

Original Research Article

Effect of total body fat on blood pressure in adolescents

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ABSTRACT

Background: Hypertension is a growing health concern among adolescents, with rising prevalence demanding a deeper understanding of its causes. Anthropometric factors are potential contributors to blood pressure variations, but their relationship with adolescent blood pressure remains unclear.

Methods: A cross-sectional study of 110 adolescents at King George's Medical College, Lucknow, from 20th June 2023 to 1st March 2024, examined the link between anthropometric parameters and blood pressure. Measurements followed standard protocols, and statistical analysis included correlation, linear regression, and multivariate methods.

Results: Participants averaged 15.98 years, with mean height, weight, and BMI of 164.92 cm, 61.98 kg, and 22.48 kg/m². Diabetes history was reported in 23.64%, and 27.27% had hypertension. Average waist and hip circumferences were 84.49 cm and 93.43 cm, with body fat at 21.33%. Mean systolic and diastolic pressures were 120.36 mmHg and 77.15 mmHg, with 9.09% showing elevated blood pressure. Males had higher physical measurements and systolic pressure, while females had higher body fat. Systolic pressure correlated with age, size, and BMI, while diastolic pressure linked to weight, BMI, and body fat.

Conclusions: Body measurements and fat levels significantly impact adolescent blood pressure. Higher body fat, waist circumference, and weight are linked to increased diastolic pressure, while systolic pressure correlates with age, height, and body size. Males tend to have higher systolic pressure and physical measurements, while females show higher body fat percentages. These findings highlight the importance of monitoring body composition to prevent hypertension and reduce cardiovascular risks in adolescents.

Keywords: Adolescents, Hypertension, Physical measurements, Total body fat

INTRODUCTION

Weight in children and youths is a worldwide wellbeing issue with expanding predominance in low-income and middle-income nations (LMICs) as well as a tall predominance in numerous high-income countries.¹ Obesity during childhood is likely to continue into adulthood and is associated with cardiometabolic and psychosocial comorbidity as well as premature mortality.²⁻⁴ Obesity and excessive central fat are changes that precede the increase in blood pressure in children and adolescents, according to epidemiological investigations that used high

precision technologies for estimating body adiposity.¹ Since the 70s, a few considers appeared body mass record (BMI) as the best indicator of tall blood weight in childhood and adolescence.^{1,4} Assist examinations too considered BMI an vital marker in the relationship between blood weight and central adiposity indicators.^{5,6} On the other hand, the accumulation of adipose tissue in the central region of the body has been considered as a better determinant for the development of high blood pressure than total adiposity.⁷

Currently, in any case, there is no agreement on the choice of anthropometric indicator of tall blood weight in this populace. Anthropometric markers such as BMI, abdomen circumference, triceps skinfold and, more as of late, the waist-to-height proportion, have been explored for legitimacy in anticipating the chance for tall blood weight in the pediatric population.^{3,8} Cardiovascular illness occasions are seen most habitually after the fifth decade. Also likely, hypertension in young did not receive a public health attention, which might be due to the lack of awareness, considering it as a problem of adults only.^{9,10}

However, pathophysiological and epidemiological evidence suggests that essential hypertension and the precursors of cardiovascular diseases such as left ventricular hypertrophy, atherosclerosis and reduced cognitive function originate in childhood but go undetected unless specifically looked for during this age-group.^{11,12} There is strong evidence that raised BMI during adolescence is associated with raised risk of developing hypertension and/ or CVD as an adult and also there is a 12% increase in risk of developing CVD for each unit increase in BMI among adolescents.^{13,14} Childhood Blood pressure (BP) is a strong indicator of adult blood pressure, hence, early intervention is important.¹⁵ Thus, early detection of hypertension and its precipitating or aggravating factors is important so that future burden and complications of hypertension can be prevented. In India, the prevalence of hypertension among adolescents, who comprise one- fifth (21%) of India's population, ranges from as low as 2% to 21.5%.^{17,18} Obesity is associated with several risk factors for the development of heart diseases and other chronic problems including hyperlipidaemia, hyperinsulinemia, hypertension and early atherosclerosis.^{19,21}

Hypertension, a global health concern, affects individuals of all ages, including adolescents. Traditionally considered a disease of adulthood, it is now recognized as a significant health issue due to its association with adverse cardiovascular outcomes. The prevalence of hypertension among adolescents is increasing, paralleling the global obesity epidemic, where obesity is a well-established risk factor for hypertension in both adults and adolescents.

