International Journal of Scientific Research in Dental and Medical Sciences

www.ijsrdms.com

Association Between Hypertension Risk in Adolescents and Body Mass Index: A Cross-Sectional Study

Bipul Pradhan [a], Poonam Punjabi [b], Manisha Sankhla [b], Anuradha Yadav [a,*], Kavita Yadav [a], Kusum Lata Guar [c]

[a] *Department of Physiology, SMS Medical College, Jaipur, India*
[b] *Department of Physiology SMS Medical College, Jaipur, India*
[c] *Department of Community Medicine, SMS Medical College, Jaipur, India*

ARTICLE INFO

Article history:
Received 01 October 2023
Received in revised form 14 November 2023
Accepted 27 November 2023
Available online 01 December 2023

Keywords:
Blood Pressure
Body Mass Index
Cross-Sectional Studies
Obesity
Prevalence

ABSTRACT

Background and aim: Hypertension, linked to lifestyle factors, is increasing among adolescents, particularly overweight and obese adolescents. Early detection is crucial to reducing disability and premature death. Moreover, most research is conducted in developed countries, leaving little information for the Indian context. Thus, this study aims to investigate the link between adolescent obesity and hypertension to address this knowledge gap.

Material and methods: A cross-sectional study of 600 school-going adolescents was conducted, collecting sociodemographic information and measuring blood pressure thrice. Body Mass Index (BMI) was categorized using Asian cut-off points, while blood pressure was classified according to the National High Blood Pressure Educational Program guidelines. The data was expressed in percentages and proportions, with a p-value less than 0.05 considered significant.

Results: Among the adolescents, 68% were categorized as underweight. Notably, the prevalence of hypertension increased dramatically from 7% in underweight to 36% in obese adolescents. BMI was found to account for 16% of the variability in Systolic Blood Pressure (SBP) (R2 = 0.157) and 6% of the variability in Diastolic Blood Pressure (DBP) (R2 = 0.06). Furthermore, a significant positive correlation was observed between blood pressure (SBP and DBP) and BMI ($p < 0.001$).

Conclusions: The study reveals a strong link between BMI and blood pressure levels, with higher BMIs increasing hypertension prevalence, especially concerning SBP. It underscores the need for continuous monitoring and proactive BMI management in adolescents to prevent and address blood pressure-related issues.

1. Introduction

Hypertension, a chronic non-communicable disease, garners global attention as it affects not only adults but also adolescents.[1, 2] The prevalence of hypertension (HTN) among children aged 6–19 has surged by a staggering 75–79% over the past 15 years.[2] In India, where adolescents comprise one-fifth (21%)[3] of the population, the prevalence of hypertension varies from as low as 2%[4] to as high as 21.5%.[5] 13–26% of children with HTN in Europe and the United States are correctly identified.[6] Adolescent hypertension is recognized as the most prevalent cardiovascular disease risk factor worldwide.[7-9] Moreover, it exerts an adverse effect on target organs such as the arteries, heart, brain, kidney, and retinal artery,[10] potentially leading to premature death[11] and the transition into adulthood with hypertension.[12-14] It is widely acknowledged that the increased prevalence of pediatric HTN is closely linked to obesity.[15] Several studies have established a positive association between Body Mass Index (BMI) and hypertension in adolescents. Recent research reveals that the strength of this association increases non-linearly with the continuous change in BMI in children and adolescents.[16] Generally, adolescents who are overweight and obese are more susceptible to HTN than normal-weight individuals, irrespective of gender.[17] A study published in the Journal of Pediatrics 2020 found that a lifestyle intervention program encompassing weight loss, increased physical activity, and dietary changes effectively reduced blood pressure in overweight and obese adolescents with hypertension. These studies underscore the importance of monitoring BMI in adolescents and the necessity for weight management interventions to prevent the development of hypertension and related cardiovascular diseases.[18] Identifying children and adolescents at hypertensive risk represents the first step in preventing the disease and its risk

