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Revealing burden of elevated blood pressure among Polish adolescent participants in a population-based ADOPOLNOR study: prevalence and potent risk factors

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Abstract: New category for elevated blood pressure introduced and described by JNC-7 for adults and adopted by the 2004 Working Group for children and adolescents stands for a pre-sign to hypertension. The ongoing rise in prevalence of high blood pressure in children and adolescents demands their regular screening. The objective of this study was to determine prevalence of elevated BP in Polish adolescents and explain the role of sex, age and body weight status as potent risk factors for this condition. A population-based cross-sectional survey was carried out on a sample of 4,941 students (2,451 boys and 2,490 girls) aged 10–18, participants in the ADOPOLNOR study. Body height and weight were measured and BMI was calculated. Blood pressure was measured twice on each visit on the right arm using a fully calibrated TECH MED TM-Z mercury gauge sphygmomanometer with sets of exchangeable cuffs and a clinical stethoscope. The blood pressure classification was determined using the surveillance method. The depended outcome variable was the elevated BP compared to normal BP for systolic (SBP), diastolic (DBP) and combined SBP and/or DBP. Explanatory variables included demographic characteristics, sex and age, and weight status. Two-way ANCOVA, Chi-square Pearson correlation, and multivariate logistic regression analysis (MLRA) were performed using the STATISTICA 13.1 data analysis software system; *p*-value <0.05 was considered statistically significant (StatSoft Inc. Tulsa, OK, USA). A clear gender pattern was found in prevalence of elevated BP with girls being more likely than boys to have elevated BP (4.9%, 5.3% and 7.4% for SBP, DBP and combined SBP and/or DBP in girls vs 3.5%, 3.5% and 5.9% in boys). The proportion of both genders with elevated BP gradually increased with age with 4.8% (SBP), 2.8% (DBP) and 5.8% (SBP and/or DBP), and 5.1%, 6.4% and 8.4% in early and late adolescence, respectively. Fifteen percent of

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obese adolescents had elevated SBP, 14.3% elevated DBP and 17.8% had elevated either SBP and/or DBP combined. At multivariate approach, the adjusted odds ratio for predictors of elevated BP revealed sex, age and weight status for SBP and SBP and/or DPB combined. Age and weight status were predictive for elevated DBP. Weight status (BMI) showed the highest predictive potential of elevated BP for both genders. The likelihood of developing elevated BP increased at least twice with each BMI category increase. Thus, overweight and obese adolescents were twice (overweight) and 4 to 5 times (obese) more likely than their normal weight counterparts in developing elevated BP. The study results confirmed predictive potential of sex, age, and weight status in developing elevated BP in adolescents. The highest odds of the weight status indicate that it is the strongest confounder of elevated BP condition.

Key words: adolescents, elevated BP, sex, age, BMI, odds ratio

Introduction

The childhood origin of primary (or essential) hypertension (HTN) has been known since the first report from the National Heart Lung and Blood Institute (NHLBI) on high blood pressure (BP) in children, published in 1977 (NHLBI 1977). Hypothesis of the developmental origin (DOHaD) of HTN in adulthood has been supported by a substantial body of epidemiologic, follow-up and longitudinal data published over subsequent years (Bayrakci et al. 2007; Stein et al. 2010; Edvardsson et al. 2012; vanDijk et al. 2012). Data on BP tracking phenomenon from childhood to adulthood demonstrate that higher BP levels in childhood correlate with higher BP in adulthood and the onset of HTN in young adulthood (Cheng and Wang 2008; Theodore et al. 2015). These data also confirmed that the precursors for cardiovascular disease (CVD) begin in childhood and that the risk for CVD begins at relatively low levels of BP (Falkner 2010; Friedman et al. 2012; Willi et al. 2012). Comorbid conditions of abnormal BP in adolescence include obesity (which is both the cause and the effect of BP conditions, elevated BP and HTN), metabolic syndrome, high blood lipid levels, learning and attention problems (Sun et al. 2007; Adams et al. 2010; Urbina et al. 2011; Skinner et al. 2015).

