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# THE PREVALENCE OF ELEVATED BLOOD PRESSURE IN A SAMPLE OF SLOVENE CHILDREN AND ADOLESCENTS: A PILOT STUDY

## PREVALENCA VISOKEGA KRVNEGA TLAKA NA VZORCU SLOVENSKIH OTROK IN MLADOSTNIKOV: PILOTNA ŠTUDIJA

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**ABSTRACT**

**Introduction**: The aim of our study was to determine the prevalence of prehypertensive and elevated blood pressure in the hypertensive range (elevated BP) and obtain some anthropometric measures in Slovene children and adolescents.

**Methods:** In the cross-sectional study lasting one year, we measured BP using mercury sphygmomanometers, as well as height, weight, waist, and hip circumferences in schools. Data from regular check-ups (oscillometric measurements) were also added to increase the sample size. Participants were 2-19 years old. For statistical analysis, we used two-sided multivariate analysis of variance, Pearson's r, and chi-squared test.

**Results:** From altogether 1594 participants, 723 (45.4%) were boys and 871 (54.6%) girls. The prevalence of elevated BP on a single oscillometric blood-pressure measurement was 12.0% (95% CI: 10.3 to 13.9), and an additional 13.9% (95% CI: 12.0 to 15.9) had prehypertensive BP. In Riva-Rocci measurements, elevated BP was present in only 7.1% (95% CI: 4.9 to 10.1) and prehypertensive BP additionally in 3.9% (95% CI: 2.4 to 6.4) in comparison to oscillometric measurements, which showed higher prevalence. Importantly, overweight participants had a 1.75 times greater relative risk for prehypertensive BP (95% CI: 1.22 to 2.53; p<0.01). Obesity carried a 1.79 times greater relative risk (95% CI: 1.22 to 2.63; p<0.01) for BP outside of the normotensive BP range.

**Conclusion:** Arterial hypertension is becoming an important public health problem, especially due to the childhood obesity. It seems to concern also Slovene young population with prevalence of elevated BP at around 7.1% after a single auscultatory BP measurement.

**Keywords:**
hypertension, prevalence, children, adolescents, Slovenia, antropometrics

***IZVLEČEK***

***Namen:*** *Namen naše raziskave je bil ugotoviti razširjenost povišanega krvnega tlaka ter pridobiti nekatere antropometrične meritve slovenskih otrok in mladostnikov.*

***Metode:*** *V tej presečni študiji, ki je trajala eno leto, smo merili krvni tlak (KT) z živosrebrnimi sfingomanometri in pridobili nekatere antropometrične meritve, kot so starost, spol, višina, teža, obseg pasu in bokov. Vzorec smo povečali s podatki, pridobljenimi z oscilometrično metodo s sistematskih pregledov in sprotnih pregledov pri pediatrih. Preiskovanci so bili stari od 2 do 19 let. Rezultate smo nato še statistično obdelali z dvosmerno multivariatno analizo variance. Izračunali smo tudi Pearsonov korelacijski koeficient r in naredili preizkus hi-kvadrat.*

***Rezultati:*** *Skupno je sodelovalo 1594 otrok in mladostnikov, od tega 723 (45,4 %) fantov in 871 (54,6 %) deklet. Pri enkratni oscilometrični meritvi KT je razširjenost visokega KT znašala 12,0 % (95 % IZ: 10,3 do 13,9) in prehipertenzivnega KT kar 13,9 % (95 % IZ: 12,0 do 15,9). Meritve krvnega tlaka z avskultatorno metodo so pokazale nižje vrednosti; povišan KT je imelo 7,1 % (95 % IZ: 4,9 do 10,1) in prehipertenzivni KT dodatno 3,9 % (95 % IZ: 2,4 do 6,4) osnovnošolskih otrok in mladostnikov. Prekomerna telesna teža je v primerjavi z normalno pomenila 1,75-krat večje relativno tveganje za prisotnost prehipertenzivnega KT (95 % IZ: 1,22 do 2,53; p<0,01). Debelost je v primerjavi z normalno telesno težo pomenila 1,79-krat večje tveganje za KT izven normotenzivnega območja (95 % IZ: 1,22 do 2,63; p<0,01).*

***Zaključek:*** *Arterijska hipertenzija postaja pomemben javnozdravstveni problem, zlasti zaradi debelosti otrok in mladostnikov. Zdi se, da to zadeva tudi slovensko pediatrično populacijo, saj znaša razširjenost visokega KT med otroki in mladostniki 7,1 % ob enkratni meritvi z avskultatorno metodo.*

***Ključne besede:***
*hipertenzija, prevalenca, otroci, mladostniki, Slovenija, antropometrija*

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## 1 INTRODUCTION

Elevated blood pressure (BP) in children and adolescents is becoming a public health concern. The increasing prevalence of arterial hypertension (HTN) is observed worldwide (1, 2) and relates to the epidemic of obesity (3, 4), among other factors.