Total body fat and anthropometric parameters like BMI, waist circumference, and waist-to-hip ratio are key indicators of adiposity and body fat distribution. They have been extensively studied in relation to blood pressure levels in adolescents, making understanding their impact on blood pressure regulation crucial for identifying hypertension risk and implementing preventive strategies.

Research consistently shows a positive association between total body fat and blood pressure levels in adolescents. Higher body fatness is linked to elevated systolic and diastolic blood pressure, while central adiposity, measured by waist circumference and waist-to-hip ratio, is also associated with increased blood pressure. These findings emphasize the importance of considering

both adiposity and body fat distribution in assessing hypertension risk among adolescents. Gender differences in body fat distribution and blood pressure have also been observed, with girls tending to accumulate more fat mass in the hip and thigh region, while boys often exhibit greater central adiposity. These gender-specific differences may contribute to variations in blood pressure regulation and highlight the need for tailored hypertension prevention and management strategies.

The relationship between body fat and blood pressure among adolescents is influenced by gender, ethnic, and racial differences. These differences can influence hypertension risk, necessitating the development of culturally sensitive interventions. Investigating the effect of total body fat and anthropometric parameters on blood pressure is crucial for early detection, prevention, and management of hypertension in adolescents. This review examines the literature on this topic, exploring mechanisms, gender differences, ethnic/racial variations, and implications for intervention and prevention strategies. By understanding these relationships, healthcare providers can better identify and support adolescents at risk of hypertension, ultimately improving long-term cardiovascular health outcomes.

METHODS

Study design

The study was designed as a cross-sectional study, which allowed for a snapshot of the health status of adolescents at a specific point in time. This design is well-suited for examining the relationships between anthropometric measurements and blood pressure. The study was conducted over a one-year period to accommodate the logistics of data collection and analysis.

Study setting and period

The research was conducted at the Department of Physiology, King George's Medical University (KGMU) in Lucknow, India. The study involved collaboration with several schools located in Lucknow, Uttar Pradesh. Ethical clearance for the study was obtained from the Research Cell at KGMU, as documented by Ethical Clearance Ref. No. XV/PGTSC-IIA/P15. Prior to initiating the study, formal written permissions were secured from the school authorities to facilitate the research activities. Additionally, informed consent was obtained from the parents or guardians of each participant to ensure that they were fully aware of the study's objectives, procedures, and any potential risks involved. This study conducted from 20th June 2023 to 1st March 2024.

Participants

The study targeted adolescents aged between 12 and 18 years. To collect data, health camps were organized during school hours, which allowed for a structured and efficient

data collection process without disrupting the students' academic activities. The process was designed to be minimally invasive and respectful of the students' daily routines. Detailed information about the study procedures was provided to school authorities, parents, and guardians prior to the commencement of the study. Participation was entirely voluntary, and only those students who gave their consent were included in the study.

Measurement and anthropometric parameters

A comprehensive set of anthropometric measurements was conducted to assess various health indicators:

Height: Measured using a wall stadiometer, which ensures accurate and consistent height measurements.

Weight: Recorded with a calibrated digital weighing scale to provide precise weight data.

Body Mass Index (BMI): Calculated using the formula:

$BMI = \text{Weight (kg)} / \text{Height (m)}^2$, which helps in assessing overall body fatness.

Waist Circumference: Measured with a flexible, non-elastic tape to evaluate abdominal fat distribution.

Hip Circumference: Also measured with a flexible, non-elastic tape to provide additional data on body fat distribution.

Body Fat Percentage: Assessed using a body fat analyzer, which provides an estimate of the proportion of body fat.

All equipment used for these measurements was calibrated and standardized to ensure accuracy and reliability.

Inclusion criteria

Participants aged between 12 and 18 years, both male and female students, and students in apparent good health, without any known medical conditions were included.

Exclusion criteria

Students aged below 12 years or above 18 years, and individuals with any diagnosed medical conditions that could impact the study results were excluded.

The methodology of the study involved several key procedures to ensure accurate and reliable data collection. Blood pressure was measured using (Beurer BP apparatus) a calibrated digital sphygmomanometer, providing consistent and precise readings. Total body fat was assessed using a body fat analyser (BODYSTAT MDD 1500), which accurately measures body composition. Height and weight were recorded using a wall stadiometer and a calibrated digital weighing scale, respectively. Waist and hip circumferences were measured with a flexible, non-elastic tape to assess fat distribution.

