Different diagnostic criteria significantly affect the rates of hypertension in 18-year-old high school students

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Abstract

Introduction: Childhood hypertension is defined based on the normative distribution of blood pressure (BP), but from the age of 18 years high BP is diagnosed using adult criteria. We compared the rates of diagnosis of hypertension in a group of 18-year-old subjects using BP percentiles and the adult criteria.
Material and methods: Blood pressure was measured by registered nurses in 1472 18-year-old high-school students (780 men and 692 women). Also weight, height and waist circumference were recorded.
Results: The prevalence of hypertension was 9% (16.2% in men and 0.9% in women, $p < 0.001$) using adult cut-off values and 14.7% (21.9% in men and 6.6% in women, $p < 0.001$) using percentile charts. Obesity was diagnosed in 2.4% and overweight in 13% of subjects, respectively. The relative risk ratio of diagnosing hypertension according to the adult criteria in overweight or obese subjects was 2.94 (95% CI 2.25-3.86) in men and 6.44 (95% CI 3.51-11.82) in women.
Conclusions: Our study indicates high prevalence of hypertension in 18-year-old students – especially in men – and the importance of obesity as a risk factor of hypertension. The use of percentile charts instead of adult cut-off values increases the prevalence of hypertension in men by 35% from 16.2% to 21.9% and in women more than 7 times, i.e. from 0.9% to 6.6%. It seems reasonable to use higher (i.e. 98th) percentile values for definition of high blood pressure.

Key words: blood pressure, obesity, adolescents.

Introduction

Essential hypertension in young subjects is frequently associated with subclinical target organ damage such as left ventricle hypertrophy [1] or increased intima-media thickness [2], as well as early atherosclerotic lesions [3].

Lack of diagnosis of blood pressure in adolescents halts the administration of efficient antihypertensive therapy and allows for the development of target organ damage. On the other hand, overdiagnosis of hypertension may have specific socioeconomic implications (e.g. job selection), and may lead to unnecessary procedures and treatment.

Eighteen-year-old people who emerge from paediatric supervision represent a special group. The prevalence of hypertension in adolescents assessed recently in the US reaches 4.5% [4], yet it is frequently undetected [5]. Numerous studies point to the continuous increase of mean blood pressure values, which can be attributed to rising prevalence of overweight and obesity [6-8].

Our study was undertaken to obtain current data on the prevalence of high blood pressure and increased body mass in a population of 18-year-olds and estimate the effect of different criteria on the diagnosis of hypertension.

Material and methods

The study was performed among 18-year-old students in 8 randomly selected Warsaw high schools. The analysed group included 1472 students, 780 men and 692 women (Table I), who had blood pressure, weight, height and waist circumference measured by registered nurses in the school offices. The blood pressure measurements were performed 4 times: twice on two visits 4 weeks apart according to the current ESC/ESH Guidelines using a standard mercury (2588 measurements) or validated automatic oscillometric sphygmomanometer (Visomat Comfort 20/40, HEM or Omron M3) (3300 measurements).

Measurements of body weight and height were performed on the first visit using the medical scale. Waist circumference was measured with non-elastic tape. All participants and their parents provided written consent for participation in the study. Measurements obtained with aneroid manometers, incomplete and performed in treated hypertensive subjects were excluded from further analysis. The study was conducted as part of a mandatory health survey funded by the City Department of Health.

The mean values from all 4 measurements were analysed. The prevalence of hypertension was estimated based on adult criteria (mean systolic blood pressure (SBP) ≥ 140 mmHg and/or diastolic (DBP) ≥ 90 mmHg according to ESC/ESH) and was compared with the prevalence assessed using percentile charts for the Polish population [9]. Due to the lack of values for the age of 18 at the time we carried out our analysis, corresponding values for the age of 17 were used. Underweight, normal weight, overweight and obesity were defined according to the WHO criteria based on BMI values. Abdominal obesity was assessed according to International Diabetes Federation (IDF) criteria and waist circumference (WC) with cut-off values of > 80 cm for women and > 94 cm for men.

Mean values of the analysed parameters in the subgroups according to gender, BMI and abdominal obesity were compared with Student's *t* test and ANOVA. Frequency was tested with χ^2. Linear correlations were assessed with Pearson's test. Confidence intervals were calculated using the normal approximation method. All calculations were performed using R-project software [10]

Results are presented as means, standard deviations, number of cases and percentages. The significance level was set at $p < 0.05$.