According to the 2016 European Society of Hypertension guidelines (5), unlike the previously used guidelines (6), high BP is defined differently in children and adolescents aged ≥16 years. Normal BP in children is defined as a systolic and diastolic BP, which is less than the 90th percentile, adjusted for gender, age, and height. Children with an average systolic blood pressure (SBP) or diastolic blood pressure (DBP) in the 90th or higher percentile, but less than the 95th percentile, are prehypertensive. HTN in children is defined as an average SBP and/or DBP, which is in the 95th or higher percentile, measured on at least three different occasions and confirmed by auscultatory measurement. The first stage of HTN is defined as the 95th to 99th percentile BP plus 5 mmHg and the second stage of hypertension as BP greater than 99th percentile plus 5 mmHg. Isolated systolic hypertension (ISH) is defined by SBP ≥95th percentile and DBP <90th percentile (5).

In adolescents aged ≥16 years, normotension is defined as a BP <130/85 mmHg. With repeated measures, a BP of 130-139/85-89 mmHg defines prehypertension, and a BP value ≥140/90 mmHg defines HTN. The first stage of HTN in older adolescents is defined as BP 140-159/90-99 mmHg, and second stage as BP 160-179/100-109 mmHg. ISH is defined as BP ≥140/<90 mmHg (5).

Most studies report the prevalence of prehypertension around 9–12% (4). On single BP measurement, an American study (7) estimated the prevalence of HTN (here described as 'elevated BP' if <3 measurements were carried out with readings in the hypertensive range) in adolescents at approximately 10%, the same applies to single-measurement prevalence of prehypertensive BP. After three BP measurements, the prevalence of HTN decreased to 3.2%, while the prevalence of prehypertension increased to 15.7%, as some of the previous hypertensive individuals dropped to the prehypertensive group. In a Swiss study (8), the prevalence of prehypertension was 13.3% and elevated BP 11.4% at the first measurement, and after the second, 9.5% and 9.4%, respectively. At the third measurement, the prevalence of prehypertension was 2.2% and HTN 1.7%. Those results are similar to a Slovene paediatric study (1978–1990), which estimated the prevalence of HTN at 1.2% (9, 10).

Since then, there has been a lack of research on this topic in Slovenia. With this pilot study, we want to contribute new data on the estimated prevalence of prehypertensive BP and elevated BP. Additionally, we also search for some anthropometric features that correlate with elevated BP, such as increased body mass index (BMI).

## 2 METHODS

### 2.1 Design and Background

This pilot study was conducted under the supervision of the Unit for Paediatric nephrology and hypertension, University Medical Centre Maribor, Slovenia. In December 2014, this cross-sectional study received the approval of the Ethics Committee of the University Medical Centre Maribor. Before starting data collection, we obtained all necessary consents. The data collection was completed in March 2016.

### 2.2 Sampling

Participants were aged 2–19. From December 2014, we began our cooperation with the Health Centre Adolf Drolc in Maribor and with the Paediatric Clinic in Lenart. There we collected BP data and certain anthropometric measurements from regular check-ups, measured with an automatic (oscillometric) device during February 2015 and March 2016. Children with a previously known diagnosis of secondary (but not essential) hypertension were excluded, as they had aetiology-based treatment and their small count would not influence the overall results.

Meanwhile, we began to cooperate with two nearby schools. There, we measured BP once a month with a mercury sphygmomanometer (auscultatory method) and gathered additional data on weight, height, hip and waist circumferences. The sampling procedure for the auscultatory and oscillometric measurements is described in Figure 1.

### 2.3 Procedure

Measurements in primary schools were carried out by two 6th year medical students, previously trained recording paediatric BP using a mercury sphygmomanometer. Height, weight, waist, and hip circumferences were also measured. Before each measurement, we explained the procedure, took a brief history on possible elevated BP and asked about children's experience with BP measuring. We waited for anxious children to relax. Participants were also not allowed to be physically active before the examination, if so, we waited for at least five minutes.

Children entered the quit room in pairs. As one of two examiners was measuring the BP of one of the two children, the other examiner obtained anthropometric measurements. BP was first measured on the right upper arm in the seated position. In the case of increased BP (≥90. p.), we obtained a second right upper arm BP measurement, followed by a third measurement by the other examiner for cross-checking, and a fourth measurement on the left upper arm for evaluation of possible aortic coarctation, with three-minute intervals in between. Three right upper arm measurements were used for later analysis.

