlations with SAP, AH and overweight and it could be used as additional diagnostic index of AH.

Conclusions. The prevalence of elevated BP in our study is higher than in European countries and exceeds 20 % of the child population. The elevated BP in our children has positive correlation with overweight and the negative with physical performance. The level of pulse pressure has significant correlation with SAP and overweight and it could be used as additional diagnostic index of AH.

Key words:

school-age children, hypertension, pulse pressure, overweight.

Zaporozhye medical journal
2017; 19 (4), 395–399

DOI:
10.14739/2310-1210.
2017.4.104872

E-mail:
nkovtyuk@gmail.com

Артеріальна гіпертензія та пульсовий тиск у дітей шкільного віку

Ю. М. Нечитайло, Н. І. Ковтюк, Д. Ю. Нечитайло

Дитяча артеріальна гіпертензія (АГ) стала глобальною проблемою не тільки для педіатрії, але й для охорони громадського здоров'я загалом.

Мета роботи – визначити поширеність артеріальної гіпертензії (АГ) серед дітей шкільного віку та діагностичну значущість пульсового тиску.

Матеріали та методи. Обстежено у школах під час скринінгу на підвищений артеріальний тиск 848 дітей віком від 10 до 17 років (середній вік – $13,9 \pm 0,06$ року, 45,4 % хлопчиків і 54,6 % дівчаток) із міських і сільських районів Чернівецької області. В умовах школи у дітей у положенні сидіння вимірювали кров'яний тиск осцилометричними автоматизованими тонометрами з віковим підбором манжет. Підвищений систолічний або діастолічний тиск діагностували в дітей із показниками вище 95 перцентилі вікової норми відповідно до національних нормативних значень. У випадках гіпертензії тиск верифікувався за допомогою анероїдного тонометра.

Результати. Встановлено, що частота підвищеного артеріального тиску у школярів становила 25,2 %, в тому числі 17,7 % – артеріальна гіпертензія (артеріальний тиск вище 95 перцентилі) та 7,5 % – передгіпертензія (90–95 перцентилі). Поширеність гіпертензії змінюється залежно від вікової підгрупи, й найвищий рівень відзначений у школярів віком 16 років – 29,9 % з підвищеним АТ (21,9 % вище 95 перцентилі та 8,0 % між 90 і 95 перцентиліями). Підвищений систолічний артеріальний тиск (САТ) поєднувався з підвищеним діастолічним тиском у 47,3 % випадків, а також у дослідженні мав позитивні кореляції з ожирінням ($r=0,27$, $p<0,05$) і негативні – з фізичною працездатністю ($r=-0,21$, $p<0,05$). Пульсовий тиск мав значущі кореляції з САТ, АГ і надмірною вагою та може використовуватись як додатковий діагностичний показник АГ.

Висновки. Поширеність підвищеного артеріального тиску в нашому дослідженні вища, ніж в європейських країнах, і сягає понад 20 % дитячого населення. Підвищення тиску в наших дітей має позитивні кореляції з ожирінням і негативні – з фізичною працездатністю. Рівень пульсового тиску має значущі кореляції з САТ і надлишковою масою тіла та може використовуватись як додатковий діагностичний показник артеріальної гіпертензії.

Ключові слова:

діти шкільного віку, артеріальна гіпертензія, пульсовий тиск, надмірна вага.

Запорізький медичний журнал. – 2017. – Т. 19, № 4(103). – С. 395–399

Артериальная гипертензия и пульсовое давление у детей школьного возраста

Ю. Н. Нечитайло, Н. И. Ковтюк, Д. Ю. Нечитайло

Детская артериальная гипертензия (АГ) стала глобальной проблемой не только для педиатрии, но и для общественного здравоохранения в целом.

Цель работы – определить распространённость артериальной гипертензии среди детей школьного возраста и диагностическую значимость пульсового давления.

Материалы и методы. Обследовано в школах во время скрининга на повышенное артериальное давление 848 детей в возрасте от 10 до 17 лет (средний возраст – $13,9 \pm 0,06$ года, 45,4 % мальчиков и 54,6 % девочек) из городских и

Ключевые слова:

дети школьного возраста, артериальная гипертензия, пульсовое давление, избыточный вес.

сельских районов Черновицкой области. В условиях школы у детей в положении сидя измеряли кровяное давление осциллометрическими автоматизированными тонометрами с возрастным подбором манжет. Повышенное систолическое или диастолическое давление диагностировалось у детей с показателями выше 95 перцентиля возрастной нормы в соответствии с национальными нормативными значениями. В случаях гипертензии давление верифицировалось с помощью anerоидного тонометра.