Table I. Mean values of blood pressure, height, weight, BMI and waist circumference in all participants and in both genders

	All	Men	Women	*p*
N	1472	780	692	Males vs. females
SBP [mmHg]	120.1 ±13.1	125.6 ±1.4	113.7 ±9.3	< 0.001
DBP [mmHg]	71.2 ±7.3	73.2 ±7.3	69.0 ±6.7	< 0.001
BMI [kg/m^2]	22.1 ±3.3	22.8 ±3.5	21.3 ±2.9	< 0.001
WC [cm]	79.3 ±10.4	82.0 ±10.1	76.3 ±9.9	< 0.001
Weight [kg]	67.2 ±13.3	74.1 ±12.6	59.4 ±9.1	< 0.001
Height [cm]	174.0 ±9.4	180.4 ±6.8	166.9 ±6.2	< 0.001

SBP – systolic blood pressure, DBP – diastolic blood pressure, BMI – body mass index, WC – waist circumference, data presented as mean ± SD

Results

The prevalence of hypertension in 18-year-old students was 9% (16.2% in men and 0.9% in women, $p < 0.001$) using adult cut-off values and 14.7% (21.9% in men and 6.6% in women, $p < 0.001$) using percentile charts. Mean SBP and DBP were significantly higher in men than in women by 12 mmHg and 4 mmHg, respectively (Table I, Figure 1). Both SBP and DBP were significantly higher in hypertensive patients than in normotensive subjects (147.8 ±8.6 mmHg *vs*. 117.3 ±9.8 mmHg, $p < 0.001$ and 78.8 ±8.6 mmHg *vs*. 70.5 ±6.7 mmHg, $p < 0.001$). No significant differences of mean SBP and DBP were observed between various methods of measurements (mercury or oscillatory sphygmomanometer) or between mean measurements taken on separate visits (data not presented).

Overweight was diagnosed in 13% of subjects, and obesity in 2.4% of subjects. Overweight was significantly more prevalent in men than in women, 15.6% *vs*. 10% ($p < 0.01$), similarly to obesity, 3.8% *vs*. 0.9%, respectively ($p < 0.001$). In contrast, underweight was twice as prevalent in women as in men (7.8% *vs*. 3.1%, $p < 0.001$). Mean BMI was slightly, but still significantly, higher in men than in women (Table I). Abdominal obesity diagnosed according to IDF criteria was present in 21.4% of subjects, and was three times more frequent in women than in men (32.8% *vs*. 11.3%, $p < 0.001$). Table II presents percentiles of blood pressure, BMI, weight, height and WC in both sexes.

The higher the BMI category, the higher was the blood pressure observed in both genders (Figure 2) and the presence of hypertension disregarding the criteria used (Figure 3). Hypertensive patients had a higher BMI than normotensive subjects (25.3 ±4.4 kg/m^2 *vs*. 21.8 ±3.0 kg/m^2, $p < 0.001$).

