Body Mass Index, Waist Circumference, Hip Circumference, Waist-to-Height Ratio: Which Affects Adolescent Hypertension More?

Vücut Kitle Indeksi, Bel Çevresi, Kalça Çevresi, Bel-Boy Oranı: Hangisi Adölesanlarda Hipertansiyonu Daha Çok Etkiler?

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ABSTRACT

Objective: To determine the prevalence of hypertension in adolescents, its relationship with obesity, and which of the BMI, waist circumference (WC), hip circumference (HC), and waist-height ratio (WHtR) affect adolescent hypertension more.

Material and Methods: In this cross-sectional study, the weights, heights, WC, HC, blood pressure and sociodemographic data measured in May 2019 for students aged 14-18 were analyzed retrospectively. Among the 4580 high school students aged 14-18, 4529 students with complete data were included in the study. Weight, height, waist circumference, hip circumference, blood pressure were measured in students. The predictive values of the variables causing high blood pressure were measured.

Results: The prevalence of hypertension in 4529 students included in the study was 14.3% as 36.5% in the obese and 12.3% non-obese (p<0.001). In correlation analysis, a significant correlation was found between systolic (SBP) and diastolic blood pressures (DBP) and BMI, WHtR, and WC (p<0.001). 34% of SBP can be explained by WC (R^2:0.346), 25% by BMI (R^2:0.25), 34% by WHtR (R^2:0.34) and 24% by HC (R^2:0.24) while 20% of the DBP can be explained by WHtR (R^2:0.20), 15% by BMI (R^2:0.15), 20% by WC (R^2:0.20) and 15% by HC (R^2:0.15).

Conclusion: BMI, WHtR and WC have a greater effect on SBP than DBP. BMI has less contribution to the development of hypertension compared to WHtR and WC.

ÖZET

Amaç: Adölesanlarda hipertansiyon prevalansı, obezite ile ilişkisi ve vücut kitle indeksi (VKİ), bel çevresi, kalça çevresi, bel-boy oranından hangisinin adolesan hipertansiyonunu daha çok etkilediğinin belirlenmesi amaçlandı.

Gereç ve Yöntemler: Çalışma tanımlayıcı kesitsel tiptedir. 14-18 yaş aralığındaki öğrencilerde 2019 Mayıs ayında ölçülen ağırlıkları, boyları, bel çevresi, kalça çevresi, kan basınçları ve sosyodemografik verileri incelendi.

Bulgular: Çalışmaya alınan 4529 öğrencinin hipertansiyon prevalansı %14,3'tür (n=648). Obezitesi olan grupta hipertansiyon saptananlar 140 (%36,5) kişi, obezitesi olmayanlarda 508 (%12,3) kişi olarak bulundu (p<0,001). Korelasyon analizinde; sistolik ve diyastolik kan basınçlarının VKİ, bel-boy oranı, bel çevresi ile arasında anlamlı ilişki bulundu (p<0,001). Lineer regresyon analizi sonucuna göre sistolik kan basıncının %34'ü bel çevresi (R^2:0,346), %25'i VKİ (R^2:0,25),%34'ü Bel-boy oranı (R^2:0,34) %24 'ü kalça çevresi (R^2:0,24) ile açıklanabilir. Diyastolik kan basıncının ise %20'si bel-boy oranı (R^2:0,20), %15'i VKİ (R^2:0,15), %20'si bel çevresi ile (R^2:0,20)ve %15 'i kalça çevresiyle (R^2:0,15) açıklanabilir.

Sonuçlar: VKİ, Bel-boy oranı ve bel çevresinin sistolik kan basıncı üzerine etkisi diyastolik kan basıncından daha fazladır. Hipertansiyon gelişiminde Bel-boy oranı ve bel çevresine göre VKİ'nin daha az katkısı bulunmaktadır.

INTRODUCTION

According to WHO, adolescence is the period of transition to adulthood, which begins with the end of childhood and covers the ages of 10-19 (1). Adolescents make up one sixth (1.2 billion) of the world's population. In Turkey, on the other hand, they constitute 16% of the total population (2). Accounting for a significant proportion of population in the world, this unique period is the transition to an important stage of human development stages, where the foundations a healthy future life are laid. Rapid physical, cognitive and psychosocial developments are observed in this period that progresses to adulthood (1).