The sample was increased using patient records from systematic check-ups. There, repeated BP measurements on the upper right arm were taken by Health Centre staff, using an Omron M6 oscillometric upper arm blood pressure monitor. In addition, data on gender, height, weight, and BMI were collected.

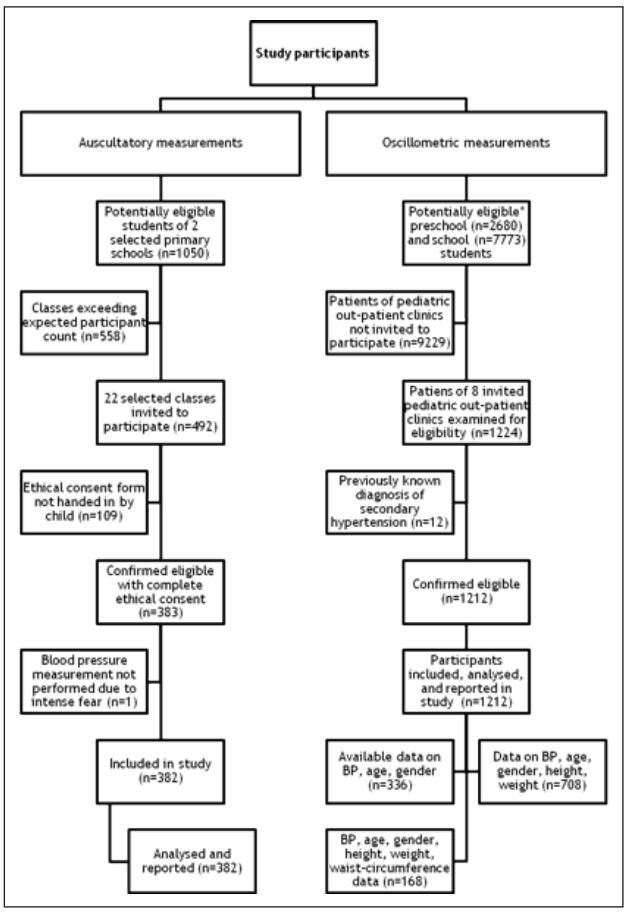


**Figure 1.** Sampling procedure of study participants.

After collecting the data, we calculated average values of SBP and DBP, and calculated mean arterial pressures (MAP). Using height and weight data, we calculated the BMI and BMI standard deviation scores (SDS).

Anthropometric measurements served us to calculate the waist-to-hip and waist-to-height ratios. In accordance with recommendations (5), we calculated percentiles of arterial BP based on sex, age and height. More about this calculation is found in the 4th Report (Supplement) of the NHBPEP Working Group on Children and Adolescents (6). Since this was a study on the Slovenian children, we decided to use the WHO and CDC growth curves (11–13) to calculate SDS scores of anthropometric parameters (weight-for-age, height-for-age, BMI-for-age). We used the European (ages 2–11) and Japanese (ages 12–19) data to calculate waist circumference SDS scores (14, 15). Children and adolescents were classified into four groups based on their BMI percentile: underweight, normal weight status, overweight and obese. The participants were also allocated to different groups dependent on their height, waist, and hip circumferences. When the waist-to-hip circumference ratio exceeded 0.85 for girls or 0.9 for boys, it was regarded as increased (16). Waist-to-height ratio was defined as increased when it exceeded 0.5 (17).

### 2.4 Statistical Methods and Sample Size

We used IBM SPSS statistical program (version 20), running on a PC with Windows 10 operating system. To calculate the independence of the distributions of categorical variables, we used the chi-square test. Pearson's correlation coefficient r was used in the calculation of correlations between the SDS score of systolic and diastolic BP and certain anthropometric parameter SDS scores.

The sample size was assessed via an online statistical program (18), using an expected hypertension prevalence (10%) and the desired confidence interval width of 95%±2%. Based on this, the recommended sample size was 912 participants.

## 3 RESULTS

### 3.1 Sample Characteristics and Epidemiology

A total of 1,594 children and adolescents have been included, 723 (45.4%) boys and 871 (54.6%) girls. The participants from two schools (N=382) were aged 6–15, with an average age of 9.78 years (SD=2.7). The age of children and adolescents from regular check-ups (N=1212) was 2–19 years, with an average age of 11.2 years (SD=4.9).