The worldwide trends in the prevalence of childhood and adolescent HTN in the past decades, though varied due to geographic location, age range and methodology, demonstrate a steady ongoing rise (Danai et al. 2011; Rosner et al. 2013; Kit et al. 2015). In Poland, the prevalence of HTN has doubled over the past decade. The overall prevalence of HTN for systolic and/or diastolic BP combined was ~4% in 2000 and 8.9% in 2010 (Krzyżaniak et al. 2003; Kardas et al. 2005; Ostrowska-Nawarycz and Nawarycz 2007, Kułaga et al. 2009; Kaczmarek et al. 2015).

This alarming rise in primary HTN is accompanied by the presence of hypertensive disease among children and adolescents, with a prevalence ranging from 3–5% now reported in some studies (McNiece et al. 2007; Acosta et al. 2011). This trend is attributed at least in part to environmental and social factors leading to adolescent overweight and obesity (Salvadori et al. 2008). High prevalence of sedentary behaviors, physical inactivity, and unhealthy sleep and dietary habits are among leading contributors to this trend (Fairclough et al. 2009).

Majority of studies on pediatric age groups are focused on HTN whereas the burden of elevated blood pressure (EBP), formerly known as prehypertension (pre-HTN), seems to be left unaddressed. Aiming to fill this gap, the objective of this study was to determine prevalence of elevated BP in Polish adolescents and explain the role of sex, age and body weight status as potent risk factors for this condition.

Materials and methods

Study design and participants

A cross-sectional survey was carried out between February 2009 and September 2010 on a representative, randomly selected sample of adolescents, aged 10–18 years, participants in the ADOPOLNOR study, a transdisciplinary study on adolescent health and the quality of life. The sample consisted of 2,451 male (mean age 14.44±2.58 years) and 2,490 female students (mean age 14.29±2.51 years), the total of 4,941 ethnically homogeneous group of students in grades 5 through 6 of primary school, 1 through 3 of junior secondary and 1 to 2 of senior secondary schools in the Wielkopolska province and its capital, the city of Poznań. A more detailed description of the sampling procedure and the ADOPOLNOR study can be found elsewhere (Kaczmarek 2011; Kaczmarek et al. 2015).

The study design and study protocol were approved by the Bioethics Commission of the Poznań University of Medical Sciences (Resolution no. 311/07) and the Poznań Board of Education (Resolution WAF-405/1/JM/07). The survey was carried out in compliance with principles outlined in the Helsinki Declaration and subsequent amendments (WHO 2001). Almost all parents (97.1%) provided written informed consent for their children to participate in the study. Additionally, 96.7% of young people aged between 16 and 18 gave us their written consent to be participants of the study.

All examinations were performed in school nursery rooms during morning hours.

Chronological age was calculated in decimal values by subtracting the date of examination from the date of birth. The age groups were divided by years, defined in terms of the whole year; e.g. 10 years old group involved subjects between 10.00 and 10.99 years old.

Anthropometric measurements

Body height and weight were measured by well-trained researchers according to standard procedures (Knussman, 1988/1992). The BMI was calculated by taking a subject's weight (kg) and dividing it by his/her height squared (m^2). Following the IOTF recommendation, Cole's cut off values were used to determine the weight status: underweight, normal weight, overweight and obesity (Cole et al. 2000, 2007).

Blood pressure measurements

Blood pressure was measured by school nurses strictly following the guidelines of the Fourth Protocol of the American Working Group of High Blood Pressure in Children and Adolescents (2004). A fully calibrated TECH MED TM-Z mercury gauge sphygmomanometer with sets of exchangeable cuffs and a clinical stethoscope was used for all BP measurements. Systolic and diastolic BP was measured in duplicate on each of the three occasions separated by two day interval. Measurements were taken on the right arm with the subjects sitting for at least 5 minutes rest and the average of the two measurements was the final result for the given day as it was suggested in the Seventh Report for adults (Chobanian et al. 2003). The systolic and diastolic BP measurements corresponded to the reading on the sphygmomanometer at the first and fifth phases of the Korotkow sounds, respectively. The scale on the sphygmomanometer was graduated in 2 millimeter Hg divisions. The readings were made to the nearest millimeter Hg. Calculated intra-observer error (intra-TEM) equalled 1.3 mmHg and inter-observer error (inter-TEM) equalled 2.3 mmHg (Krzyżaniak et al. 2009).