Although less common in children and adolescents than in adults, hypertension has recently started to be seen more frequently and has become a public health problem (1). In developed countries such as the USA, India, China, and Hong Kong, the prevalence of hypertension in adolescents is between 3% and 40% (3). Obesity, defined as abnormal or excessive fat accumulation that may impair health, is an important risk factor for hypertension with its direct or indirect effects, and there has been a simultaneous increase in hypertension and obesity in the last two decades (1,4). Adolescent and childhood blood pressure values are correlated with adult blood pressure. That is, children and

adolescents with high blood pressure are more likely to develop hypertension in adulthood than children with low blood pressure. It has also been reported that overweight or obese adolescents are more likely to remain overweight or obese in adulthood (5,6). Since the individual in the adolescence period undergoes the process that forms the basis of their health in the future life, the investments made by the countries in terms of chronic diseases such as hypertension and obesity provide benefits for the next generation (1,7).

Obesity in childhood and adolescence is associated with higher risk of hypertension. However, it remains unclear which of anthropometric indices are the best predictors of hypertension in adolescents. The relationships between obesity indices and hypertension among adolescence have not been studied in Turkey. The aim of this study is to determine which of the hypertension prevalence, obesity and body mass index (BMI), waist circumference (WC), hip circumference (HC), waist-to-height ratio (WHtR) in high school students in Tavsanlı/Turkey influence adolescent hypertension more.

MATERIALS AND METHODS

Study design and setting:
In this cross-sectional study, the data obtained in cooperation with the District Health Directorate between March-May 2019 in high schools in Tavsanlı/Turkey were analysed between May-December 2021.

Study participants:
All 4580 high school students aged 14-18 years were included in the study. No sample was taken Students whose blood pressure measurements (n=51) were incomplete or incorrectly recorded were excluded. Analyzes were made with 4529 students with complete data.

Data collection tools and procedures:
Weight Measurement: Children's weight measurements were made with an electronic scale with ±100 g precision, preferably in the morning, after the scale was adjusted to zero, wearing light clothes without shoes and jackets. Height Measurement: With the steel meter fixed to the wall, the student completely leaning against the wall, the shoes removed, the feet adjacent, the head, back, hips and the back of the heel of the feet touching the height ruler, the height was measured. Blood Pressure Measurement: After the student has rested for at least five minutes, in a sitting position, the cuff air completely evacuated from the right arm, the cuff at the level of the heart 2-2.5 cm above the elbow pit, and the stethoscope placed on the brachial artery covering 1/3 of the arm, measurement was taken with a stethoscope and sphygmomanometer without being placed under the cuff by pressing lightly. Waist Circumference Measurement: It was measured with a non-stretchable tape measure from the midpoint of the lateral iliac prominences and the lowest rib at the level of the umbilicus, while standing and arms open to the sides. Hip Circumference Measurement: It was measured by surrounding the symphysis pubis anteriorly and the most protruding and widest part of the gluteal region posteriorly with a non-stretchable tape measure (8).

American Academy of Pediatrics classification for adolescents 13 years of age and older (normal if <120/80 mmHg, elevated if 120/80-129/80 mmHg, Stage 1 if 130/80 mmHg-139/89 mmHg, Stage 2 hypertension if ≥140/90 mmHg) was taken as the criterion (8). BMI Z Score (standard deviation), a method used to determine the degree of obesity, ≤+1SD – ≥-2SD was accepted as normal weight, while >+1SD as overweight and >+2SD as obesity (9).

Data analysis:
The data of the research were evaluated with IBM SPSS v20 (Statistical Package for the Social Sciences) using descriptive statistics as number and percentage if categorical, and as mean, standard deviation, median and minimum-maximum values if numerical. Pearson's Chi-square test was used to compare categorical variables. Independent Sample T-Test, One-Way Analysis of Variance (ANOVA), Pearson Correlation and Simple Linear Regression Analysis were used to evaluate numerical variables. The results were evaluated within the 95% confidence interval and the p<0.01 value was considered significant.

Ethical considerations:
Ethical approval was obtained from Kütahya Health Sciences University Non-Invasive Clinical Research Ethics Committee (date: 10.06.2021 and decision number: 2021/10-22). The participants were informed about the study and all agreed to participate and gave informed verbal consent. All data were anonymized and confidentiality was maintained.