**Table 1.** Mean values of sample characteristics.

| | Auscultatory measurements - Mean (SD; N) | | | Oscillometric measurements - Mean (SD; N) | | | All measurements - Mean (SD; N) | | |
|---|---|---|---|---|---|---|---|---|---|
| **Characteristic** | **2-6 years** | **7-12 years** | **13-19 years** | **2-6 years** | **7-12 years** | **13-19 years** | **2-6 years** | **7-12 years** | **13-19 years** |
| **Age** | 6.0 (0.0; 46) | 9.2 (1.6; 253) | 13.7 (0.7; 83) | 4.8 (1.2; 303) | 8.8 (1.9; 319) | 15.7 (1.8; 590) | 5.0 (1.2; 349) | 9.0 (1.8; 572) | 15.5 (1.8; 673) |
| **Gender - N (Male: Female)** | 46 (25: 21) | 253 (119 : 134) | 83 (35: 48) | 303 (144: 159) | 319 (163: 156) | 540 (237: 353) | 349 (169: 180) | 572 (282: 290) | 673 (272: 401) |
| **SBP [mmHg]** | 100.4 (7.5; 46) | 100.9 (12.0; 253) | 114.4 (11.5; 83) | 98.9 (10.2; 427) | 109.6 (10.7; 319) | 119.4 (11.7;590) | 99.1 (9.9; 349) | 105.8 (12.1; 572) | 118.8 (11.8; 673) |
| **DBP [mmHg]** | 57.0 (8.1; 46) | 55.1 (9.2; 253) | 64.2 (11.7; 83) | 62.3 (8.8; 427) | 66.7 (9.5; 319) | 72.1 (8.8; 590) | 61.6 (8.9; 349) | 61.6 (11.0; 572) | 71.1 (9.5; 673) |
| **MAP [mmHg]** | 71.5 (7.2; 46) | 70.4 (9.0; 253) | 81.0 (10.1; 83) | 74.5 (8.0; 427) | 81.0 (9.5; 319) | 87.8 (8.4; 590) | 74.13 (8.0; 349) | 76.3 (10.2; 572) | 87.0 (8.9; 673) |
| **Height [SDS]** | 1.45 (0.84; 46) | 0.79 (1.00; 253) | 0.32 (1.20; 83) | -0.57 (1.23; 233) | 0.43 (1.44; 196) | 0.61 (0.98; 469) | -0.21 (1.40; 257) | 0.63 (1.22; 449) | 0.56 (1.02; 552) |
| **Weight [SDS]** | 0.53 (0.81; 46) | 0.51 (1.01; 253) | 0.56 (1.27; 83) | 0.10 (1.64; 233) | 0.79 (1.36; 196) | 0.94 (1.40; 469) | 0.18 (1.53; 257) | 0.63 (1.18; 449) | 0.88 (1.39; 552) |
| **BMI [SDS]** | -0.05 (0.82;46) | 0.16 (0.74; 253) | 0.09 (0.52; 83) | 0.34 (0.86; 233) | 0.40 (0.81; 196) | 0.27 (0.58; 469) | 0.27 (0.86; 257) | 0.27 (0.78; 449) | 0.21 (0.57; 552) |
| **WC [SDS]** | 1.41 (1.89; 46) | 0.48 (1.63; 253) | 0.04 (1.61; 83) | 0.54 (1.58; 77) | 0.56 (1.90; 81) | 1.00 (1.97; 33) | 0.93 (1.77;104) | 0.50 (1.70; 334) | 0.31 (1.77; 116) |
| **HC [cm]** | 69.1 (6.3; 46) | 78-4 (9.4; 253) | 92.3 (8.67; 83) | NA | NA | NA | 69.1 (6.3; 46) | 78.4 (9.4; 253) | 92.3 (8.7; 83) |
| **Waist-to-hip ratio** | 0.87 (0.06; 46) | 0.83 (0.07; 253) | 0.80 (0.08; 83) | NA | NA | NA | 0.87 (0.06; 46) | 0.83 (0.07; 253) | 0.80 (0.08; 83) |
| **Waist-to-height ratio** | 0.48 (0.06; 46) | 0.46 (0.06; 253) | 0.45 (0.06; 83) | 0.51 (0.05; 76) | 0.49 (0.07; 79) | 0.49 (0.07; 32) | 0.48 (0.06 ;46) | 0.47 (0.06; 332) | 0.46 (0.07; 115) |

N - number of participants; SD - standard distribution; SDS - standard distribution (Z) score; SBP - systolic blood pressure; DBP - diastolic blood pressure; MAP - mean arterial pressure; BMI - body mass index; WC - waist circumference; HC - hip circumference; NA - data not available

