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# What is the role of body-mass index, waist circumference and waist to height ratio in predicting the risk of high blood pressure in children aged 3-18 years?

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## ABSTRACT

**Aims**: Obesity has increased among children in recent years, becoming one of the most serious health issues due to an increase in the risk of cardiovascular illnesses. The aim of this study was to assess prevalence of obese and hypertensive children aged 3-18 years and to determine the role of body-mass index (BMI), waist circumference (WC) and waist to height ratio (WHtR) in predicting the risk of high blood pressure (BP) and hypertension (HT).

**Methods**: The demographic characteristics, BMI, WC, WHtR, and BP percentiles were evaluated, and the relationship between high BP and BMI, WC and WHtR was investigated.

**Results**: The study included 752 children aged 3-18 years, 73.9% of children aged 3 to 12 years old. Obese children were found at 8.4%, overweight at 13%, HT at 9.6%, and high BP at 8%. The risky WHtR ratio (≥0.5) for abdominal obesity was found to be 23.7%. Males had significantly higher rates of obesity, risky WHtR, and HT ($p<0.05$). Being between 3 and 12 years of age, overweight, obese and risky WHtR were the most prevalent risk factors for high BP and HT ($p<0.05$).

**Conclusion**: Obesity and HT rate was increased, particularly in males. Since risky WHtR and increased BMI have been determined to be the most important risk factors for high BP and HT, it is critical to monitor BP more frequently, especially in the neglected 3-12 age group, in the presence of risky WHtR and higher BMI.

**Keywords**: Children, high blood pressure, hypertension, abdominal obesity, waist circumference, waist to height ratio

## INTRODUCTION

Obesity is a condition characterized by abnormal fat accumulation due to energy balance disorders, first recognized by the World Health Organization (WHO) in 1948. It is caused by various genetic, physiological, behavioral, sociocultural, and environmental factors.[1] Childhood obesity can lead to various health issues, including diabetes, hypertension (HT), and psychosocial disorders. Due to limited pharmacotherapy options, it is recommended to implement a program involving nutrition, exercise, and behavioral changes, breastfeed exclusively for at least six months, reduce screen time, and increase physical activity to reduce obesity risk.[1]

WHO reported a significant increase in overweight and obese children and adolescents aged 5-19, from 4% in 1975 to 18% in 2016. Over 124 million children and 41 million children under 5 were found to be overweight or obese.[3] Recent studies indicate that around 20% of school-aged children in European countries are overweight or obese, highlighting the global health threat of obesity.[2]

Obesity can be determined using methods like skinfold thickness measurement and bioelectrical impedance, but these are costly and not easily accessible. BMI is a widely used and easy method for classifying obesity, calculated from height and weight in children. Z-scores (SDS) or percentiles are used to assess BMI in children, which vary based on age and gender.[1] The waist/height ratio (WHtR) can also be used to assess obesity in children. Studies have shown that a WHtR≥0.5 predicts kardiovascular diseases and diabetes in adults and children.[3]

HT is a condition characterized by high blood pressure (BP) on the vascular wall, influenced by lifestyle, behavioral, environmental, and genetic factors.[4] Risk factors include family history, obesity, race/ethnicity, physical inactivity, and high sodium intake.[4,5] Primary HT is common in children and adolescents, especially those over six years old, and may be linked to obesity. Secondary HT is more common in childhood, with kidney and renovascular diseases being the most common causes. Therefore, all children diagnosed with HTN in childhood should be evaluated for secondary causes.[5]

The prevalence of high BP and HT in children aged 1-12 years has increased in recent years, linked to an increase in obese children, according to the National Health and Nutrition Examination Survey data.[7] This increase has been associated with the increase in obese children. Normal and high BP values for children vary based on age, height, and gender.[4] Around 3.5% of United States (US) children have HT, while 2.2-3.5% have high BP. Central European countries have a prevalence of 2.2-4.9%, while Southern and Western European children have rates ranging from 9% to 13%.[6] Turkiye's childhood HT prevalence varies between 8.5% and 15%, with few studies on its epidemiology.[5]