These measurements were conducted in a controlled environment to minimize errors and ensure the accuracy of the data. By following standardized procedures and using calibrated equipment, the study aimed to obtain reliable results that would contribute valuable insights into the relationship between body composition and blood pressure in adolescents. The findings are intended to inform future health interventions and preventive measures targeting adolescent cardiovascular health.

Sample size

The study included a sample size of 110 participants. This number was selected to provide sufficient data for analyzing the relationships between body composition parameters and blood pressure, ensuring that the results would be statistically meaningful and representative of the adolescent population in the study area.

RESULTS

The demographic data collected from the participants revealed the age distribution of the subjects, with 29.09% in the 12-14 years age group, 19.09% in the 15-16 years age group, and 51.82% in the 17-18 years age group. The mean age of the participants was 15.98 ± 2.15 years. Regarding gender distribution, the majority of participants were male, accounting for 79.09%, while females represented 20.91% of the sample. The anthropometric measurements, including height, weight, and BMI, showed a mean height of 164.92 ± 11.69 cm, ranging from 120 to 190 cm. The mean weight was 61.98 ± 16.28 kg, with values ranging from 23.60 to 106 kg. The mean BMI was 22.48 ± 4.20 kg/m², with a range of 12 to 34.60 kg/m². In terms of BMI classification, 18.18% of participants were classified as underweight (<18.5 kg/m²), 35.45% as normal weight (18.5 - 22.9 kg/m²), 20.91% as overweight (23 - 24.9 kg/m²), and 25.45% as obese (≥ 25 kg/m²) (Table 4).

Table 1: Details of height, weight and BMI of the participants.

	Mean	Median	Std. Deviation	Minimum	Maximum
Height (cm)	164.92	166.00	11.69	120.00	190.00
Weight (kg)	61.98	61.00	16.28	23.60	106.00
BMI (kg/m²)	22.48	22.45	4.20	12.00	34.60

Table 2: Details of waist circumference (WC), hip circumference (HC) and total body fat (%) of the subjects.

	Mean	Median	Std. Deviation	Minimum	Maximum
Waist circumference (cm)	84.49	84.00	11.88	37.00	115.00
Hip circumference (cm)	93.43	94.00	12.61	38.00	127.00
Total body fat (%)	21.33	20.05	7.73	10.00	45.40

Table 3: Details of blood pressure (systolic BP (mmHg) and diastolic BP (mmHg) of the subjects.

	Mean	Median	Std. Deviation	Minimum	Maximum
Systolic BP (mmHg)	120.36	122.00	12.16	78.00	146.00
Diastolic BP (mmHg)	77.15	74.00	10.38	56.00	115.00

Table 4: Association of mean total body fat (%) between male and female.

	Male (n=87)		Female (n=23)		t	P value
	Mean	±SD	Mean	±SD		
Total body fat (%)	20.42	7.59	24.74	7.47	-2.43	0.017

Family history data revealed that 23.64% of participants had a family history of diabetes mellitus, and 27.27% had a family history of hypertension. Regarding body composition, the mean waist circumference was 84.49 ± 11.88 cm, ranging from 37.00 to 115.00 cm. The average hip circumference was 93.43 ± 12.61 cm, with values ranging from 38.00 to 127.00 cm. The mean total body fat percentage was $21.33 \pm 7.73\%$, with a range from 10.00 to 45.40%.

The blood pressure measurements showed a mean systolic BP of 120.36 ± 12.16 mmHg, ranging from 78.0 to 146 mmHg, and a mean diastolic BP of 77.15 ± 10.38 mmHg, with a range from 56 to 115 mmHg (Table 3).

Finally, the association between total body fat percentage and gender indicated that males had an average total body fat percentage of 20.42 ± 7.59 , while females had a higher average of 24.74 ± 7.47 . This difference was statistically significant, with females showing a substantially greater total body fat percentage than males (Table 4).

DISCUSSION

High blood pressure in adolescents is associated with a higher likelihood of developing cardiovascular disease and premature atherosclerosis in adulthood. Increased body weight is associated with an increase in high blood pressure, which in turn may contribute to the development of atherosclerotic disease in the future. Obesity is associated with a range of health problems, including cardiovascular disease and a variety of metabolic, pulmonary, neurological, orthopaedic and social conditions. Gender, age and body composition are other factors that influence blood pressure. It is therefore essential to start monitoring high blood pressure in adolescents.