### 3.2 The Prevalence of Prehypertensive and Elevated Blood Pressure in Hypertensive Range

The prevalence of elevated BP after a single Riva-Rocci auscultatory measurement in schools was 7.1% (95% CI: 4.9 to 10.1), and the prevalence of elevated BP at regular check-ups, measured with automatic oscillometric device, was approximately 12.0% (95% CI: 10.3 to 13.9). Furthermore, the prevalence of children and adolescents with BP in stage 1 hypertensive range, using auscultatory measurement, was 1.6% (95% CI: 0.7 to 3.4), and in stage 2 hypertensive range, 1.0% (95% CI: 0.4 to 2.7). In oscillometric measurements, stage 1 hypertensive range BP was observed in 6.5% (95% CI: 5.3 to 8.0), and stage 2 hypertensive range BP in 1.1% (95% CI: 0.6 to 1.8).

The prevalence of prehypertensive BP in children and adolescents after auscultatory measurement was at 3.9% (95% CI: 2.4 to 6.4), and majorly different in oscillometric measurements, that is, 13.9% (95% CI: 12.0 to 15.9). Regarding ISH, it was prevalent in 4.5% (95% CI: 2.8 to 7.0) of cases with auscultatory measurements and 4.5% (95% CI: 3.4 to 5.8) of cases with oscillometric measurements. For more details on normotension, prehypertensive BP, elevated BP, stage 1 and stage 2 hypertensive range BP, and isolated systolic hypertension prevalence at different ages, see Table 2.

**Table 2.** Blood pressure categories by the participants' age.

| Characteristic | Participant count - N (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2-3 years | 4-5 years | 6-7 years | 8-9 years | 10-11 years | 12-13 years | 14-15 years | 16-17 years | 18-19 years |
| **Auscultatory measurements - N (%)** | | | | | | | | | |
| **Normal** | NA | NA | 91 (96.8%) | 92 (91.1%) | 69 (93.2%) | 51 (77.3%) | 37 (78.7%) | NA | NA |
| **Prehypertensive BP** | NA | NA | 2 (2.1%) | 4 (4.0%) | 1 (1.4%) | 4 (6.1%) | 4 (8.5%) | NA | NA |
| **Hypertension‡** | NA | NA | 1 (1.1%) | 5 (5.0%) | 4 (5.4%) | 11 (16.7%) | 6 (12.8%) | NA | NA |
| **Stage 1 Hypertension‡** | NA | NA | 1 (1.1%) | 0 (0.0%) | 1 (1.4%) | 2 (3.0%) | 2 (4.3%) | NA | NA |
| **Stage 2 Hypertension‡** | NA | NA | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | 4 (6.1%) | 0 (0.0%) | NA | NA |
| **ISH‡** | NA | NA | 0 (0.0%) | 5 (5.0%) | 3 (4.1%) | 5 (7.6%) | 4 (8.5%) | NA | NA |
| **Oscillometric measurements - N (%)** | | | | | | | | | |
| **Normal** | 38 (48.7%) | 70 (70.7%) | 30 (53.6%) | 25 (45.5%) | 60 (71.4%) | 125 (77.2%) | 88 (73.9%) | 187 (74.2%) | 60 (65.9%) |
| **Prehypertensive BP** | 13 (16.7%) | 18 (18.2%) | 13 (23.2%) | 10 (18.2%) | 9 (10.7%) | 20 (12.3%) | 13 (10.9%) | 52 (20.6%) | 20 (22.0%) |
| **Hypertension‡** | 27 (34.6%) | 11 (11.1%) | 13 (23.2%) | 20 (36.4%) | 15 (17.9%) | 17 (10.5%) | 18 (15.1%) | 13 (5.2%) | 11 (12.1%) |
| **Stage 1 Hypertension‡** | 25 (32.1%) | 6 (6.1%) | 8 (14.3%) | 11 (20.0%) | 4 (4.8%) | 3 (1.9%) | 8 (6.7%) | 7 (2.7%) | 7 (7.7%) |
| **Stage 2 Hypertension‡** | 2 (2.6%) | 1 (1.0%) | 1 (1.8%) | 2 (3.6%) | 1 (1.2%) | 1 (0.6%) | 4 (3.4%) | 1 (0.4%) | 0 (0.0%) |
| **ISH‡** | 0 (0.0%) | 4 (4.0%) | 4 (7.1%) | 7 (12.7%) | 10 (11.9%) | 13 (8.0%) | 6 (5.0%) | 5 (2.0%) | 4 (4.4%) |
| **All measurements - N (%)** | | | | | | | | | |
| **Normal** | 38 (48.7%) | 70 (70.7%) | 121 (80.7%) | 117 (75.0%) | 129 (81.6%) | 176 (77.2%) | 125 (75.3%) | 187 (74.2%) | 60 (65.9%) |
| **Prehypertensive BP** | 13 (16.7%) | 18 (18.2%) | 15 (10.0%) | 14 (9.0%) | 10 (6.3%) | 24 (10.5%) | 17 (10.2%) | 52 (20.6%) | 20 (22.0%) |
| **Hypertension‡** | 27 (34.6%) | 11 (11.1%) | 14 (9.3%) | 25 (16.0%) | 19 (12.0%) | 28 (12.3%) | 24 (14.5%) | 13 (5.2%) | 11 (12.1%) |
| **Stage 1 Hypertension‡** | 25 (32.1%) | 6 (6.1%) | 9 (6.0%) | 11 (7.1%) | 5 (3.2%) | 5 (2.2%) | 10 (6.0%) | 7 (2.7%) | 7 (7.7%) |
| **Stage 2 Hypertension‡** | 2 (2.6%) | 1 (1.0%) | 1 (0.6%) | 2 (1.3%) | 1 (0.6%) | 5 (2.2%) | 4 (2.4%) | 1 (0.4%) | 0 (0.0%) |
| **ISH‡** | 0 (0.0%) | 4 (4.0%) | 4 (2.7%) | 12 (7.7%) | 13 (8.2%) | 18 (7.9%) | 10 (6.0%) | 5 (2.0%) | 4 (4.4%) |