Obese children have a higher prevalence of HT compared to lean children, with a 3 times higher prevalence in obese adolescents.[7] Primary HT prevalence in children is increasing due to the increasing epidemic of overweight and obesity. It is diagnosed in 4-14% of overweight children and 11-33% of obese children, indicating a significant concern as both overweight and HT are often transmitted from childhood to adulthood.[7]

BMI and waist circumference (WC) are commonly used to define obese children and adolescents, but BMI is not a measure of fat distribution and different cut-offs are used based on age and gender. WC indicates abdominal obesity, which is clinically useful as a predictor of metabolic syndrome, type 2 diabetes, dyslipidemia, HT, and coronary artery disease.[8] Studies show that cardiovascular death and myocardial infarction increase with WC.[8] The WHtR is superior to BMI or WC in predicting metabolic diseases like HT, type 2 diabetes, dyslipidemia, and metabolic syndrome in children.[9]

This study aims to assess the prevalence of obesity and HT in children aged 3-18 years and to determine the role of BMI, WC and WHtR in predicting the risk of high BP and HT in children.

# METHODS

The Dışkapı Yıldırım Beyazıt Training and Research Hospital Ethics Committee approved the study (Date: 12.09.2022, Decision No: 146/25). Informed consent were obtained from the children' parents. All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

The study, a prospective cross-sectional study, involved 752 children aged 3-18 from Turgut Özal Family Health Center between 05.09.2022-05.09.2023.

Children with prior HT diagnoses due to renal, cardiovascular, medication, neurological, or other reasons and those with anatomical abnormalities in the areas to be measured were excluded children included in the study had anthropometric measurements, systolic blood pressure (SBP) and diastolic blood pressure (DBP) according to the specified criteria. Body weights were measured using a calibrated electronic scale with a sensitivity of (±) 100 g. The height measurements of the children were measured in centimeters on the vertical plane using a stadiometer. The BMI value was calculated by dividing the measured body weight by the square meter of the height. The calculated values were used for percentile and SDS calculations using the WHO data for the ages of 2-20. Weight classification in children and adolescents was made according to the WHO classification.[1,10] Children whose BMI values were calculated below the $5^{th}$ percentile for age were classified as underweight, those between the $5^{th}$ and $85^{th}$ percentiles as normal weight, those between the $85^{th}$ and $95^{th}$ percentiles as overweight, and those above the $95^{th}$ percentile as obese.[1,10]

Children's BP was measured using a calibrated air sphygmomanometer and a cuff appropriate for their age and arm circumference. SBP and DBP were measured, with resting time of at least 5 minutes before measurement. Percentile and SDS calculations were made according to the American Pediatric Academy (AAP) 2017 guideline.[4] For children under 13 years of age, $<90^{th}$ percentile is normal BP; $\geq 90^{th}$ percentile - $<95^{th}$ percentile (120/80 mm Hg-$<95^{th}$ percentile) (whichever is lower) is high BP; $\geq 95^{th}$ percentile - $<95^{th}$ percentile+12 mmHg (130/80 to 139/89 mm Hg) (whichever is lower) is Stage 1 HT, $\geq 95^{th}$ percentile. Percentile+12 mm Hg (≥140/90 mm Hg) (whichever is lower) was evaluated as stage 2 HT. Children aged 13 and above have different blood pressure levels: normal (<120/<80 mm Hg), high (120/<80-129/<80 mm Hg), stage 1 HTN (130/80-139/89 mm Hg), and stage 2 HT (≥140/90 mm Hg).[4] If their BP exceeds the $90^{th}$ percentile, they are measured twice, averaged, and staged for further evaluation.