Anthropometric measurements such as BMI, waist circumference and skinfold thickness are cost-effective and non-invasive methods to assess the nutritional status of adolescents. However, there is still uncertainty about the factors that influence blood pressure. Several studies have found a direct correlation between blood pressure (BP) and body mass index (BMI). However, BMI is considered an inaccurate measure of body fat percentage and has been criticized for its limited ability to distinguish between fat and lean muscle. In addition, the measurement of abdominal fat is used to evaluate the risk of cardiometabolic disorders, as the distribution of adipose tissue significantly influences the likelihood of developing such disorders.

The aim of this study was to determine the effect of various anthropometric parameters and total body fat on blood pressure in adolescents.

In our study the age, height, weight, BMI, waist circumference and hip circumference were all positively correlated with systolic blood pressure. However, there is a positive correlation between weight (kg), BMI (kg/m^2), waist circumference (cm), hip circumference (cm), total body fat percentage (%) and diastolic blood pressure.

Sebati et al (2020) discovered remarkable associations between systolic blood pressure (SBP) and diastolic blood pressure (DBP) with various factors including age, weight, height, body mass index (BMI), waist circumference (WC), hip circumference (HC), waist-to-hip ratio (WHR), triceps skinfold thickness, under hood skinfold thickness, and body fat percentage in children (both girls and boys) aged 5 to 15 years. Kelis Hadi et al (2012) investigated the correlation between various anthropometric measures, such as body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR), and skinfold thickness, and blood pressure levels in a large group of Iranian teenagers. The results showed that there were positive

correlations between BMI, WC, WHR and skinfold thickness with blood pressure levels in teenagers. This suggests that higher body fat percentage and central obesity are associated with increased blood pressure. Savva et al (2000) found that there was an association between higher BMI, WC and skinfold thickness and increased blood pressure levels. They also observed an increased risk of developing hypertension in adolescence in those who had these higher levels. The study conducted by Zhang et al. (2019) showed a clear association between a higher body fat percentage and increased blood pressure levels as well as an increased risk of hypertension in the group studied.

Mushengezi and Chillo found a similar correlation with fat mass.¹⁸ In addition, Gomwe et al found a strong correlation between systolic blood pressure (SBP) in children and many anthropometric factors, including stature, weight, BMI, WC, triceps, subscapular and gluteal fold thickness and % body fat.² No association was found for waist-to-hip ratio (WHR). Gaskin et al discovered an association between hypertension, height and gender-specific body composition features in adolescents.¹⁹

Our study found that 9.09% of participants had high blood pressure, with 2.73% having high systolic blood pressure and 10.0% having high diastolic blood pressure, defined as a blood pressure reading of $\geq 140/90$ mmHg. Among males, 9.2% exhibited elevated blood pressure, with 3.45% experiencing elevated systolic blood pressure and 10.34% experiencing elevated diastolic blood pressure. Out of the female population, 9.7% had elevated blood pressure, with 0.0% having high systolic blood pressure and 8.70% having high diastolic blood pressure. Another study found that the occurrence of high systolic blood pressure (SBP) was 5.6% among girls and 4.8% among boys. The results were comparable to those obtained when DBP was utilized.² Sebati et al (2020) demonstrated that the occurrence of elevated systolic blood pressure (SBP) was 5.7% and 4.8% among girls and boys, respectively. Similarly, elevated diastolic blood pressure (DBP) was found in 6.1% of girls and 5.1% of boys. Lloyd et al found that higher body weight is linked to an increase in hypertension, which in turn can contribute to the development of atherosclerotic disease in the future.⁴

The study has several limitations, including its cross-sectional design, which restricts the ability to determine cause-and-effect relationships. The sample size of 110 participants and its location in Lucknow, India, may limit the generalizability of the findings. Self-reported family history data could introduce bias, and the study did not account for potential confounding factors like diet, physical activity, and socioeconomic status. Using BMI as the primary measure of adiposity may not accurately reflect fat distribution, and measurement errors in waist and hip circumferences could affect data reliability. Lastly, the one-year duration may not capture long-term effects.

CONCLUSION

In conclusion, the impact of overall body fat on blood pressure in adolescents highlights the significance of treating adiposity as a changeable risk factor for hypertension during this crucial stage of growth. Incorporating a thorough evaluation of cardiovascular risk and implementing specific therapies as part of regular medical care can effectively reduce the impact of cardiovascular disease during adolescence and beyond.

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