Результаты. Установлено, что частота повышенного артериального давления у обследованных школьников составила 25,2%, в том числе 17,7% – артериальная гипертензия (артериальное давление выше 95 перцентиля) и 7,5% – предгипертензия (90–95 перцентиль). Распространённость гипертензии меняется в зависимости от возрастной подгруппы, и самый высокий уровень отмечен у школьников в возрасте 16 лет – 29,9% с повышенным АД (21,9% выше 95 перцентиля и 8,0% между 90 и 95 перцентилями). Повышенное систолическое артериальное давление (САД) сочеталось с повышенным диастолическим давлением в 47,3% случаев, а также в исследовании имело положительные корреляции с ожирением ($r=0,27$, $p<0,05$) и отрицательные – с физической работоспособностью ($r=-0,21$, $p<0,05$). Пульсовое давление имело значимые корреляции с САД, АД и избыточным весом и может использоваться как дополнительный диагностический показатель АД.

Выводы. Распространённость повышенного АД в нашем исследовании выше, чем в европейских странах, и превышает 20% детского населения. Повышенное давление у наших детей имеет положительные корреляции с ожирением и негативные – с физической трудоспособностью. Уровень пульсового давления имеет значимые корреляции с САД и избыточной массой тела и может быть использован как дополнительный диагностический критерий артериальной гипертензии.

Arterial hypertension (AH) among adults remains a public health problem all over the world [1–3]. The prevalence of hypertension is increasing at an accelerated rate not only in adult but in school-age children too. This has raised great concern about premature development of cardiovascular disease, which has important long-term health and financial implications [4–6]. Blood pressure (BP) screening may be effective in identifying children with hypertension though evidence is limited and false-positive rates are high [7,8].

The BP wave consists of a steady and pulsatile component, mean arterial pressure and pulse arterial pressure (PAP), respectively. Current definitions of AH are primarily based on systolic arterial pressure (SAP) and diastolic blood pressure (DAP) but not on pulse pressure. Widely used mean arterial pressure is the product of cardiac output and peripheral arterial resistance. Pulse pressure – the difference between systolic and diastolic arterial pressure, depends on left ventricular ejection, the elasticity of the central arteries [6,9]. Pulse pressure is an indicator of the stiffness of large arteries, especially of the aorta. More recently, increased attention has been given to PAP as a predictor of cardiovascular risk [4,5,10]. In the Framingham study it was shown that the systolic blood pressure and pulse pressure reflect arterial stiffness, demonstrated that with increasing age, a gradual shift occurs from diastolic to systolic pressure and then to pulse pressure as predictors of coronary heart disease [6]. The diagnostic value of PAP in children has not been studied thoroughly yet.

Unlike in adults, where a single blood pressure cutpoint is utilized for diagnostic of AH, normative BP values in children are age-, sex-, and height- dependent. The detection of children AH is generally based on blood pressure adjusted for height in the relation to national gender and age percentile standard. In addition to use of the correct normative values, repeated measurements of BP are also recommended before making a diagnosis of AH [1,8]. Hypertension is diagnosed in children with readings above the 95th percentile as results of three ambulatory BP measurements in different days. Stage I hypertension was diagnosed if a child's BP is greater than the 95th percentile but less than or equal to the 99th percentile plus 5 mm Hg, stage II – if a child's BP is greater than the 99th percentile plus 5 mm Hg. There was also introduced a new category – prehypertension, which

is diagnosed when a child's average BP is above the 90th percentile but below the 95th. Although such a complex approach is aimed to avoid overdiagnosis of AH in the children, but unfortunately hypertension actually was underdiagnosed, what has been demonstrated in several recent studies [3,6,8]. Early diagnostic and prevention of childhood AH therefore needs high priority and additional investigations.

Objective

The aim of this study was to determine the prevalence of arterial hypertension among school-age children and diagnostic value of pulse pressure.