RESULTS
Of the 4529 students participating in the study, 2269 (50.1%) were female and 3500 (77.4%) were residing in urban areas (Table 1).

The mean WC of the students was 74.3±10.3 cm, and the mean HC was 93.6±9 cm. Their mean BMI was 22.1±4.24, while their mean WHtR was 0.44±0.05. The mean SBP was 110.6±14.1 mmHg, and the mean DBP was 69.86±9.92 mmHg. The mean SBP for boys was 112.2±14.5 mmHg, DBP 70.4±9.9 mmHg, and girls had a mean SBP of 109.1±13.5 mmHg, DBP 69.2±9.8 mmHg (SBP: t =7.30, p<0.001 DBP: t=4.20, p<0.001). The mean BMI was 22.2±4.2 in girls and 22.1±4.2 in boys (p:0.020). The mean WHtR was 0.44±0.05 in girls and 0.44±0.07 in boys (t=2.31, p:0.020). The mean WC for boys was 77±10.6, and it was 71.5±9.3 for girls (t=18.34, p<0.001). HC mean for boys was 93.8±9.1, it was 93.3±8.8 for girls is (t=2.1, p=0.03).

Table 1: Distribution of students by sociodemographic characteristics (n=4529)

Characteristics		n (%)
Gender	Female	2269 (50.1)
	Male	2260 (49.9)
Place of residence	Urban	3500 (77.4)
	Rural	1024 (22.6)
Age distribution	14	528 (11.7)
	15	1126 (24.9)
	16	1126 (24.9)
	17	1113 (24.6)
	18	636 (14.0)

Table 2: Blood pressure stage distribution in obesity and non-obesity groups (n=4529)

BMI Classification	Blood pressure classification			
	Hypertension n (%)	High normal n (%)	Normal n (%)	x2, p value
Non-Obesity	508 (12.3)	1242 (30.0)	2395 (57.8)	
Obesity	140 (36.5)	103 (26.8)	141 (36.7)	173.0, <0,001
Total	648 (14.3)	1345 (29.7)	2536 (55.99)	

BMI: Body Mass İndex

Table 3: Mean of waist-to-height ratio, waist circumference, hip circumference measurements by blood pressure stages

Parameters	Blood Pressure Stages	Mean±SD	Min-max	p value
WHtR	Normal	0.43±0.05	0.31-0.70	
	High	0.44±0.05	0.28-0.68	
	Stage 1	0.46±0.06	0.26-0.65	<0.001
	Stage 2	0.48±0.07	0.34-0.80	
	Total	0.44±0.05	0.26-0.80	
WC	Normal	72.4±9.2	48-116	
	High	74.7±10	50-124	
	Stage 1	78.4±10.9	45-114	<0.001
	Stage 2	82.5±13.3	56-138	
	Total	74.3±10.3	45-138	
HC	Normal	92.0±8.1	54-130	
	High	94.1±8.5	60-130	
	Stage 1	96.7±9.4	66-126	<0.001
	Stage 2	100.3±11.5	78-142	
	Total	93.6±9	54-142	

SD: Standard Deviation, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, BMI: Body Mass İndex, WHtR: Waist-to-height ratio, WC: Waist Circumference, HC: Hip Circumference

The prevalence of hypertension in students was 14.3% (n=648) (Table 2). Of the female students, 1454 (64.3%) had normal blood pressure and 174 (8.1%) had hypertension. Of the boys, 1082 (47.7%) had normal blood pressure and 466 (20.5%) had hypertension. There was a significant difference (x2=183.48, p<0.001) between the blood pressure stages between the two genders. Hypertension was detected in 178 (17.4%) people living in rural areas and 470 (13.4%) people living in urban areas (x2=14.053, p:0,003). 80 (15.1%) of 14-year-olds, 130 (11.4%) of 15 years old, 155 (13.8%) of 16 years old, 184 (16.5%) of 17 years old, 99 (15.5%) of the 18 years old students were found to be in the hypertensive stage (x2=27.42, p:0,007). The obesity prevalence of the students was found to be 8.5% (n:384). In the classification of adolescents according to body mass index, 1626 (71.9%) girls were normal weight and 166 (7.3%) were obese, whereas 1624 (71.6%) boys were normal and 218 (9.6%) were obese (x2=21.79, p<0.001).