The BP classification was determined using the surveillance method. For each participant, the mean of measurements taken on three occasions was calculated. The values of mean SBP and DBP were adjusted by sex, age and height percentile using current reference data for Polish children and adolescents (Kułaga et al. 2010, 2011). Normal BP was defined as systolic and diastolic BP less than 90th percentile, elevated BP (formerly known as prehypertension) was defined as an average systolic or diastolic BP of greater than or equal to 90th percentile but less than 95th percentile (Flynn et al. 2017). Prevalence of elevated BP was counted separately for SBP and DBP and SBP and/or DBP combined.

Data analysis

Complete data on anthropometry and blood pressure measures across age and sex were collected. The dependent outcome variable was elevated BP level assessed for SBP, DBP, and SBP and/or DBP combined. The potential predictor factors were: sex, age and weight status.

Two-way ANCOVA model was used to determine SBP and DBP differences stratified by predictor variables sex and BMI as the main factors after controlling for age.

Bi-variate associations of elevated BP with all potential covariate variables were evaluated individually using the Chi-square Pearson test.

Multivariate logistic regression analysis (MLRA) was used to assess the association between elevated BP and the variables in question. The odds ratio was used as a measure of association. A final explanatory model with a subset and odds ratios (OR) of factors associated with elevated BP was obtained using a stepwise procedure with backward elimination and rejection criterion of the *p*-value greater than 0.05.

Statistical analyses were performed using the STATISTICA 13.1 data analysis software system (StatSoft Inc. Tulsa, OK, USA). All significance tests comprised two-way determinations. A value of $p<0.05$ was considered statistically significant.

Results

Table 1 presents the mean and corresponding standard deviation values for age, somatic traits (body height and weight, and BMI), SBP and DBP stratified by sex.

It was a cohort study therefore both adolescent males and females were of the same age with respective means 14.4±2.6 and 14.3±2.5 years. Similar proportions of study participants had family history of hypertension (FHH) (20.8% boys vs 21.6% girls) and obesity (FHO) (14.6% boys vs 16% girls). As expected, boys were taller and heavier than girls with 5.3 cm and 5.3 kg statistically significant differences between them ($p<0.001$). Boys' BMI exceeded that of girls with mean values 20.4±3.6 and 19.9±3.4 kg/m^2 ($p<0.001$). Regarding sex differences in BP values, boys

Table 1. Summary characteristics of study participants

Variables	Males n=2451		Females n=2490		*p*-value[b]
	Mean[a]	Range	Mean[a]	Range	
Age (years)	14.4±2.6	10.1–18.98	14.3±2.5	10.2–18.92	0.08
Height (cm)	164±11.5	125.9–192	158.7±9.6	124.5–183.2	<0.001
Weight (kg)	55.8±16.2	22.8–118.6	50.5±12.1	21.8–104.1	<0.001
BMI (kg/m^2)	20.4±3.6	12.3–38.1	19.9±3.4	12.4–35.8	<0.001
SBP (mmHg)	115.1±10.7	76.3–166.6	111.3±9.8	81.7–156.6	<0.001
DBP (mmHg)	68.6±8.1	42.6–97.3	67.0±7.4	43.3–98.3	<0.001
	n (%)[c]		n (%)		
Family history					
Hypertenstion	509 (20.8)		538 (21.6)		0.51
Obesity	358 (14.6)		398 (16.0)		0.19

[a]Normally distributed data are presented as arithmetic mean±SD; [b]The *p*-values were calculated by Student's *t*-test for continuous variables and chi-square Pearson test for categorical variables; [c]Categorical variables are presented as counts and percentages (in parentheses).
BMI – body mass index; SBP – systolic blood pressure; DPB – diastolic blood pressure.

were likely to have higher mean values of SBP and DBP than girls (115.1±10.7 vs 111.3±9.8 mmHg for SBP and 68.6±8.1 vs 67.0±7.4 mmHg for DBP).