WC was measured with a 1 mm precision tape measure, placed in the midline between the lower part of the lowest rib and the highest point of the iliac crest, while standing upright with feet together. WC SDS was calculated using WC percentiles in Turkish children and adolescents. The WHtR was calculated as the ratio of WC (cm) to height (m), and a cut-off value of 0.5 has been used as a threshold. Those with a WHtR of ≥0.5 were considered to be at risk for abdominal obesity.[11]

## Statistical Analysis

Data analysis was performed with SPSS 27.0 program and was studied with 95% confidence level. Frequency (n) and percentage (%) for categorical (qualitative) variables mean (Average), standard deviation (SD), minimum and maximum statistics were given for numerical (quantitative) variables. Logistic regression, Chi-square, Pearson correlation test, One-way ANOVA tests were used in the study. Logistic regression was used in determining the factors affecting HT in the study, Chi-square was used in the relationships between grouped variables, one-way ANOVA was used in comparing the measurements according to the groups, and Pearson correlation test was used in the relationships between the measurements.

# RESULTS

The study involved 752 children, with 54% male and 46% female, with an average age of 10.05±3.64. The majority were aged 3-12, with 73.9% aged 3-12 and 26.1% aged 13 and over. 2.4% had chronic diseases, with asthma (38.9%), diabetes

(16.7%), and epilepsy (16.7%) being the most common diagnoses.

When the BMI distribution of the children was examined, 67.3% were normal, 11.3% underweight, 13.0% overweight, and 8.4% obese. The majority of children did not have a risky WHtR for abdominal obesity (76.3%). 82.4% had normal BP, with high BP rates at 8.0% and HT at 9.6%. Demographic and clinical characteristics are provided in **Table 1** and **Table 2.**

**Table 1.** Distribution of demographic and clinical characteristics of children

| n=752 | | n (%) |
|---|---|---|
| Gender | Male | 406 (54) |
| | Female | 346 (46) |
| Age(years) | 3-12 | 556 (73.9) |
| | ≥13 | 196 (26.1) |
| Chronic disease | No | 734 (97.6) |
| | Yes | 18 (2.4) |
| Diagnosis | Acute rheumatic fever | 1 (5.6) |
| | Astma | 7 (38.9) |
| | Behçet's disease | 1 (5.6) |
| | Celiac disease | 1 (5.6) |
| | Type 1 diabete mellitus | 3 (16.7) |
| | Epilepsy | 3 (16.7) |
| | Familial Mediterranean fever | 1 (5.6) |
| | Pituitary insufficiency | 1 (5.6) |
| | Inflammatory bowel disease | 1 (5.6) |
| WHtR | No risk | 574 (76.3) |
| | Risky | 178 (23.7) |
| BMI | Underweight | 85 (11.3) |
| | Normal | 506 (67.3) |
| | Overweight | 98 (13) |
| | Obese | 63 (8.4) |
| Blood pressure | Normal | 620 (82.4) |
| | High | 60 (8) |
| | Hypertension | 72 (9.6) |

WHtR: Weist to height ratio, BMI: Body-mass index

Age distribution between males and females were similar (73.9% and 74%), with a significant relationship between gender and BMI, risky WHtR, and BP levels (p<0.05). Males had higher obesity (11.6%), risky WHtR (28.1%), and HT (12.3%) rates, but no significant relationship was found with age and chronic disease (p>0.05) (**Table 3**).

A significant relationship found between children's age and BMI and BP levels (p<0.05), with obesity (8.5%) and HT (12.2%) more common in children aged 3-12 years compared to those aged 13 and over, but not for chronic disease and risky WHtR (p>0.05) (**Table 3**). A significant correlation found between children's BP, BMI, and risky WHtR (p<0.05), with obesity (33.3%) and WHtR (72.2%) more prevalent in children with HT, but not in chronic disease (p>0.05) (**Table 3**).

There was a significant relationship between BP levels and BMI levels and risky WHtR in males and females, with obesity and risky WHtR being higher in females and males with high-tension (HT) (p<0.05). The relationship was not significant for chronic disease (p>0.05). A significant correlation found between BP levels, BMI, and risky WHtR in children aged 3-12 and over 13 years (p<0.05), with higher risky WHtR and obesity in children with HT, but not in chronic disease and BMI (p>0.05) (**Table 3**).