Materials and methods

In total 848 children in age of 10–17 years (mean age – $13,9 \pm 0,06$ years, 45,4% boys and 54,6% girls) from urban and rural areas of region were examined in schools during screening for elevated BP. The study included assessment of resting anthropometric data, physical activity habits, structure and quality of nutrition, food preferences, family and socioeconomic data etc. Body mass index (BMI) was calculated and Z-index of BMI was estimated according to local anthropometric percentiles standards. School-based ambulatory seated blood pressure was measured by oscillometric automated recording devices. Three sequential measurements were made at least 1 minute apart were obtained and the average of the second and third measurements was recorded. Elevated SAP or DAP was diagnosed in those children with indicators above the 95th percentile, according to the national normative values. In cases of BP elevation the measurements were verified by aneroid device. Statistical analysis was made with the program Statistica (version 5.11, StatSoft Inc.). Data were expressed as mean \pm standard error for quantitative variables and as numbers and percentages for categorical variables. Pearson correlation coefficient was used for studied variables. Statistical analysis was performed using the Student's t-test for numerical variables. All p-values were two-tailed and $p < 0,05$ was considered statistically significant.

Results and discussion

Because BP values in childhood are height-dependent the first step of children physical examination was stature measurements. The anthropometric data obtained during screening were presented for age groups between 10 and 17 years (Table 1). Except the stature measurements and assessments according to local percentiles standard we also analyzed the prevalence of overweight and obesity in children of age groups according to BMI. The prevalence of total overweight in our children was 19.9% including 13.6% of obesity. The highest prevalence of obesity was in age of 12 and 13 years – more than 20%. The decrease in next age period correlated with puberty stage ($r=-0.14$, $p<0.05$) and pubertal stature growth acceleration ($r=-0.21$, $p<0.05$) – the velocity of the stature increment exceeded the rate of increase in the body mass.

For BP measurements we chose cuffs which corresponded to the size of the child's arm and could vary widely. In addition, the child should be calm and rested at least 5 minutes before the BP measurements were taken. From the dataset we excluded those children who were previously treated in pediatric nephrology. The BP components measurements obtained during screening were changed with age and without significant gender difference. The average results of age subgroups are shown lower (Table 2). We identified 150 (17.7%) hypertensive children (blood pressure >95th percentile) and 64 (7.5%) with prehypertension (blood pressure between 90th and 95th percentile). Among the 214 children with elevated BP gender proportion was nearly equal – 50.7% boys and 49.3% girls without noticeable difference by age. The BP measurements in children in the school based screening could be inaccurate therefore it is imperative that the measurements were repeated several times before referral for further evaluation of hypertension.

When compared incidence of AH in age subgroups we found out that the highest level was in age of 16 years – 29.9% with elevated BP (21.9% over 95th percentile and 8.0% between 90th and 95th percentiles) (Fig. 1).

Based on the health questionnaire and anthropometric measurements we tried to identify various causative factors for hypertension. The most common causes in each age group were obesity and low physical activity. The elevated SAP in our children had positive correlations with overweight

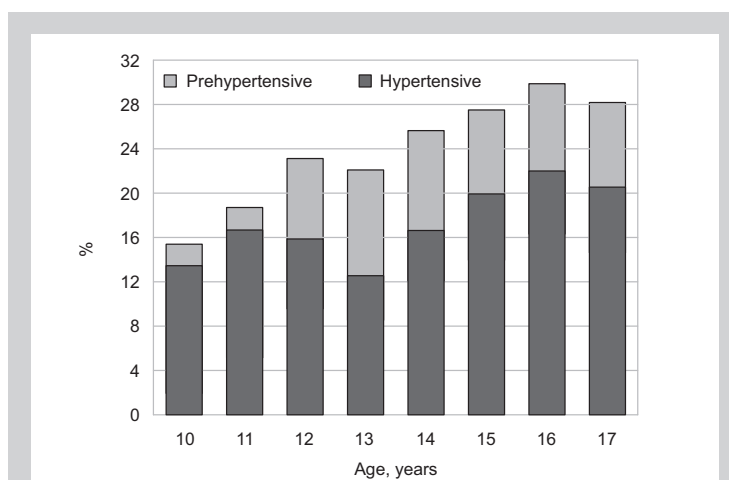


Fig. 1. Incidence of elevated BP in age subgroups.

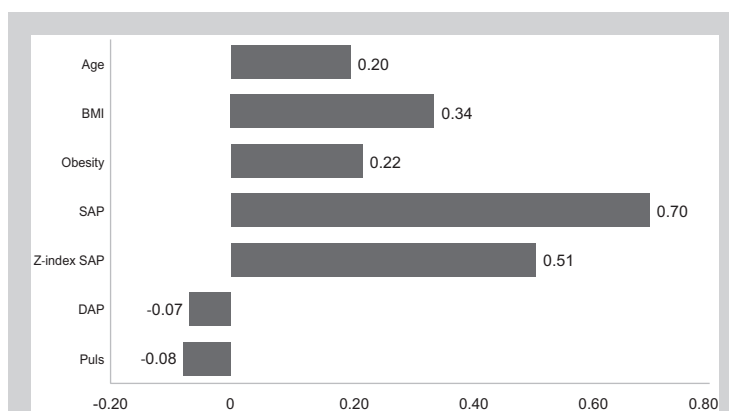


Fig. 2. Correlation of pulse pressure data with other variable.