The two-way ANCOVA model revealed that sex and weight status (BMI category) were two main effect variables significantly associated with SBP and DBP normal values (Figure 1 and Figure 2). Statistics *F* for the model with SBP as outcome variable and sex and weight status as main effects after controlling for age was $F_{5,4911}=71.1$ ($p<0.0001$). The adjusted $R^2=0.13$. Sex and weight status, two main predictor variables explained 13% of the total SBP variation.

Additionally, there was a statistically significant interaction between weight status and age at $p<0.001$.

For the DBP model $F_{5,4911}=29.2$ ($p<0.0001$) and adjusted $R^2=0.05$. Sex and weight status explained 5% of the

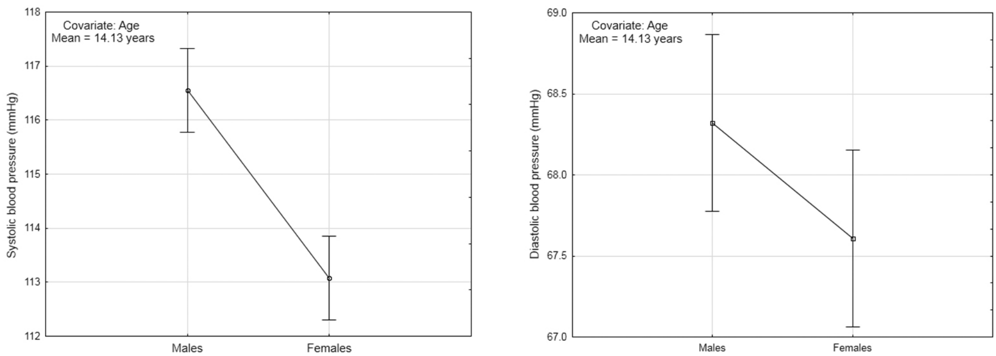

Fig. 1. Results from an analysis of covariance (ANCOVA) demonstrating an effect of sex on systolic and diastolic blood pressure measurements after controlling for age of adolescent study participants (mean differences and 95% confidence intervals)

total DBP variation. It was also interaction effect between weight status and age ($p<0.001$).

Information on the prevalence of elevated BP and its covariate variables: sex, age and weight status, is shown in Table 2. Crude associations between elevated BP status and covariates are expressed in terms of Chi-square test.

The elevated BP, irrespective its type (SBP, DBP and combined SBP and/or DBP), was associated with sex, age and weight status. Girls were more likely than boys to have elevated BP with 4.9%,

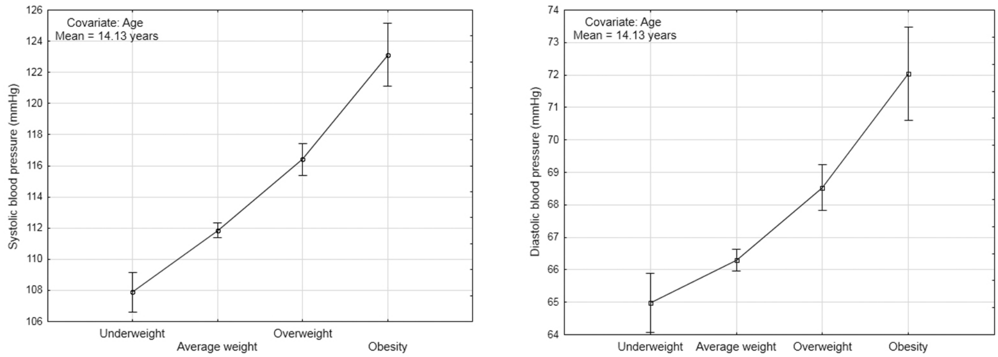

Fig. 2. Results from an analysis of covariance (ANCOVA) demonstrating an effect of weight status on systolic and diastolic blood pressure measurements after controlling for age of adolescent study participants (mean differences and 95% confidence intervals)

Table 2. Prevalence of the elevated BP status stratified by sex, age and weight status in adolescent study participants