N - number of cases; ISH - isolated systolic hypertension; NA - data not available; N - number of cases; ‡ Due to BP measurement on a single occasion, the term hypertension is used as a synonym with "elevated BP in the hypertensive range"

### 3.3 The Influence of Anthropometric Characteristics on Blood Pressure Values

#### Relative Risks

For each pair of variables (anthropometric characteristic, blood pressure category), the relative risk with confidence intervals and chi-square test were calculated (Table 3).

Focusing on auscultatory measurements, which show a more complete set of data, it is seen that children aged 7–12 years and adolescents aged 13–19 years have 1.10 times (95% CI: 1.01 to 1.19; $p<0.05$) greater and 0.82 times (95% CI: 0.72 to 0.93, $p<0.01$) smaller relative risk for being normotensive in comparison to the rest of participants, respectively. Interestingly, not any of the three age groups has an increased relative risk for having prehypertensive or elevated BP.

The relative risk for being prehypertensive (1.23; 95%CI: 0.48 to 3.50) or having elevated BP (1.13 95% CI: 0.63 to 2.04) for boys was not significantly different in comparison to girls in the auscultatory measurement group.

As expected, the frequency of hypertensive range BP was higher among participants with elevated BMI (overweight and obesity). After calculation of the chi-square value, we found that the relative risk for having prehypertensive BP was 6.67 times (95% CI: 2.53 to 17.60; p<0.001) greater in the overweight group, with an insufficient number of cases to calculate the relative risk for prehypertensive BP in the obese group. Interestingly, neither overweight nor obesity carried a significantly greater relative risk of elevated BP in the hypertensive range (relative risk of elevated BP for overweight = 1.37; 95% CI: 0.22 to 8.62 and relative risk of elevated BP for obese = 1.12; 95% CI: 0.18 to 7.17), but this was again most likely due to not enough obese (pre)hypertensive patient cases.

There was a positive correlation between increased waist-to-hip ratio as well as waist-to-height ratio and elevated BP in the hypertensive range, but both were statistically insignificant (Table 3).

**Table 3.** Blood pressure categories by the relative risks for having normotensive, prehypertensive or hypertensive BP in correlation with some participants' characteristics, e.g. participants' age.