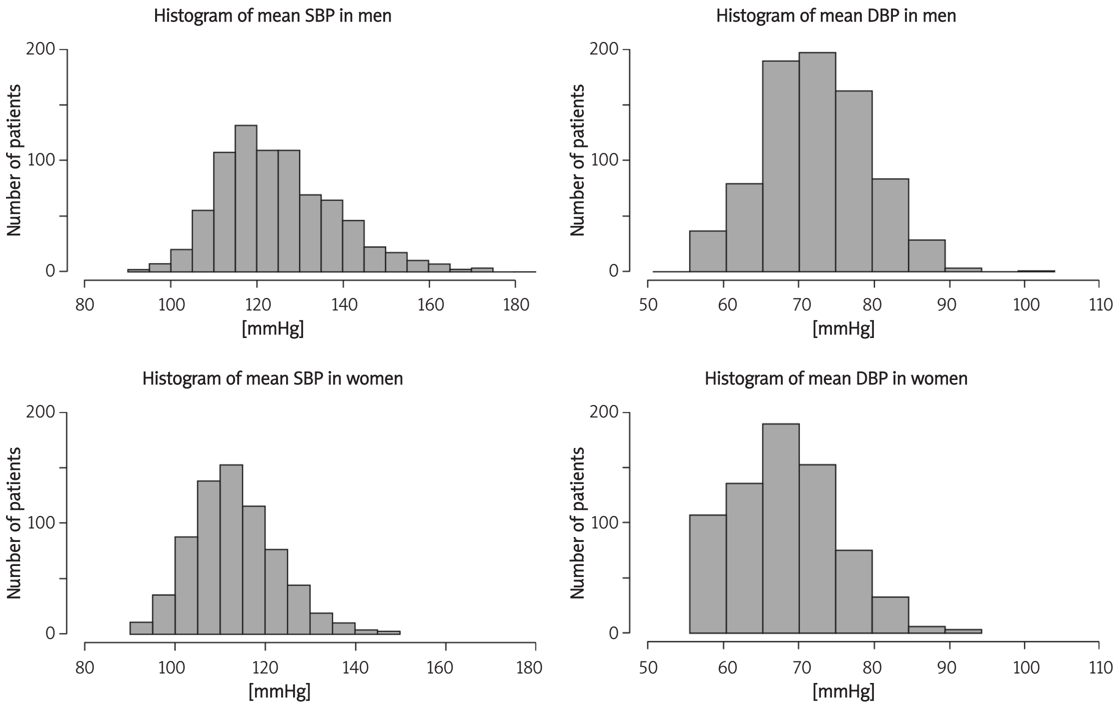

Figure 1. Distributions of SBP and DBP in both genders. Data presented as number of subjects

Table II. Percentiles of analysed parameters

Parameter	50%	75%	85%	87%	90%	93%	95%	97%
SBP M [mmHg]	124	133	140	141	144	147	150	153
SBP F [mmHg]	113	120	124	124	126	128	130	134
DBP M [mmHg]	72	78	80	81	82	84	85	88
DBP F [mmHg]	68	74	76	77	78	80	81	83
BMI M [kg/m^2]	22.2	24.4	25.8	26.3	27.1	28.2	29.3	30.9
BMI F [kg/m^2]	20.8	22.9	24.2	24.5	25.2	26.1	26.6	28.1
WC M [cm]	80	88	92	94	95	98	100	103
WC F [cm]	75	84	87	88	90	92	94	96
Height M [cm]	180	185	187	188	189	190	192	193
Height F [cm]	167	171	173	174	175	176	177	179
Weight M [kg]	72.0	80.0	85.2	87.0	89.8	93.8	97.3	101.6
Weight F [kg]	58.0	64.0	69.0	70.0	71.9	73.6	76.0	79.0

M – males, F – females, SBP – systolic blood pressure, DBP – diastolic blood pressure, BMI – body mass index, WC – waist circumference

The relative risk ratio of diagnosing hypertension according to the adult criteria in overweight or obese subjects was 2.94 (95% CI 2.25-3.86) in men and 6.44 (95% CI 3.51-11.82) in women. Analogous values for percentile criteria were 2.96 (95% CI 2.26-3.88) in men and 4.43 (95% CI 2.86-6.87) in women.

The relative risk ratio of diagnosing hypertension according to the adult criteria in abdominal obesity was 3.43 (95% CI 2.34-5.02) in men and 2.05 (95% CI 1.15-3.65) in women. Analogous values for percentile criteria were 3.56 (95% CI 2.43-5.22) in men and 1.9 (95% CI 1.45-2.48) in women.

Positive correlations between BMI and SBP were observed in men (r = 0.39) and women (r = 0.35), as well as for BMI and DBP (r = 0.20 and r = 0.23, respectively). Positive correlations between waist circumference and SBP were observed in men (r = 0.33) and women (r = 0.31), as well as for waist circumference and DBP (r = 0.20 and r = 0.23, respectively). The significance level for all the listed correlations was $p < 0.05$.

Discussion

Our study demonstrates that during transition from adolescence to adulthood prevalence of high