Variable	Blood pressure type and level[a]								
	SBP+DBP (mmHg)			SBP (mmHg)			DBP (mmHg)		
	Norm BP	Elev BP	*p*-value[b]	Norm BP	Elev BP	*p*-value	Norm BP	Elev BP	*p*-value
Sex			0.012			0.009			0.047
Male (n=2451)	84.8	5.9		89.9	3.5		91.3	3.5	
Female (n=2490)	83.7	7.4		90.8	4.9		90.7	5.3	
Age group (years)			0.005			0.047			<0.001
Early adolescence 10–12.99 (n=1675)	85.7	5.8		89.6	3.8		92.6	2.8	
Middle adolescence 13–15.99 (n=1641)	85.5	5.7		88.8	4.3		92.3	4.1	
Late adolescence 16–18 (n=1625)	81.4	8.4		89.2	5.1		87.7	6.5	
Weight status – BMI (kg/m^2)			<0.001			<0.001			<0.001
Underweight (n=532)	93.1	3.2		97.2	2.4		96.0	2.8	
Normal weight (n=3548)	86.9	5.9		92.3	4.4		92.9	3.8	
Overweight (n=698)	72.6	10.7		83.0	9.1		82.9	7.7	
Obesity (n=163)	45.4	17.8		58.2	15.1		72.1	14.3	

[a]Blood pressure criteria assessed for SBD, DBP separately and SBP and/or DBP combined: normal BP, <90 percentile; elevated BP, ≥90 percentile and <95 percentile; [b]The *p*-values were calculated by chi-square Pearson test. SBP – systolic blood pressure; DBP – diastolic blood pressure; NormBP – normal blood pressure; ElevBP – elevated blood pressure (former high normal or prehypertension).

5.3% and 7.4% for SBP, DBP and combined SBP and/or DBP as compared to 3.5%, 3.5%, and 5.9% in boys. The proportion of boys and girls with elevated BP gradually increased with age. In early adolescence (10–12.99 years) the elevated BP accounted for 4.8% (SBP), 2.8% (DBP) and 5.8% (combined SBP and/or DBP). In late adolescence (16–18 years) the respective proportions increased to 5.1%, 6.4% and 8.4%. The largest proportion of elevated BP was associated with obesity. Fifteen percent of obese adolescents had elevated SBP, 14.3% elevated DBP and 17.8% had elevated either SBP and/or DBP combined.

At multivariate level, the adjusted odds ratio for predictor variables of elevated BP were sex, age and weight status for SBP and combined SBP and or/DBP and age and weight status for DBP.

sare presented in Table 3.

The MLR models revealed that most parsimonious set of factors affecting the likelihood of developing elevated BP in adolescent study participants included three predictors: sex, age and weight status for SBP and combined SBP and/or DBP and two predictors, age and weight status for DBP.

The likelihood of developing elevated SBP was almost twofold higher in girls than boys (OR=2.1, 95% CI:1.52;2.9, p_{trend}<0.0001). Girls were also 1.58 times more likely than boys to develop elevated combined SBP and/or DBP (OR=1.58, 95% CI:1.26;1.99, p_{trend}<0.0001).

The risk of developing elevated BP increased with age revealing that those in late adolescence as compared to their youngest counterparts were at higher risk: almost 3 times for SBP (OR=2.68, 95%CI:1.82;3.95, p_{trend}<0.0001), and 1.5 for both DBP and combined SBP and/or DBP (OR=1.52, 95%CI:1.33;2.06, p_{trend}<0.0001 and OR=1.56, 95%CI:1.18; 2.07, p_{trend}<0.0001).

Table 3. Multivariate logistic regression analysis of most parsimonious set of factors affecting the likelihood of developing elevated BP in adolescent study participants

Variable	Elevated BP (mmHg)		
	SBP+DBP[a] OR (95%CI)	SBP[b] OR (95%CI)	DBP[c] OR (95%CI)
Sex: Male (reference)	1	1	
Female	1.58 (1.26;1.99)	2.10 (1.52;2.90)	
p-value for trend	<0.0001	<0.0001	
Age group (years)			
EA 10–12.99 (refrerence)	1	1	1
MA 13–15.99	1.25 (1.08;1.44)	1.64 (1.35;1.99)	1.49 (1.22;1.81)
LA 16–18	1.56 (1.18;2.07)	2.68 (1.82;3.95)	1.52 (1.33;2.06)
p-value for trend	0.0016	<0.0001	0.0027
Weight status (BMI kg/m^2)			
Normal weight	1	1	1
Overweight	2.06 (1.56;2.74)	2.29 (1.65;3.18)	2.11 (1.68;2.66)
Obesity	4.27 (2.43;7.49)	5.26 (2.73;10.13)	4.47 (2.81;7.08)
p-value for trend	<0.00001	<0.00001	<0.00001