| Characteristic | Auscultatory measurements - RR (95% CI) | | | Oscillometric measurements - RR (95% CI) | | | All measurements - RR (95% CI) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Normotensive | Prehypertensive | Hypertensive | Normotensive | Prehypertensive | Hypertensive | Normotensive | Prehypertensive | Hypertensive |
| **Age** | | | | | | | | | |
| • 2-6 years: rest | 1.11 | NA | 0.81 | 0.66 | 0.98 | 0.96 | 0.89 | 1.04 | 0.98 |
| | (1.05;1.18)* | | (0.30; 2.18) | (0.48; 0.90)** | (0.70; 1.38) | (0.66; 1.38) | (0.82; 0.98)** | (0.70; 1.54) | (0.70; 1.38) |
| • 7-12 years: rest | 1.10 | 1.02 | 1.06 | 0.88 | 0.93 | 1.50 | 1.09 | 0.60 | 1.15 |
| | (1.01; 1.19)* | (0.36; 2.92) | (0.57; 1.98) | (0.78; 0.99)* | (0.65; 1.32) | (1.06; 2.12)* | (1.03; 1.16)** | (0.43; 0.83)** | (0.86; 1.54) |
| • 13-19 years: rest | 0.82 | 1.80 | 1.05 | 1.20 | 1.06 | 0.77 | 0.99 | 1.48 | 0.89 |
| | (0.72; 0.93)** | (0.63; 5.13) | (0.52; 2.11) | (1.09; 1.31)** | (0.80; 1.41) | (0.56; 1.06) | (0.93; 1.05) | (1.12; 1.94)** | (0.67; 1.18) |
| **Gender** | | | | | | | | | |
| (male: female) | 0.96 | 1.23 | 1.13 | 0.81 | 1.71 | 1.36 | 0.87 | 1.63 | 1.29 |
| | (0.92; 1.06) | (0.48; 3.50) | (0.63; 2.04) | (0.74; 0.88)** | (1.30;2.26)** | (0.99; 1.87) | (0.82; 0.93)** | (1.24;214)** | (0.98; 1.71) |
| **Waist-to-hip ratio** | | | | | | | | | |
| (increased: normal) | 1.03 | 0.80 | 2.03 | NA | NA | NA | 1.03 | 0.80 | 2.03 |
| | (0.94; 1.12) | (0.26; 2.45) | (0.82; 5.03) | | | | (0.94; 1.12) | (0.26; 2.45) | (0.82; 5.03) |
| **Waist-to-height ratio** | | | | | | | | | |
| (increased: normal) | 1-23 | 0.51 | 1.77 | 1.23 | 1.28 | 1.43 | 1.37 | 0.68 | 1.20 |
| | (1.08; 1.40)** | (0.18; 1.43) | (0.72; 4.36) | (0.90; 1.68) | (0.72; 2.29) | (0.73; 2.79) | (1.20; 1.57)** | (0.40; 1.14) | (0.70; 2.05) |
| **Body mass index** | | | | | | | | | |
| overweight: normal | 0.67 | 6.67 | 1.37 | 0.79 | 1.37 | 1.16 | 0.74 | 1.75 | 0.97 |
| | (0.52; 0.88)** | (2.53; 17.60)** | (0.22; 8.62) | (0.66; 0.95)** | (0.92; 2.05) | (0.71; 1.89) | (0.64; 0.86)** | (1.22; 2.53)** | (0.60; 1.57) |
| obese: normal | 0.95 | NA | 1.12 | 0.43 | 1.36 | 0.78 | 0.56 | 1.42 | 0.87 |
| | (0.73; 1.24) | | (0.18; 7.17) | (0.24; 0.76)** | (0.66; 2.80) | (0.27; 2.29) | (0.38; 0.82)** | (0.67; 2.99) | (0.34; 2.21) |

RR - relative risk; CI - confidence interval; NA - comparison not possible due to too few cases in the 2x2 contingency table;
* - p<0.05 using chi-square test; ** - p<0.01 using chi-square test

### 3.3.2 Pearsons' Correlations

Some anthropometric characteristics (with continuous range of values) correlated with SBP and DBP SDS scores differently than others (Table 4).

**Table 4.** Pearsons' r correlation coefficients between sample characteristics and blood pressure SDS scores.

| Sample characteristic | Auscultatory BP m. - r (N) | | Oscillometric BPm. - r (N) | | All BP measurements - r (N) | |
|---|---|---|---|---|---|---|
| | Systolic blood pressure (SDS) | Diastolic blood pressure (SDS) | Systolic blood pressure (SDS) | Diastolic blood pressure (SDS) | Systolic blood pressure (SDS) | Diastolic blood pressure (SDS) |
| **Age [yr]** | 0.20 (382)** | 0.12 (382)* | 0.04 (878) | -0.21 (878)** | 0.11 (1260)** | -0.04 (1260) |
| **Height [SDS]** | 0.10 (382) | 0.07 (382) | 0.06 (878) | -0.07 (878)* | 0.17 (1260) | -0.12 (1260)** |
| **Weight [SDS]** | 0.41 (382)** | 0.31 (382)** | 0.21 (878)* | 0.08 (878) | 0.26 (1260)** | 0.14 (1260)** |
| **WC (SDS)** | 0.31 (382)** | 0.20 (382)** | 0.35 (174)** | 0.23 (174)** | 0.31 (556)** | 0.20 (556)** |
| **HC (cm)** | 0.43 (382)** | 0.30 (382)** | NA | NA | 0.43 (382)** | 0.30 (382)** |
| **Waist-to-hip ratio** | 0.08 (382) | 0.02 (382) | NA | NA | 0.08 (382) | 0.02 (382) |
| **Waist-to-height ratio** | 0.32 (382)** | 0.20 (382)** | 0.23 (170)** | 0.20 (170)** | 0.35 (552)** | 0.30 (552)** |
| **Body mass index (SDS)** | 0.39 (382)** | 0.26 (382)** | 0.23 (878)** | 0.20 (878)** | 0.29 (1260)** | 0.24 (1260)** |