While 140 (36.5%) people were found to have hypertension in the obese group, hypertension was found in 508 (12.3%) people in the non-obese group (x2=173.00, p<0.001) (Table 2). Of the obese students, 46 (12.0%) were in Stage 1 hypertension stage, 94 (24.5%) were in Stage 2 hypertension stage.

A statistically significant difference was found between the groups in the mean of WHtR, WC and HC according to the blood pressure stage of the students participating in the study (WHtR: F=72.5, p<0.001), (WC: F=128.8, p<0.001), (HC: F=114, p<0.001)(Table 3).

A positive and statistically significant correlation was found between SBP and DBP and BMI, WHtR, HC and WC variables. A statistically moderate, positive and significant relationship was found between SBP and BMI (r=0.509; p<0.001), between SBP and WHtR (r=0.588; p<0.001), between SBP and HC (r=0.496; p<0.001), and between SBP and WC (r=0.588; p<0.001). A weak, positive and statistically significant relationship was found between DBP and BMI values (r=0.391; p<0.001). A moderate, positive and significant relationship was found between DBP and WHtR values at moderate level (r=0.451; p<0.001), between DBP and HC values at weak level (r=0.389; p<0.001), and between DBP and WC values were (r=0.453; p<0.001) at statistically moderate level (Table 4).

According to the results of the linear regression analysis, performed to determine how much BMI, WHtR, WC, and HC affected DBP and SBP, 34% of SBP can be explained by WC (R2:0.346; Beta (β):0.80; 95% CI: 0.77-0.83; p<0.001), 25% by BMI (R2:0.25; Beta (β):1.69; 95% CI:1.61-1.78; p<0.001), 34% by WHtR (R2:0.34; Beta (β):142; 95% CI:136-147.2; p<0.001), 24% by HC (R2:

Table 4: Pearson correlation analysis results between SBP, DBP, BMI, WHtR, hip circumference and waist circumference

		SBP	DBP	BMI	WHtR	WC	HC
SBP	r	1					
	p	-					
DBP	r	0.719	1				
	p	<0.001	-				
BMI	r	0.509	0.391	1			
	p	<0.001	<0.001	-			
WHtR	r	0.588	0.451	0.812	1		
	p	<0.001	<0.001	<0.001	-		
WC	r	0.496	0.389	0.849	0.743	1	
	p	<0.001	<0.001	<0.001	<0.001	-	
HC	r	0.588	0.453	0.785	0.929	0.800	1
	p	<0.001	<0.001	<0.001	<0.001	<0.001	-

SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, BMI: Body Mass İndex, WHtR: Waist-to-height ratio, WC: Waist Circumference, HC: Hip Circumference

0.24; Beta (β):0.78; 95% CI:0.74-0.82; p<0.001). On the other hand, 20% of DBP can be explained by WHtR (R2:0.20; Beta (β):0.43; 95% CI:0.40-0.45; p<0.001), 15% by BMI (R2:0.15; Beta (β): 0.91; 95% CI:0.85-0.97; p<0.001), 20% by WC (R2: 0.20; Beta (β): 76.1; 95% CI:71.7-80.5;p<0.001) and 15% by HC (R2:0.15; Beta (β): 0.42; 95% CI:0.40-0.45; p<0.001).

DISCUSSION

In this study, the prevalence of hypertension was found 14.3% (8.1% in girls and 20.5% in boys). The prevalence of obesity was found 8.5% (7.3% in girls, 9.6% in boys). Hypertension was found in 36.5% of the obese group and 12.3% of the non-obese group. In addition, it was found that the SBP and DBP average of obese students were higher. Accordingly, the findings of our study support the evidence on the effect of obesity on the development of hypertension (10).

The prevalence of hypertension determined in our study was 14.3%. In previous studies, the prevalence of hypertension was found to be between 2% and 5%, and the prevalence of prehypertension ranged from 4% to 15% (3,10). In a systematic review evaluating adolescents in Brazil, the prevalence of hypertension was found 8.1% (11). In a small number of studies conducted in Turkey, it was reported that hypertension in adolescents varied between 6.25% and 15.0% (12,13). The prevalence of hypertension may be higher in adolescents. Studies conducted in the USA and Europe have found that only 13% to 26% of childhood hypertension is correctly diagnosed (10). Furthermore, it is difficult to compare the prevalence of hypertension in adolescents due to methodological differences and different reference criteria, which may cause high variability in hypertension prevalence (14).