($r=0.27$, $p<0.05$) and negative with physical performance ($r=-0.21$, $p<0.05$). Separately we analyzed correlation of PAP with different factors (Fig. 2). The most significant correlations of PAP were established with SAP, AH (presented by Z-index of SAP) and overweight (presented by BMI).

The level of DAP was elevated in 47.3% cases of hypertensive students and only in 4.3% of normotensive and

Table 1. Anthropometric data and indexes (means) in different age subgroups

Index	Age of children and measurements							
	10	11	12	13	14	15	16	17
Stature, cm	140.9	147.3	153.4	158.4	166.0	168.4	168.9	169.6
Body mass, kg	34.5	41.0	47.4	50.5	56.9	58.6	59.7	61.9
Chest circumference, cm	67.1	72.8	77.6	79.6	82.6	83.7	85.4	87.9
BMI, kg/m ²	17.3	18.7	19.9	20.0	20.5	20.6	20.7	21.9

Table 2. Blood pressure components and pulse rate in different age subgroups (mean ± standard error)

Variable	Children age, years							
	10	11	12	13	14	15	16	17
SAP, mm Hg	105.7 ± 1.81	108.3 ± 2.07	112.2 ± 1.41	111.0 ± 1.38	118.0 ± 1.11	121.0 ± 0.87	124.4 ± 1.11	124.1 ± 2.15
DAP, mm Hg	65.3 ± 1.38	64.6 ± 1.65	65.2 ± 0.98	64.5 ± 0.84	70.3 ± 0.73	72.1 ± 0.69	74.0 ± 0.81	75.7 ± 1.80
PAP, mm Hg	40.4 ± 1.53	43.6 ± 1.62	46.9 ± 1.18	53.5 ± 1.18	47.7 ± 0.78	48.9 ± 0.81	50.4 ± 0.90	48.4 ± 2.02
Pulse, bpm	88.6 ± 1.62	85.3 ± 1.76	88.9 ± 1.60	88.8 ± 1.14	86.1 ± 1.06	86.8 ± 1.06	85.3 ± 1.16	86.6 ± 2.41

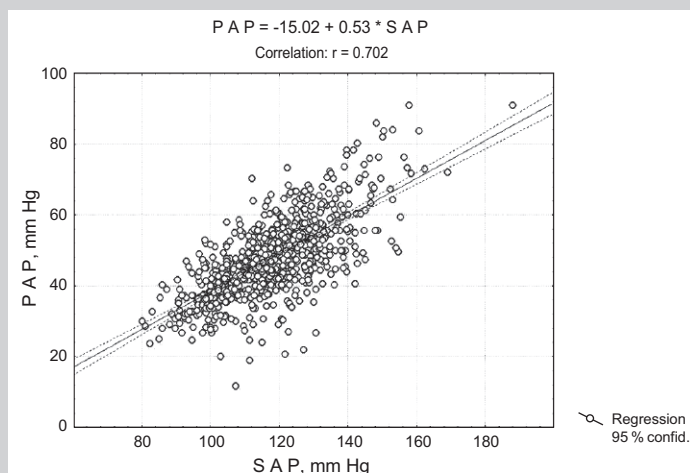


Fig. 3. The linear regression model of PAP correlation with SAP.

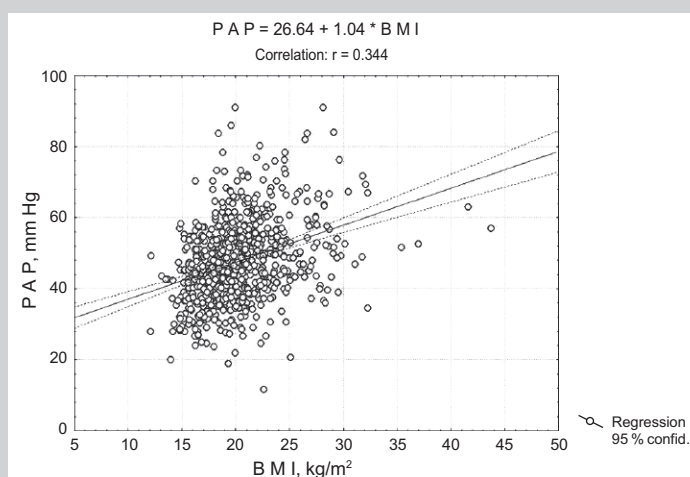


Fig. 4. The linear regression model of PAP correlation with BMI.

did not associate with PAP. It gave us possibility to build up regression model (Fig. 3).

