

High-Normal Arterial Blood Pressure in Children With Excess Body Weight

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Abstract

Background: Childhood overweight and obesity are common causes of metabolic disorders that persist until adulthood.

Objectives: The purpose of this study was to determine the prevalence of high-normal arterial blood pressure (ABP) in children with excess body weight.

Material and Methods: A total of 1,093 schoolchildren aged 10 - 12 years (51% girls and 49% boys) participated in the study. The children's weight, height, body fat percentage (BFP), waist and hip circumference, and ABP were measured. The waist-to-height ratio (WHtR) and body mass index (BMI) were calculated and compared to the normative reference values accepted by the International obesity task force (IOTF).

Results: Excess weight was identified in 20% of the participants, and obesity in 5%. A total of 35.5% of overweight children had above-normal ABP, which implied hypertension. In obese children, that proportion equaled 59.3%. BFP was 6.5% greater in children with hypertension than in those with normal BP. The children with hypertension also had a 7.6-cm larger waist circumference, a 7.6-cm larger hip circumference, and a greater WHtR (by 0.04).

Conclusions: Excess body weight was identified in 25% of children aged 10-12 years, significantly increasing their risk of developing hypertension.

Keywords: Arterial Blood Pressure, Overweight, Obesity, School Age

1. Background

The academic literature contains increasing numbers of reports on the global obesity epidemic. Poland has joined the group of countries in which the growing issue of childhood obesity requires immediate action. Throughout the world, more than 22 million children under 5 years of age are overweight, and approximately 10% of those aged 5 - 17 years are either overweight or obese (1). In 2012, the problem of excess body weight affected over 30% of children and adolescents in the United States (2). In the European Union, overweight and obesity are recognized in 25% of children. In Poland in 2009, excess body weight was identified in 16.4% of children and adolescents aged 6 - 19 years (3).

Nutritional and metabolic disorders in children and adolescents mainly result from improper lifestyle (due to the preferred passive forms of relaxation) and poor eating habits (4, 5). Excess body weight is regarded as a factor in the development of metabolic disorders, such as cardiovascular disease, arterial hypertension, disturbed lipid and carbohydrate metabolism (including type 2 diabetes), and, most of all, a greater risk of obesity and obesity-related

health problems in adulthood (6, 7). The joint prevalence of lipid/carbohydrate metabolism disorders and hypertension resulting from obesity and insulin resistance (IR) is known as metabolic syndrome, and was first described by Reaven in 1988 (8).

At least one element of metabolic syndrome is found in two thirds of overweight or obese adolescents, and the complete syndrome can be recognized in almost a third (9). It should be emphasized that 80% of children with metabolic syndrome are overweight (10). In children, as in adults, there is a strong link between obesity and hypertension. In 1995, Chen et al. presented study findings confirming that childhood obesity affects systolic arterial blood pressure (11).

Both the prevention and the early recognition and treatment of metabolic syndrome are important due to the direct connection between metabolic syndrome and a distinctly increased risk of cardiovascular disease.

2. Objectives

The purpose of this study was to determine the prevalence of high-normal arterial blood pressure (ABP) in chil-

dren with excess body weight.

3. Materials and Methods

3.1. Study Design and Participants

The survey was conducted from September to December 2014 in Tarnow (Malopolska Region, Poland). Primary schools were randomly selected, and a total of 1,093 schoolchildren aged 10-12 years, including 556 girls (51.0%) and 537 boys (49.0%), participated in the study. The mean age of the participants was 11.04 ± 0.83 years for girls and 11.01 ± 0.81 years for boys. The precise numbers of participants in the various age groups are presented in Table 1. The participants took part in the project after written informed consent was obtained from their parents/legal guardians. Those with certified disabilities or who were being treated for chronic diseases were excluded from the study. The consent of the local bioethics committee was obtained prior to conducting the study.

Table 1. Number of Participating Girls and Boys According to Age

Age/Gender	Number of Participants	Total, %
10		
Girls	182	16.65
Boys	177	16.19
11		
Girls	167	15.28
Boys	177	16.19
12		
Girls	207	18.94
Boys	183	16.74
All		
Girls	556	50.87
Boys	537	49.13

3.2. Data Collection

Measurements were conducted in a well-lit and warm room. The same sequence of measurements was maintained and the same equipment, operated by the same individuals, was used. The participants were measured in their underclothes, with no footwear. Height was measured with a calibrated anthropometer to within 0.01 m, from the floor to the skull vertex, as the participants stood in the erect position with feet together and looking straight ahead.