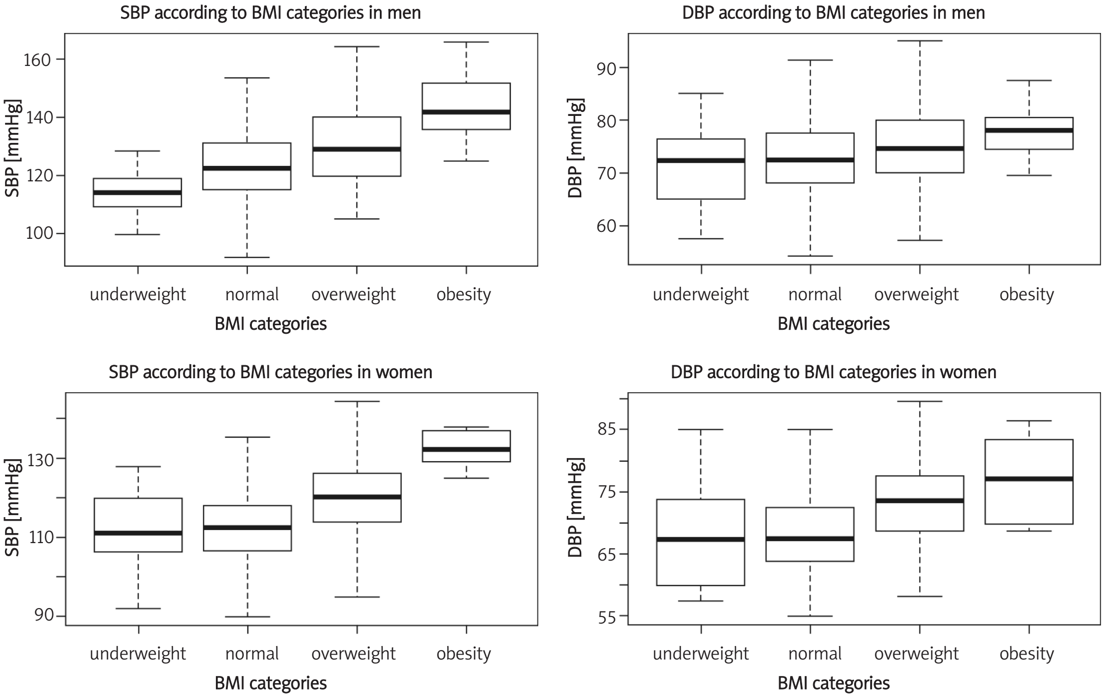

Figure 2. Mean SBP and DBP in BMI categories in both genders. Data presented as means, interquartile range and SD
p for trends for SBP and DBP in women and SBP in men < 0.001; for DBP in men p < 0.01

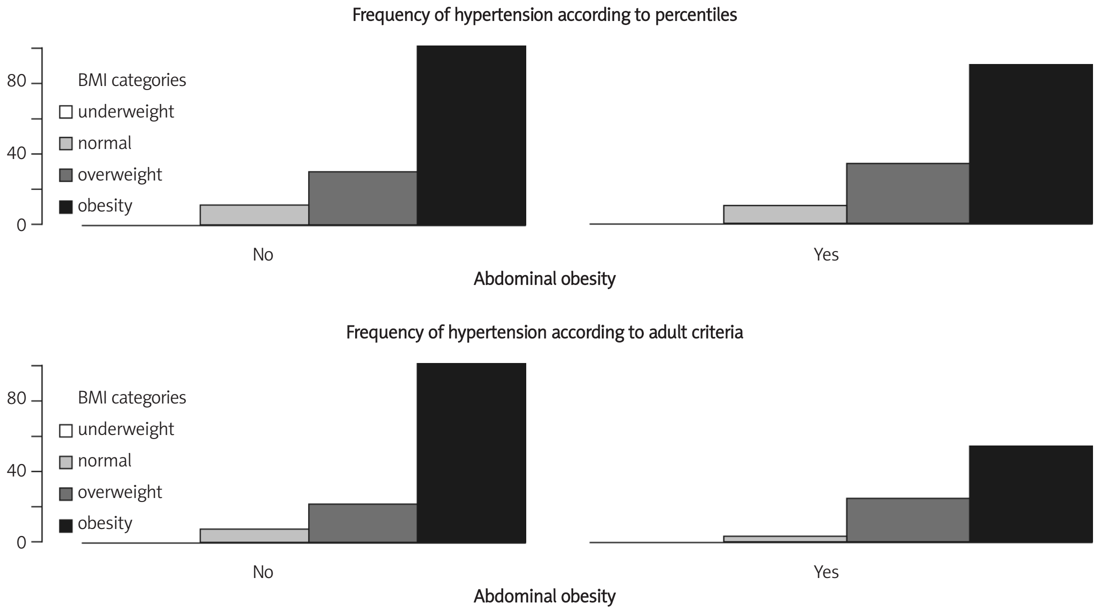

Figure 3. Prevalence of hypertension (adult criteria and percentile criteria) in BMI and abdominal obesity categories. Data presented as percentages

blood pressure changes due to different diagnostic criteria. The use of percentile charts instead of adult cut-off values increases the prevalence of hypertension in men by 35%, from 16.2% to 21.9%, and in women more than 7 times, from 0.9% to 6.6%. In our group of 18-year-old males abnormal values represented the 85th centile, but in females they corresponded to the 97th centile and stayed within the normal range, similar to the findings of Antal *et al.* [11].