**Table 2.** Descriptive statistics of children's androtopometric and blood pressure measurements

| | Min-Max | Mean±SD |
|---|---|---|
| Age (years) | 3.29-18.01 | 10.05±3.64 |
| Weight | 11.75-107.15 | 37.15±17.59 |
| Weight percentile | 0.03-99.99 | 54.76±30.33 |
| Weight SDS | -3.4-3.63 | 0.18±1.1 |
| Height | 90-192 | 140.19±21.11 |
| Height percentile | 0.25-99.99 | 60.46±27.52 |
| Height SDS | -2.81-4.3 | 0.37±1 |
| BMI | 11.86-34.59 | 17.78±3.8 |
| BMI percentile | 0.02-99.98 | 48.97±32.88 |
| BMI SDS | -3.74-3.58 | -0.09±1.26 |
| WC | 45-110 | 64.09±11.34 |
| WC SDS | -3.28-4.31 | 0.73±1.13 |
| WHtR | 0.33-0.67 | 0.46±0.05 |
| SBP | 70-140 | 100.76±12.76 |
| SBP percentile | 1-99 | 50.71±31.73 |
| SBP SDS | -2.33-2.33 | -0.04±1.19 |
| DBP | 40-90 | 65.18±8.33 |
| DBP percentile | 4-99 | 65.36±23.64 |
| DBP SDS | -1.75-2.33 | 0.49±0.79 |

Min: Minimum, Max: Maximum, SD: Standard deviation, SDS: Z-score, BMI: Body-mass index, WC: Waist circumference, WHtR: Weist to height ratio, SBP: Sistolic blood pressure, DBP: Diastolic blood pressure

A positive, statistically significant relationship found between SBP and BMI (r=0.318), WHtR (r=0.170) measurements in children (p<0.05). There was a positive, statistically significant relationship between DBP and BMI (r=0.336), WHtR (r=0.174) in children (p<0.05).

A positive and statistically significant relationship found between SBP and BMI (r=0.257) (p<0.05) in males, and between DBP and BMI (r=0.297) and WHtR (r=0.137) in males (p<0.05). The relationship with SBP for WHtR was not significant (p>0.05). In females, there was a positive and statistically significant relationship between SBP and BMI (r=0.343), WHtR (r=0.182) (p<0.05), and between DBP and BMI (r=0.351), WHtR (r=0.179) (p<0.05) (**Table 4**).

The study found a significant positive relationship between SBP and BMI (r=0.380), WHtR (r=0.264) in children aged 3-12, and a positive relationship between DBP and BMI(r=0.410), WHtR (r=0.247) in children aged 13 and over (p<0.05), but not significant in children aged 13 and over (p>0.05) (**Table 4**).

There was a statistically significant difference in terms of BMI, Waist, WHtR in children with different BP levels (p<0.05). BMI (20.29), BMI percentile (83.01), BMI SDS (1.18), waist (70.44), waist SDS (1.8), WHtR (0.51) were the highest in children with HT.

A significant difference found in BMI, Waist, and WHtR among males and females with varying BP levels (p<0.05). Children with HT had the highest BMI, BMI percentile, BMI SDS, waist, waist SDS, and WHtR measurements (**Table 5**). There was a statistically significant difference in terms of BMI, Waist, WHtR in children aged 3-12 with different BP levels (p<0.05). BMI, BMI percentile, BMI SDS, waist, waist SDS, WHtR were

**Table 3.** Relationship between demographic and clinical characteristics of children and their gender, age, blood pressure levels