The current understanding of overweight health consequences in children is predominately based on adult studies but increasing evidence suggests that childhood obesity has a number of not only immediate but long-term health programming consequences. Overweight represents a predominance of visceral fat that usually exhibit elevated free fatty acid production, thrombogenic tendency and increasing risk of coronary heart disease [4,8]. In our investigation we have established significant relationship between PAP and overweight expressed by BMI (Fig. 4) and our data closely correlated with results obtained by Polish investigators [8].

In the general pediatric population, the real prevalence of hypertension is still unknown. However, various screening studies primarily in adolescents have identified a prevalence of any hypertension (essential or secondary) between 3.2% and 13.8%. Our data differed from results obtained in other countries but was close to results obtained by other Ukrainian pediatricians [1].

The limitations of our investigation included observational and screening study design which did not exclude “white

coat” hypertension. Certain stratified analyses performed for this study were also limited in power by the small sample size in the stratified groups. Also we were not able to make a detailed analysis of the hypertensive patients and hence did not report their clinical and the comorbid conditions. Although we had screened children in schools but we established only elevated BP stratified by level and it is not representative for real prevalence of AH in general pediatric population without following clinical examination.

In conclusion, arterial hypertension is a serious public threat in many countries worldwide including Ukraine. AH has many health and financial consequences for individuals, their families and society in general and is largely preventable. Therefore, high national priority for health protection should be given to early diagnostic and prevention of childhood AH.

Conclusions

1. The prevalence of elevated BP established by screening in our research is higher than in European countries and exceeds 20% of child population. The elevated BP in our children has positive correlations with overweight and negative with physical performance.

2. The level of pulse pressure has significant correlations with SAP and body overweight and could be used as additional diagnostic index of AH.

Prospects of further research. To establish real prevalence of AH in general pediatric population following clinical examination must be done. The possible diagnostic role of pulse pressure could be also studied.

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Information about authors:

Nechytailo Yu. M., MD, PhD, DSci, Professor,
Head of the Department of Pediatrics, Neonatology and Perinatal
Medicine, Bukovinian State Medical University, Chernivtsi, Ukraine.
Kovtyuk N. I., MD, PhD., Associate Professor,
Department of Pediatrics, Neonatology and Perinatal Medicine,
Bukovinian State Medical University, Chernivtsi, Ukraine.
Nechytailo D. Yu., MD, PhD., Associate Professor,
Department of Pediatrics, Neonatology and Perinatal Medicine,
Bukovinian State Medical University, Chernivtsi, Ukraine.

Відомості про авторів:

Нечитайло Ю. М., д-р мед. наук, професор, зав. каф. педіатрії,
неонатології та перинатальної медицини, ВДНЗ «Буковинський
державний медичний університет», м. Чернівці, Україна.
Ковтюк Н. І., канд. мед. наук, доцент каф. педіатрії, неонатології
та перинатальної медицини, ВДНЗ «Буковинський державний
медичний університет», м. Чернівці, Україна.
Нечитайло Д. Ю., канд. мед. наук, доцент каф. педіатрії,
неонатології та перинатальної медицини, ВДНЗ «Буковинський
державний медичний університет», м. Чернівці, Україна.

Сведения об авторах:

Нечитайло Ю. Н., д-р мед. наук, профессор, зав. каф. педиатрии,
неонатологии и перинатальной медицины, ВГНЗ «Буковинский
государственный медицинский университет», г. Черновцы,
Украина.
Ковтюк Н. И., канд. мед. наук, доцент каф. педиатрии,
неонатологии и перинатальной медицины, ВГНЗ «Буковинский
государственный медицинский университет», г. Черновцы,
Украина.
Нечитайло Д. Ю., канд. мед. наук, доцент каф. педиатрии,
неонатологии и перинатальной медицины, ВГНЗ «Буковинский
государственный медицинский университет», г. Черновцы,
Украина.

Конфлікт інтересів: відсутній.**Conflicts of interest:** authors have no conflict of interest to declare.

Надійшло до редакції / Received: 07.02.2017

Після доопрацювання / Revised: 01.03.2017

Прийнято до друку / Accepted: 17.04.2017