* p<0.05; ** p<0.01; N - number of cases; SDS - standard distribution (Z) score; NA - data not available; r - Pearson's r correlation coefficient; WC - waist circumference; HC - hip circumference; BP m. - blood pressure measurements

### 3.3.3 Comparisons of BP SDS Score Mean Values

The initial intent was to analyse possible interactions between anthropometric characteristics and mean scores of BP percentiles using the two-way Students' t-test, but no significant interactions were seen on MANOVA analysis, so that subsequent testing was not performed.

## 4 DISCUSSION

The only published study on the prevalence of HTN in children in Slovenia between 1978 and 1990 estimated the prevalence at 1.2% (9, 10). In foreign literature, the prevalence of elevated BP ranges from 9%–19% on a single measurement, and the prevalence of prehypertension 10%–30%, which is higher than our results, with 3.9% prevalence of prehypertensive BP and 7.1% of elevated BP in hypertensive range (7, 8, 19).

If we compare the results of the prevalence from regular check-ups (12.0%) and the results obtained with the auscultatory method (7.1%), we can see that they differ to a high extent. This could be explained with findings from research by Park et al. (20), where the values of BPs measured with automatic-oscillometric device were 10 mmHg higher in systolic BPs and 5 mmHg higher in diastolic BPs, compared to the auscultatory method. Differences between settings of out-patient clinics in oscillometric measurements and primary school cabinets in auscultatory measurements could have led to some differences in BP values, further potentiated by the white-coat effect in the clinical setting. We also observed relatively large proportions of elevated BP readings in the young child group, aged 2–6 years, which were seen by primary care paediatricians. The reason might be a positive selection of patients, in which a BP measurement was indicated and not measured only as part of a screening protocol.

We believe that our estimate of HTN prevalence of about 7% obtained with auscultatory measurement at one occasion is the most accurate. Based on these findings and the assumption that the prevalence of HTN is at least halved after the second and third measurement (7, 21), we presume the actual prevalence of HTN in Slovenian paediatric population is around 3–4%, concordant with results from recent foreign literature (20).

In the second part of our analysis, we have seen that BMI is positively correlated to BP height, which is consistent with findings from several other studies (3, 4, 21). Surprisingly, the relative risk for HTN was not statistically increased with an increase in waist-to-hip ratio, as it would be expected (16). Foreign studies (16, 17, 22) also report

that an increased waist-to-height ratio strongly correlates with a high BP, which was not observed in our study, due to unknown reasons, and should be further elucidated.

A major methodological issue was the difference between the auscultatory and oscillometric cohorts, which prevented us from analysing the two groups together. The most important limitation of our study were measurements of BP on a single occasion, often with a single measurement if below 90th percentile, and not at three, as it is expected (5). Single measurement studies (7, 8, 19) overestimate the prevalence of HTN. In at least two studies, the prevalence of arterial hypertension was more than halved after completion of the second and third measurements (7, 21). A limitation of our sample was also the absence of measurements of certain parameters which could correlate with HTN, such as family history of hypertension, race, birth weight, quality of diet, drug therapy and physical activity.

Our methodology risked a selection bias due to opportunistic sampling of children in primary schools. This was reduced by supplementing it with data from regular check-ups. Observer bias was reduced by double-checking the measured elevated BP by another examiner.

## 5 CONCLUSION

The estimated prevalence of elevated BP in hypertensive range in Slovenian paediatric population, measured at a single occasion, is around 7.1%, and prehypertensive BP approximately 3.9%, which is consistent with recent foreign studies. Moreover, a positive correlation between blood pressure and body mass index was shown. In other words, normal blood pressure appeared less often in overweight and obese children and adolescents. These findings of a pilot study give a reason to conduct a representative, larger-scale study on the prevalence of elevated BP and obesity in Slovene paediatric population, and, thereby, gather insight into the burden of a disease gaining epidemic proportions worldwide.

## CONFLICTS OF INTEREST

The authors declare that no conflicts of interest exist.

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## ETHICAL APPROVAL

The study was granted ethical approval by the University

Medical Centre Maribor Ethics Committee on 19 December 2014.

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