[a]Chi-square = 81.4; df=3; p<0.0001; [b]Chi-square = 50.9; df=1; p<0.0001; [c]Chi-square = 35.9; df=3; p<0.0001. SBP, systolic blood pressure; DBP, diastolic blood pressure; EA, early adolescence; MA, middle adolescence; LA, late adolescence.

Of all predictor variables involved to analysis, weight status (BMI) showed the highest predictive potential of elevated BP for both genders. The likelihood of developing elevated BP increased at least twice with each BMI category increase. Thus, overweight and obese adolescents were twice (overweight) and 4 to 5 times (obese) more likely than their normal weight counterparts in developing elevated BP (in overweight adolescents of both genders OR=2.29, 95%CI:1.65;3.18, OR=2.11, 95%CI:1.68;2.66, and OR=2.06, (95%CI: 1.56;2.74 with p_{trend}<0.0001 for elevated SBP, DBP, SBP and/or DBP combined; and in obese adolescents of both genders OR=5.26, 95%CI:2.73;10.14, OR=4.47, 95%CI:2.81;7.08, and OR=4.27, (95%CI: 2.43;7.49 with p_{trend}<0.0001 for elevated SBP, DBP and SBP and/or DBP combined).

Discussion

The present study provides for the first time to our knowledge data on the prevalence of different types elevated BP in Polish adolescents. The findings revealed that proportion of adolescents with elevated BP varied from 4.4% when counted on SBP, 3.9% on DBP and 7.8% when counted on combined SBP and/or DBP. Prevalence of elevated BP in Polish adolescents, though slightly higher, is comparable to respective values in adolescents from other countries (Din-Dzietham et al. 2006; Chiolero et al. 2007; Salvadori et al. 2008; May et al. 2012; de Moraes et al. 2014). Hansen and colleagues (2007) attributed between-population differences to methodological issues i.e. various measurement techniques, epidemiological vs ambulatory monitoring of BP, ethnically heterogeneous groups and others.

Girls were more likely than boys in developing elevated BP (4.9%, 5.3% and 7.4% vs 3.5% and 5.9% for three types of elevated BP in girls and boys, respectively).

Among adolescents aged over 16 (late adolescence group) prevalence of elevated BP was 5.1%, 6.5% and 8.4% for three types of elevated BP. Age-related growing proportion of adolescents with elevated BP presents evidence that problem with abnormal BP begins prior to adulthood.

The greatest proportion of elevated BP was found among obese adolescents with 15.1%, 14.3% and 17.8% for SBP, DBP and SBP and/or DBP combined.

Our study presents evidence that the adjusted likelihood of developing elevated BP indicated female sex (with the exception for DBP), late adolescence (age over 16 years) and overweight/obese weight status as most powerful predictive factors of elevated BP condition.

The direct association of female sex with elevated SBP or either types of BP combined that was found in our study is consistent with results from some other studies (Dasgupta et al. 2006; Wang et al. 2006). There is however inconsistency as to this finding. Several studies indicate that male sex adolescents are at higher risk of both elevated BP and HTN conditions than their female peers (Shi et al. 2012; Silva et al. 2013).

Interestingly, our previous study showed an inverse association of female sex with HTN (Kaczmarek et al. 2015). It means that female sex is more likely than male to be associated with elevated BP but not HTN. The evidence for gender inequality in BP conditions is well known phenomenon in adults. Our findings show that the onset of gender inequality in BP conditions is anchored in adolescence. This finding is in line with the adolescent-emergent model (AEM), which states that the relationship between environmental exposures and health outcomes, including elevated BP condition, typically strengthen during adolescence (Chen et al. 2002). Indeed, the adolescent stage of life is the most critical for current and future (adult) health status. Additionally, apart from somatic, sexual, physiological and endocrine changes during puberty, young people, and especially boys, undertake risky for health behaviors i.e. uncontrolled substance abuse, avoiding any kind of physical activity, chronic deficit in sleep duration, unsafe sex and many others (Au et al. 2014). These behaviors may substantially increase risk of elevated BP. Risky-for-health behaviors undertaken in adolescence can explain at least in part gender BP inequalities in adulthood.