| | | Age (years) n (%) | | Cronic disease n (%) | | WHtR n (%) | | BMI n (%) | | | | BP n (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 3-12 | ≥13 | No | Yes | No risk | Risky | Under weight | Normal | Over weight | Obese | Normal | High | HT |
| **Gender** | Male | 300 (73.9) | 106 (26.1) | 395 (97.3) | 11 (2.7) | 292 (71.9) | 114 (28.1) | 48 (11.8) | 247 (60.8) | 64 (15.8) | 47 (11.6) | 314 (77.3) | 42 (10.3) | 50 (12.3) |
| | Female | 256 (74) | 90 (26) | 339 (98) | 7 (2) | 282 (81.5) | 64 (18.5) | 37 (10.7) | 259 (74.9) | 34 (9.8) | 16 (4.6) | 306 (88.4) | 18 (5.2) | 22 (6.4) |
| **p** | | 0.976 | | 0.708 | | 0.002* | | <0.001* | | | | <0.001* | | |
| **Age (years)** | 3-12 | | | 544 (97.8) | 12 (2.2) | 416 (74.8) | 140 (25.2) | 80 (14.4) | 363 (65.3) | 66 (11.9) | 47 (8.5) | 438 (78.8) | 50 (9) | 68 (12.2) |
| | ≥13 | | | 190 (96.9) | 6 (3.1) | 158 (80.6) | 38 (19.4) | 5 (2.6) | 143 (73) | 32 (16.3) | 16 (8.2) | 182 (92.9) | 10 (5.1) | 4 (2) |
| **p** | | | | 0.586 | | 0.101 | | <0.001* | | | | <0.001* | | |
| **BP** | Normal | | | 604 (97.4) | 16 (2.6) | 514 (82.9) | 106 (17.1) | 80 (12.9) | 457 (73.7) | 51 (8.2) | 32 (5.2) | | | |
| | High | | | 58 (96.7) | 2 (3.3) | 40 (66.7) | 20 (33.3) | 3 (5) | 33 (55) | 17 (28.3) | 7 (11.7) | | | |
| | HT | | | 72 (100) | 0 (0) | 20 (27.8) | 52 (72.2) | 2 (2.8) | 16 (22.2) | 30 (41.7) | 24 (33.3) | | | |
| **p** | | | | 0.395 | | <0.001* | | <0.001* | | | | | | |

*p<0,05 significant relationship; Chi-square test, BMI: Body-mass index, WC: Waist circumference, WHtR: Weist to height ratio, BP: Blood pressure, HT: Hypertension

**Table 4.** Relationship between SBP, DBP and BMI, WHtR measurements in children according to gender and age

| | | BMI SDS | | WHtR | |
|---|---|---|---|---|---|
| | | r | p | r | p |
| **Male** | SBP | 0.257** | <0.001 | 0.099 | 0.065 |
| | DBP | 0.297** | <0.001 | 0.137* | 0.011 |
| **Female** | SBP | 0.343** | <0.001 | 0.182** | <0.001 |
| | DBP | 0.351** | <0.001 | 0.179** | <0.001 |
| **3-12 years** | SBP | 0.380** | <0.001 | 0.264** | <0.001 |
| | DBP | 0.410** | <0.001 | 0.247** | <0.001 |
| **≥13 years** | SBP | 0.065 | 0.364 | 0.067 | 0.353 |
| | DBP | 0.018 | 0.801 | 0.080 | 0.265 |

**p<0.001, *p<0.05 significant relationship, p>0.05 no significant relationship, 0≤r≤0.25 very weak, 0.26≤r≤0.49 weak, 0.50≤r≤0.69 moderate, 0.70≤r≤0.89 strong, 0.90≤r≤1 very strong; Pearson correlation test, BMI: Body-mass index, SDS: Z-score, WHtR: Weist to height ratio, SBP: Systolic blood pressure, DBP: Diastolic blood pressure

the highest in children with HT. No significant difference was found in BMI, waist, and WHtR in children aged 13 and over with different BP levels (p>0.05) (**Table 5**).

In the logistic regression analysis established to determine the factors affecting HT (HT=1: Other:0), the model was found to be statistically significant ($X^2$=151.540; p<0.001; Nagelkerke $R^2$=0.390). The logistic regression analysis revealed that age, BMI level, and risky WHtR significantly affect HT (p<0.05). Age was found to be 10.295 times more prevalent in individuals aged 3-12, 13.929 times more in overweight individuals, 13.207 times more in obese individuals, and 3.011 times more in the risky WHTR group. However, the effect was not significant for gender (p>0.05) (**Table 6**).