In our study, 8.1% of female and 20.5% of male adolescents were found to be hypertensive. Similarly, in studies in Malaysia and Hong Kong, hypertension was found to be higher in boys than in girls (10,15). In Brazilian adolescents, female gender was found to be more hypertensive with a rate of 12.7% (16). In addition, in our study, the mean SBP and DBP levels were found to be higher in boys than girls. In some studies, the mean of SBP and DBP was found to be higher in men, similar to our study (17,18). In studies conducted in Brazil and Spain, no difference was found between the two genders in DBP (19,20). In general, hypertension is more common in children, adolescents and adult men than in premenopausal women (21). As seen in these epidemiological studies, men are the gender that has a higher risk for hypertension from childhood. Therefore, male adolescents should be evaluated primarily during screening, prevention and intervention stages.

In our study, hypertension was seen at a higher level in those living in rural areas. In a study conducted in China, although hypertension was observed more frequently in urban areas in males, a similar situation was not observed in female students (22). In a study conducted in India, unlike our study, the prevalence of hypertension was found to be higher in urban areas (23). According to some studies, the prevalence of hypertension in developed countries and many developing countries is higher in urban areas than in rural areas (23). It appears that there is a need for studies that will examine the reasons for the higher prevalence of hypertension in rural adolescents, contrary to the literature.

In our study, in which it was aimed to evaluate the relationship between obesity and hypertension epidemiologically, 36.5% of the students in the obese group were found to be hypertensive, and 12.3% of the students in the non-obese group were found to be hypertensive. In the literature, hypertension was observed more frequently in obese adolescents (10,22,24). According to our study, as the WHtR, HC, WC averages of the students increased, so did the hypertension stage. Similar to our study, in another study, as WC, WHtR and BMI averages increased, so did the stage of hypertension. SBP and DBP averages are higher among obese adolescents (10,25).The findings of our study are similar to the studies in which the relationship between hypertension and obesity in adolescents was established. In our findings, SBP and DBP were positively correlated with BMI, WHtR, HC, and WC, and in a study conducted in China, similarly, BMI levels were found to be positively correlated with SBP and DBP levels (26).

Again, as in our study, SBP, DBP and BMI, WHtR and WC were found to be correlated in studies conducted in South Asia, China and Uganda (3,27,28). In another study, a low-moderate correlation was found only between WC and blood pressure (29). The relationship of BMI, WHtR and WC, which are used to determine obesity and body fat distribution, with hypertension are also seen in these studies, as in our study.

According to our study, the effects of BMI, WHtR and WC on SBP are more than DBP. It is understood that the primary effect of obesity on blood pressure is on SBP. In obesity research, WC measurements are used to determine central obesity in addition to BMI. WHtR is used as a measure of the distribution of body fat in the body (10,28). According to our study, 34% of SBP could be explained by WC, 25% by BMI and 34% by WHtR. In addition, 20% of DBP can be explained by WHtR, 15% by BMI, and 20% by WC. It is seen that BMI, which is frequently used in the evaluation of obesity, contributes less to the development of hypertension than WHtR and WC. Our study also shows that evaluations made with BMI alone in adolescents are not sufficient especially in the evaluation of hypertension risk. Therefore, in the selection of interventions for the prevention of both systolic and diastolic hypertensions in adolescents, it will be more effective to prefer interventions that reduce the ratio of WC and WHtR.

This study is the first to examine the relationship between obesity indices and hypertension in Turkey. The strengths of the study are that it covers all high school students in the Tavsanlı/Turkey and that the measurements are made by authorized and trained health professionals. The limitation of the study is that the study was conducted in a specific region and the results do not reflect the whole country. One of the limitations of the study is the determination of blood pressure with a single measurement.

CONCLUSION

According to our study, the effects of BMI, WHtR and WC are more on SBP than on DBP. WHtR and WC contribute more to the development of hypertension than BMI. Since the effects of WC and WHtR on both SBP and DBP are higher than those of BMI, it is thought that in the selection of interventions for the prevention of both systolic and diastolic hypertensions in adolescents, interventions that reduce WC and WHtR will be more effective.

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