As expected, elevated BP was independently directly associated with age. The likelihood of developing elevated SBP increased almost three times for adolescents of both gender in late adolescence as compared to their younger counterparts (early adolescence aged between 10 and 12.99 years). Slightly weaker though significant association was observed between proportion of elevated SBP and age (p=0.047). Age-related changes in BP conditions seem to follow general pattern of developmental trajectories during puberty and adolescence (Cameron and Bogin 2012). Chronological age stands for a proxy of developmental trajectories. Its contribution varies in importance during each period prior to adulthood, so it does for BP condition during adolescence (age and BP).

Our findings show that weight status (BMI) is the most informative predictor of elevated BP for both genders. BMI seems to perform better in virtually all age groups than age itself not only in adults but also in adolescents. This finding is consistent with our previous study (Kaczmarek et al. 2015) and corroborates well with those of other authors (Chiolero et al. 2007; Salvadori et al. 2008; Shi et al. 2012; Rosner et al. 2013; Silva et al. 2013; Skinner et al. 2013). Elevated weight status, overweight and obesity, places a growing number of children at risk for the early development of abnormal BP sequelae including myocardial infarction, stroke, and renal failure.

The new category for elevated BP condition, known as high normal BP or prehypertensive was introduced and described by JNC-7 for adults (Chobanian 2003). The 2004 National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents, known as Fourth Report created new criteria for classification of BP in children (Working Group 2004). In accordance with the recommendations of the Task Force, casual values of BP in children have to be adjusted for the child's sex, age and height. BP is considered normal when the systolic and/or diastolic values are less than 90th percentile; high when SBP and/or DBP values are > 95th percentile; elevated when SBP and/or DBP values are between 90th and 95th percentile or if BP is ≥120/80 mmHg. An update to the 2004 Fourth Report replaced the term prehypertension with the term elevated blood pressure, the one addressed in this paper. The elevated BP condition is most often without symptoms but as it has been established, presents a high risk for the development of clinical hypertension and cardiovascular and coronary heart disease. Early diagnosis of this condition and early intervention may help prevent the development of essential hypertension later in life. An initial attempt should be made to lower

BP by lifestyle modification such as aerobic physical exercise, weight reduction, and lowered sodium intake.

This study has some limitations that have introduced some bias into the study results. A cross-sectional design makes it difficult to assess the direction and causality of potential predictor factors. This design, however, was methodologically appropriate for solving the research question, i.e. evaluating the association between BP levels (outcome variable) and predictors, sex, age and weight status (Mann 2003). It would have been useful to have longitudinal, prospective data. However, the longitudinal design and attrition of study participants do not meet requirements of epidemiologic/population purposes.

The strengths of this study include a population-based cohort study of healthy adolescents, a multivariate approach and integration of demographic (sex, age) and anthropometric (BMI weight status) factors hypothesized as to be associated with the outcome variable – adolescent elevated BP condition.

Conclusion

The study results provide evidence for the DOHaD hypothesis applicable to BP conditions. They confirm predictive potential of demographic, sex and age and anthropometric, weight status variables in developing elevated BP in adolescents. The highest odds of the weight status indicate that it is the strongest confounder of BP conditions.

Adequate interventional attention by promoting lifestyle modification in young ages to prevent progression to blood pressure or other related chronic diseases should be given in both family and school settings.

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Authors' contributions

AK coordinated medical research, conceived the paper, and designed the manuscript; MK was the ADPOLNOR project manager, conceived study design, coordinated the research and drafted the manuscript; BS-W, MK-W and AS made contributions to the design of medical research, analysed and interpreted medical data. All authors critically read and approved the final manuscript.

Conflict of interest

The authors declare that they have no financial relationship with the organization that sponsored the research.

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