**Table 5.** Comparison of BMI, waist circumference, WHtR measurements in children according to blood pressure level in terms of gender and age

| | | BMI (mean±SD) | BMI percentile (mean±SD) | BMI SDS (mean±SD) | WC (mean±SD) | WC SDS (mean±SD) | WHtR (mean±SD) |
|---|---|---|---|---|---|---|---|
| BP* | Normal | 17.61±3.95 | 44.19±32.94 | -0.27±1.28 | 64.97±12.51 | 0.58±1.13 | 0.46±0.05 |
| Male | High | 18.84±3.42 | 73.05±25.08 | 0.73±1.02 | 66.25±11.49 | 1.16±0.92 | 0.48±0.04 |
| | HT | 20.4±3.3 | 84.09±21.53 | 1.25±0.9 | 71.15±11.08 | 1.74±1.03 | 0.52±0.05 |
| p | | <0.001* | 0.001* | <0.001* | <0.001* | <0.001* | <0.001* |
| BP* | Normal | 17.27±3.6 | 41.95±29.38 | -0.33±1.11 | 61.63±9.59 | 0.56±1.02 | 0.44±0.05 |
| Female | High | 17.04±2.59 | 59.23±29.06 | 0.18±1.22 | 60.08±8.03 | 0.91±1.21 | 0.48±0.06 |
| | HT | 20.03±3.61 | 80.56±25.74 | 1.03±1.01 | 68.84±8.5 | 1.93±1.11 | 0.51±0.05 |
| p | | <0.001* | <0.001* | <0.001* | 0.002* | <0.001* | <0.001* |
| BP* | Normal | 15.96±2.7 | 38.72±30.88 | -0.48±1.23 | 58.81±7.98 | 0.46±1.02 | 0.45±0.05 |
| 3-12 years | High | 17.5±2.72 | 68.06±27.79 | 0.53±1.17 | 61.33±8.7 | 1.03±1.06 | 0.48±0.05 |
| | HT | 20.02±2.99 | 83.75±21.04 | 1.22±0.86 | 69.68±9.31 | 1.81±0.99 | 0.52±0.05 |
| p | | <0.001* | <0.001* | <0.001* | <0.001* | <0.001* | <0.001* |
| BP* | Normal | 21±3.63 | 53.58±29.59 | 0.12±1 | 74.2±10.62 | 0.82±1.15 | 0.44±0.06 |
| ≥13 years | High | 22.3±2.99 | 73.13±22.34 | 0.73±0.73 | 79.75±7.1 | 1.38±0.71 | 0.47±0.05 |
| | HT | 24.81±6.48 | 70.41±46.49 | 0.63±2 | 83.5±19.02 | 1.55±2.02 | 0.49±0.1 |
| p | | 0.074 | 0.075 | 0.12 | 0.071 | 0.168 | 0.069 |

*p<0.05 significant difference, p>0.05 no significant difference; ANOVA test, SD: Standard deviation, BMI: Body-mass index, SDS: Z-score, WC: Waist circumference, WHtR: Weist to height ratio, BP: Blood pressure, HT: Hypertension

**Table 6.** Evaluation of factors affecting hypertension according to logistic regression analysis

| | B | p | ODDS | 95% GA ODDS | |
|---|---|---|---|---|---|
| | | | | Bottom | Upper |
| Gender (male) | 0.350 | 0.261 | 1.419 | 0.770 | 2.616 |
| Age (3-12 years) | 2.332 | <0.001* | 10.295 | 3.524 | 30.075 |
| WHtR (risky) | 1.102 | 0.003* | 3.011 | 1.463 | 6.198 |
| BMI | | <0.001* | | | |
| Normal | 0.400 | 0.602 | 1.492 | 0.332 | 6.708 |
| Overweight | 2.634 | 0.001* | 13.929 | 2.921 | 66.418 |
| Obese | 2.581 | 0.002* | 13.207 | 2.569 | 67.907 |

*p<0.05 significant effect, p>0.05 no significant effect; Logistic regression, WHtR: Weist to height ratio, BMI: Body-mass index

## DISCUSSION

Our study investigated the relationship between BMI, WC, WHtR and BP in children aged 3-18 years. Results showed that prevalence of obese and hypertensive children increased. Males had higher rates of obesit, High BP and HT were more common in children aged 3-12 years, with overweight, obese, and WHtR risky individuals.