Body weight was measured on Tanita BR-350 scales to within 0.1 kg. The same equipment was used to assess

body fat percentage (BFP) using foot-to-foot bioelectrical impedance analysis (BIA) technology. Body mass index (BMI) was calculated based on height and weight, using the Cole and Bellizzi standards (accepted by the international obesity task force). Each participant was classified into one of three groups: healthy weight, overweight, or obese (Table 2) (12).

The arterial blood measurements were conducted using the auscultatory method based on Korotkoff sounds. The Hi-End Accoson Greenlight 300 sphygmomanometer was used. Systolic blood pressure (SBP) was recorded at the appearance of Korotkoff sounds (phase I), and diastolic blood pressure (DBP) was recorded at the muffling of sounds (phase IV) (13). The principles of proper preparation for measurements were maintained by the participants. The results of BP, after taking into account gender, age, and height, were compared to BP tables for children and adolescents as elaborated by American experts. Prehypertension in children is defined as average SBP or DBP levels greater than or equal to the 90th percentile, but less than the 95th percentile. Hypertension is defined as average SBP and/or DBP levels greater than or equal to the 95th percentile for sex, age, and height (14). Hypertension would have been recognized if high-normal ABP had been revealed during several examinations within a few week or several months, hence in such cases, only suspected arterial hypertension could be taken into account. When ABP equaled at least the 90th percentile, the measurement was repeated and the mean values for SBP and DBP were calculated. The results were categorized into the following groups: normal BP, high-normal BP, or hypertension.

3.3. Data Analysis

The analysis of the results was conducted using basic descriptive statistics: mean, median, minimum and maximum values, and standard deviations. The normality of distribution was assessed by means of the Shapiro-Wilk test (if the value of the Shapiro-Wilk test was > 0.05 , the data was normal). Because the data was not normally distributed ($P < 0.05$), the significance of intergroup differences was assessed with non-parametric tests: the Mann-Whitney U test (for two groups) or the Kruskal-Wallis and post-hoc Tukey test (for three groups). The level of significance was accepted at $P = 0.05$. Statistical analyses were performed using SPSS 20.0.

4. Results

4.1. Comparison of Results Between Boys and Girls

Boys and girls did not differ significantly in height, weight, and BMI. The girls had a 4.8% greater BFP. The girls'

Table 2. International Cut-Off Points for BMI for Overweight and Obesity by Sex Between 10 and 12 Years (12)

Age, y	BMI \geq 25, kg/m ²		BMI \geq 30 kg/m ²	
	Males	Females	Males	Females
10	19.84	19.86	24.00	24.11
10.5	20.20	20.29	24.57	24.77
11	20.55	20.74	25.10	25.42
11.5	20.89	21.20	25.58	26.05
12	21.22	21.68	26.02	26.67

waist circumference was 3 cm smaller than that of the boys, whereas hip circumference was 5.5 cm greater in the girls; however, this difference was not of statistical significance. It was determined that the WHtR was considerably smaller in girls. Gender did not strongly correlate with SBP and DBP (Table 3).

4.2. Comparison of Participants With Normal and High ABP

Normal ABP prevailed in 764 (70.0%) of the participants, high-normal BP was identified in 130 (11.8%), and hypertension was found in 199 (18.2%). Seventy-two percent of the girls and 68.0% of the boys had normal BP, while hypertension was found in 16.0% of the girls and 20.3% of the boys. Participants with normal ABP were considerably shorter and lighter, and had significantly lower BMI than their age-mates with high-normal and normal BP. There were similar findings with regard to BFP, which was 4.6% greater in participants with high-normal BP and 6.5% greater in those with hypertension than in participants with normal BP. Children with high-normal BP and those with hypertension also had greater waist circumferences (5.0 and 7.6 cm greater, respectively), hip circumferences (6.0 and 7.6 cm greater, respectively), and WHtR (0.02 and 0.04 points greater, respectively) than their age-mates with normal BP.

4.3. Comparison of Participants With Healthy and Excess Body Weight

Healthy weights were found more frequently in boys than in girls (78.2% and 71.8%, respectively). Excess body weight was found in 20.6% of girls and 19.2% of boys, and obesity in 7.5% of girls and 2.5% of boys. In total, excess weight was identified in 218 (20.0%) participants, with obesity in 54 (5.0%). Weight status differentiated all of the variables under investigation. BFP was 10.4% greater in children with excess body weight and 16.0% greater in obese children than in healthy-weight participants. The obese children's waist circumference was 10.3 cm larger and hip circumference was 9.1 cm larger than in the non-obese

overweight children, and 22.2 cm and 20.1 cm larger, respectively, than in children with healthy weight. In the healthy-weight children, normal BP was identified in 78.0%, high-normal BP in 10.0%, and hypertension in 12.0%. In the participants with excess weight, those values were 47.7%, 16.8%, and 35.5%, respectively, and in obese participants they were 18.5%, 22.2%, and 59.3%, respectively.