The imperfectness of the percentile method of diagnosing hypertension in adolescents and young adults is reflected by different proposed percentile cut-off values (95th [12, 13] or 98th [14]), and different cut-off age for using percentile methods (15 years [11], 17 years [12, 13] or 24 years [14]). Numerous authors point to the difference between the cut-off values of hypertension calculated on the basis of percentile charts for various populations, which even reach 8-12 mmHg for the 95th percentile

[9, 14, 15]. The differences may result also from different numbers of subjects evaluated and methodology of blood pressure measurements. The incidence of hypertension in an epidemiological study of adolescents differing by 5% also clearly indicates imperfectness of percentile charts or different methodology of blood pressure.

It is worth mentioning that a similar, relatively high incidence of hypertension in adolescents, especially males (6.8-23%, compared to 1.5-6% in females), was reported by authors from other European countries [11, 14, 16] and former Polish studies [17, 18], although the last two presented some methodological drawbacks.

Higher incidence of hypertension in men in our study was primarily driven by the 12.7 mmHg difference of SBP values between genders, which is in accordance with data from other studies [11, 16, 19].

Mean SBP and DBP in our population were similar to those reported in the above-mentioned studies [11, 16]. However, recently published results of BP measurements that included a smaller group of 18-year-old Polish adolescents revealed similar BP values for girls, but lower in boys, presumably due to height differences [20].

Our study has shown that 19.4% of men and 10.9% of women aged 18 have increased BMI according to the WHO classification (overweight or obesity), while abdominal obesity according to the current IDF criteria was present in 11.3% of men and in 32.8% of women.

In the European population aged 15-24 years the incidence of increased BMI ranges from 1% to 11% [21] and 15% in the American population between 6 and 19 years of age [22]. The prevalence of obesity in children and adolescents in the US doubled between the 1960s and the 1990s [23]. The observed correlation of BMI with SBP and DBP has been reported by other authors [7, 24]. In our study elevated BMI increased the risk of hypertension three times in men and four to six times in women depending on the criteria of hypertension, and these findings are in accordance with data from other countries and earlier Polish studies [25]. There is general agreement that elevated body mass is responsible for the increased incidence of hypertension currently observed [8] and its higher prevalence in young men [14].

One limitation of our study is that we included a relatively homogeneous population of students from senior high school. However, the major goal of our investigation was to compare the effect of paediatric and adult criteria on the rate of diagnosis of hypertension in this population, which is on the borderline between childhood and adulthood, as well as different diagnostic criteria.

Also, our subjects completed only two, instead of three visits, as suggested by the American guidelines, and two methods of blood pressure measurement were used – the mercury sphygmomanometer and the oscillometric device. However, we did not observe any differences in blood pressure values between the consecutive visits or different methods of measurements. Therefore, it is highly unlikely that a third visit would significantly decrease the frequency of hypertension. Even if we were to assume that a single blood pressure measurement may double the incidence of hypertension when compared to the results of three measurements (according to an observation derived from the results of studies performed in younger groups of children), still the frequency of blood pressure in men would be high. The striking similarities of the mean values of blood pressure and the frequency of diagnosed hypertension to the data presented in recent large epidemiological studies performed independently in several European countries indicate that our results reflect the actual data [11, 14, 16]. Although some authors have suggested the inaccuracy of oscillometric techniques, still this method was successfully used in preparation of the newest percentile charts in the UK [14]. The use of a validated oscillometric device may minimize observer bias and digit preferences [26].

The results of our study support other evidence on rising prevalence of hypertension in young adults, especially males, and underscore the importance of obesity as a major risk factor. A substantial reduction in the rate of positive diagnosis when adult criteria are applied might reduce the alertness of patients and physicians. On the other hand, there is no evidence that specific treatment in this age group reduces cardiovascular risk and overdiagnosis may result in unnecessary pharmacotherapy. Therefore, it seems reasonable to use higher (i.e. 98^{th}) percentile values for definition of high blood pressure.

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