Obese people prevalence worldwide is increasing, with the World Obesity Atlas 2023 predicting a rise from 10% to 20% in males and 8% to 18% in females by 2035.[2] According to WHO data, the rate of obese children and adolescents aged 5-19 rose from 4% in 1975 to 18% in 2016.[1] In China, obese prevalence increased from 2.51% to 10.56% between 2000 and 2019, resulting in a total prevalence of overweight and obesity from 9.81% to 25.88%.[12]A 2015 study on 5206 children in seven European countries (Turkiye, Bulgaria, Romania, Lithuania, Germany, Italy, and Netherlands) revealed that 15.6% were overweight and 4.9% obese. Romanian children had the highest prevalence of obesity, while Italian children had the lowest. Turkish children had the second highest obesity rate in Europe, at 7.7%.[13] In the United States (USA), the obesity rate was 21.4% in males and 21.6% in females.[14] Based on studies conducted in our country over a 20-year period, obesity rates were shown to be 1.3% in the 2000s, 3.7% in 2009, 7.9% in 2013, and 11.8% in 2022.[1,15,16] According to data from research conducted in our country, the obesity rate ranges between 4.4% and 13%.[16] In our study, 8.4% of the children were obese and 13% were overweight, indicating that roughly one in every five children is obese or overweight. The reasons for this increase in obese prevalence in our study may include decreased physical activity and increased energy intake due to changes in eating habits. Furthermore, the widespread use of technological devices that easily fill free time (smart phones, televisions, computers, etc.) contributes significantly.[1] Obese children prevalence is higher in our study than in the general population, lower than in the USA, but comparable to the findings in Turkiye. The high rates in the USA could be attributed to the country's increased intake of fast food and convenience meals.[14] The prevalence of obesity in Western Europe decreases due to increased public health studies and expenditures.[13] To prevent the epidemic, more emphasis should be placed on programs promoting healthy nutrition, active lifestyles, school activities, and sports in children.[1] According to WHO data, males have a higher obesity rate (8%) than females (6%), and this is also observed in our study (11.6% of males and 4.6% of females).[1] This is likely due to males spending more time on screens and playing video games, leading to a decrease in physical activity.[14]

We found that high BP was present in 8.0% of children and high HT in 9.6%. An increasing trend in the prevalence of childhood HT has been observed in the last 20 years. However, there are few global studies on childhood HT prevalence. In 2019, a meta-analysis found a 4% HT rate and 9.7% high BP rate among children aged 19 and under.[17] We found a two-fold increase in HT rates compared to the 2019 meta-analysis. Childhood HT prevalence in Turkiye varies between 8.5% and 15%, with rates ranging from 4.4% in Sivas in 2004, 5.4% in Bursa in 2007, and 7.9% in Ankara in 2014.[5,18-20] Studies show an increase in HT over the years, attributed to factors such as obesity, increased salt and calorie consumption, lack of physical activity, and stress. The prevalence of HT in Turkiye has been observed to rise due to factors such as obesity, increased salt and calorie consumption, and stress.[18-20]

In our study, males had a higher rate of high BP and HT than females, which is consistent with prior research in our nation and around the World.[18,21,22] This is related to variables such as obesity and computer game addiction, which make males more inactive and prone to high BP. The findings challenges the widely held belief that BP rises with age and body size in children.[23] High BP and HT were more common in children aged 3 to 12, but low BP and HT were more common in children aged 13 and over. This could be attributed to a reduced, less equal population dispersal over 13 years. A study conducted in India in 2022 found that, similar to our study, the increase in BP was inversely correlated with age.[24]