5. Discussion

Excess body weight was identified in 20.0% of the participants in this study, and obesity in 5.0%. Similar proportions were reported by researchers in Greece, who found excess weight and obesity in 22.4% and 6.5% of their participants, respectively (15). They also noted that excess body weight was more common in boys than in girls. The present study did not reveal statistically significant differences in BMI between boys and girls. On the other hand, a group of researchers from Saudi Arabia found distinctly higher BMI values in girls (16). The same researchers discovered that it was typical of boys to have greater BFP than girls, which was also confirmed by the findings of our study. Bacopoulou et al. revealed that boys had higher values than girls for waist and hip circumference and for WHtR (17). These differences with our study are due to the fact that in our research, the girls had greater hip circumference than the boys.

In the Bogalus Heart Study, one of the largest epidemiological investigations into the incidence of arterial hypertension in young populations, arterial hypertension was found in 7.0% of participants (18). In the Lande and Flynn research, chronic arterial hypertension was discovered in 11.0% of children (19). In our study, values indicating arterial hypertension were revealed in 18.2% of children. According to the academic data, arterial hypertension is 3 - 5 times more common in obese children than in their healthy-weight age-mates (20). Janus et al. revealed a high correlation between the prevalence of obesity and arterial hypertension (21). Moselakgomo et al. found a posi-

Table 3. Comparison of Selected Variables in Gender Groups (Mann-Whitney U Test, P = 0.05)

Variable/Gender	Mean	Median	Min	Max	SD	P Value
Height, cm						0.9
Girls	148.85	148.60	126.80	176.60	8.99	
Boys	149.13	148.20	123.60	174.50	9.30	
Weight, kg						0.7
Girls	41.60	40.50	22.20	70.20	9.85	
Boys	42.72	40.10	23.70	107.80	12.32	
BMI, kg/m²						0.8
Girls	18.58	18.04	12.80	28.41	3.11	
Boys	18.95	17.90	12.80	39.20	3.91	
% Fat						< 0.001 ^a
Girls	22.08	21.80	5.00	40.20	6.93	
Boys	17.32	15.40	5.00	44.70	7.59	
Waist circumference, cm						< 0.001 ^a
Girls	62.69	62.00	48.40	93.00	7.29	
Boys	65.69	63.70	42.60	115.00	9.62	
Hip circumference, cm						0.05
Girls	81.02	81.05	72.40	106.00	8.83	
Boys	80.47	79.40	64.00	124.30	9.66	
WHtR						< 0.001 ^a
Girls	0.42	0.41	0.33	0.60	0.04	
Boys	0.44	0.43	0.08	0.71	0.05	
Systolic blood pressure, mmHg						0.9
Girls	107.32	110.00	70.00	174.00	14.49	
Boys	107.49	110.00	70.00	170.00	14.16	
Diastolic blood pressure, mmHg						0.4
Girls	66.21	65.00	40.00	141.00	10.28	
Boys	66.96	70.00	40.00	144.00	10.10	

^aStatistically significant difference.

tive correlation between systolic and diastolic blood pressure, weight, and BFP (22). This was also confirmed in our study. Children with excess weight and obesity had high-normal ABP significantly more often than those with healthy weights, and BFP was also greater in children with high-normal ABP.

Rutkowski et al. confirmed the joint prevalence of high-normal ABP and greater WHtR, and identified a correlation between obesity and arterial hypertension; this was found significantly more often in participants with a greater WHtR (23).

Bakeri et al. were the first to show a significant correlation between high BMI in childhood and the incidence

of coronary disease and higher mortality due to cardiac problems in adulthood (24). Moreover, other studies have revealed the distant consequences of obesity, such as disturbed carbohydrate metabolism or the development of circulatory diseases in adulthood, even when it was possible for the obese child to attain a normal weight before maturity (25-27).

5.1. Conclusions

1) Excess body weight was identified in 28% of girls and 22% of boys aged 10 - 12 years.

2) Overweight and obesity increased the risk of high-normal ABP in schoolchildren.

5.2. Implications for Practice

In light of these findings, all possible steps should be taken to identify arterial hypertension in school-aged children, and preventive measures against overweight and obesity should be implemented for these children. Regular blood pressure control is an essential part of medical care for children with excess body weight.

Footnote

Authors' Contribution: Malgorzata Kolpa: study concept and design, analysis and interpretation of data, critical revision of the manuscript for important intellectual content, statistical analysis, administrative, technical, and material support, and study supervision; Agnieszka Jankowicz-Szymanska: acquisition of data, analysis and interpretation of data, statistical analysis, and study supervision; Beata Jurkiewicz: analysis and interpretation of data, drafting of the manuscript, and study supervision.

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