Some studies conducted to establish the best anthropometric predictor of HT risk in children discovered a substantial association between WC and HT.[22] In a study of Chinese children aged 9 to 17, a greater prevalence of HT was seen in abdominal obesity, particularly in young children with high WC, compared to those with normal WC.[25] To determine whether WC is a predictor of cardiovascular complications in children, a study of 160 overweight/obese children and adolescents aged 6-18 years found that visceral obesity in children was not a risk factor for vascular or heart failure, but it was a significant predictor in adolescents.[26]

In our study, we observed that WC and WC SDS measurements were high in children with HT between the ages of 3 and 12 years. A significant relationship was found between HT and WC in this age group, but no significant relationship was found in children over 13. The findings suggest that WC is an effective method for predicting HT in childhood, but its accuracy may be limited by the positive relationship between WC and height.[9] Long-term monitoring is crucial to prevent cardio-metabolic complications.

A Korean study discovered that the WHtRis useful in predicting cardiometabolic risk in normal-weight and overweight children.[27] Males had a higher risky WHtR (28.1%) than females (18.5%), and high-risk children (HT) were found in 72.2% of those with a risky WHtR in our study. Our findings indicate that the WHtR is a highly useful indicator for predicting HT. A favorable link was discovered between SBP, DBP, and WHTR, with slight variations according on gender and age. We found a significant positive relationship between WHtR and SBP in both gender, but no significant relationship with SBP in males. WHTR had a significant relationship with SBP/DBP in the 3-12 age group, but no significant relationship over 13. HT was seen in 72.1% of children with a risky WHtR in the 3-12 age group and 75% of children over 13. This difference may be due to changes in physical and hormonal structures during adolescence.

According to research, there is a significant link between high BMI and WHtR and high BP in young children.[18-20] Similarly, high BMI in adolescence has been shown to be a powerful indication of adult obesity and HT risk, can be utilized to avoid cardiometabolic diseases.[5] These findings underscore the importance of understanding the link between obesity and HT in health policies and prevention strategies, emphasizing the need for targeted interventions to prevent cardiometabolic diseases.[18-20] A study in Korea found that WHtR was higher than BMI in defining cardiometabolic diseases among overweight adolescents. Metabolic syndrome was more common in those with WHtR ≥0.5.[27] Our study supported these findings; HT risk was 13.207 times higher in obese individuals according to BMI and 3.011 times higher in those with WHTR ratio ≥0.5. However BMI was found to be superior to WHtR in predicting HT in our research.

Obesity was discovered in 10.5% of females and 13.9% of males with HT in a 2010 study conducted in Turkiye to investigate the frequency of asymptomatic HT in school-age children.[28] In a 2014 Ankara study, overweight and obesity were shown to be more prevalent in males.[21] Similarly, in our study, obese males (38%) had a higher HT rate than obese females (22.7%). Obesity is thought to be the primary risk factor for developing HT, according to studies.[21,28-30] Our study reveals that obesity and an increased WHtR increase the risk of HT in children, emphasizing the need to prevent and treat childhood obesity to prevent further complications.

### Limitations

The study sample, consisting of a small number of children in a single region, primarily males, does not exhibit a homogeneous distribution between genders. Additionally, the number of children over 13 years old is also less, indicating a lack of uniformity in the distribution.

## CONCLUSION

In conclusion, we discovered that children aged 3 to 12, overweight, obese, risky WHtR had a higher HT rate. BMI was more important than WHtR in predicting high BP ve HT in children. Therefore controlling obesity and the WHtR is critical for preventing HT development. Regular BP monitoring is critical for early detection and intervention. Developing health policies and prevention initiatives for childhood obesity and HT can help to lower adult obesity and cardiovascular problems.

## ETHICAL DECLARATIONS

### Ethics Committee Approval

The Dışkapı Yıldırım Beyazıt Training and Research Hospital Ethics Committee approved the study (Date: 12.09.2022, Decision No: 146/25).

### Informed Consent

Families of all children signed the informed consent form.

### Referee Evaluation Process

Externally peer-reviewed.

### Conflict of Interest Statement

The authors have no conflicts of interest to declare.

### Financial Disclosure

The authors declared that this study has received no financial support.

### Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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