* Corresponding author. *Anuradha Yadav*
E-mail address: dr.anuradhayadav@yahoo.co.in
Department of Physiology, SMS Medical College, Jaipur, India
https://doi.org/10.30485/IJSRDMS.2023.422714.1544

factors, including cigarette smoking, alcohol intake, physical inactivity, obesity, steroid abuse, family history of hypertension, low birth weight, hypercholesterolemia, hyperinsulinemia, homocysteinemia, and poor nutrition.[19] It has been demonstrated that hypertension observed in children can progress into adulthood, contributing to increased cardiovascular morbidity and mortality in adults.[20-22] Hence, early detection of HTN in adolescents is imperative to reduce the potential burden of disability and premature death. From a disease prevention standpoint, it is crucial to consider elevated blood pressure as a risk factor in the pediatric age group well before clinical manifestations become apparent in later life.[23] Unfortunately, the public remains largely unaware that obesity is one of the major risk factors for adolescent hypertension. Additionally, most research is conducted in developed nations, with limited literature available for the Indian context. Therefore, the present study hypothesizes an association between childhood obesity and hypertension, seeking to fill this knowledge gap.

2. Material and methods

A cross-sectional, community-based survey was conducted on 600 healthy school-going adolescents aged 10-19. Before the study commenced, approval was obtained from the Ethical Committee, and consent was obtained from the school administration and parents, laying the foundation for the present study. Students who were unwilling to participate, suffered from any acute or chronic diseases, were taking medication, or had substance addiction issues were diligently excluded from the study to ensure data integrity. Each participant was then tasked with completing a pre-designed working proforma, collecting essential personal information such as age, gender, place of residence, religion, caste, and the educational status of parents, among other pertinent details. Additionally, comprehensive anthropometric measurements were taken for all subjects, allowing for the subsequent calculation of Body Mass Index (BMI) using Quetelet's index formula: BMI = weight (kg) / Height (m^2). These calculations facilitated the classification of participants into three distinct categories using the WHO Asian BMI risk cut points: 18.5 ‑ 22.9 kg/m^2 (normal weight), 23-27.5 kg/m^2 (overweight), and ⩾27.5 kg/m^2 (obese).[24] Adolescents were granted a five-minute resting period in a seated position to measure blood pressure accurately. Following this, using a standardized mercury sphygmomanometer and with all necessary precautions in place, three readings of systolic and diastolic blood pressure (SBP, DBP) were obtained at 5-minute intervals. The subsequent average blood pressure readings were then converted into percentiles, facilitating the classification of adolescents into one of three categories: normotensive, pre-hypertensive, or hypertensive. These categorizations were based on the National High Blood Pressure Educational Program (NHBPEP) guidelines outlined in the fourth report on blood pressure.[25] (Table 1)

Table 1. Classification of Hypertension in Children and Adolescents.

Normal	<90th
Prehypertension	90th to <95th or if BP exceeds 120/80 mmHg even if below 90th percentile up to <95th percentile
Stage 1 hypertension	95th percentile to the 99th percentile plus 5 mmHg
Stage 2 hypertension	>99th percentile plus 5 mmHg

Ethical clearance

Taken from the Institutional Ethics Committee (3952/Medical College/Ethical Committee).

Statistical analysis

All the collected data was entered and compiled into an Excel sheet, and statistical analyses were performed using a statistical software primer (version 6). The qualitative data was expressed in percentages and proportions; the chi-square test was used to infer the significance of proportion. The regression analysis was performed for the correlation coefficient. A p-value less than 0.05 is considered as significant.

3. Results

The present study encompassed 600 adolescents of both genders hailing from urban and rural areas, with a predominant representation from the early (44%) and middle adolescent (50%) age groups. Notably, 68% of the participants fell underweight, and their parents had attained education levels up to the school level. The recorded data revealed average systolic blood pressure (SBP) readings from 62 to 156 mmHg and diastolic blood pressure (DBP) readings ranging from 31 to 99 mmHg among adolescents attending government.(Table 2).

Table 2. Ranges of Systolic and Diastolic Blood Pressure and BMI of Study Population (n=600).

Variables	Min	Max	Mean
SBP (mmHg)	62	156	117
DBP (mmHg)	31	99	72
BMI (Kg/m2)	11	37	18

The prevalence of hypertension exhibited an upward trend with increasing age, with the highest prevalence occurring among adolescents aged 18 years. Furthermore, the prevalence of hypertension exhibited a corresponding increase with Body Mass Index (BMI), with the lowest prevalence observed among underweight (7%) and the highest among obese (36%) adolescents. Normal-weight adolescents fell in between, with a prevalence of 12%, as depicted in Fig. 1.

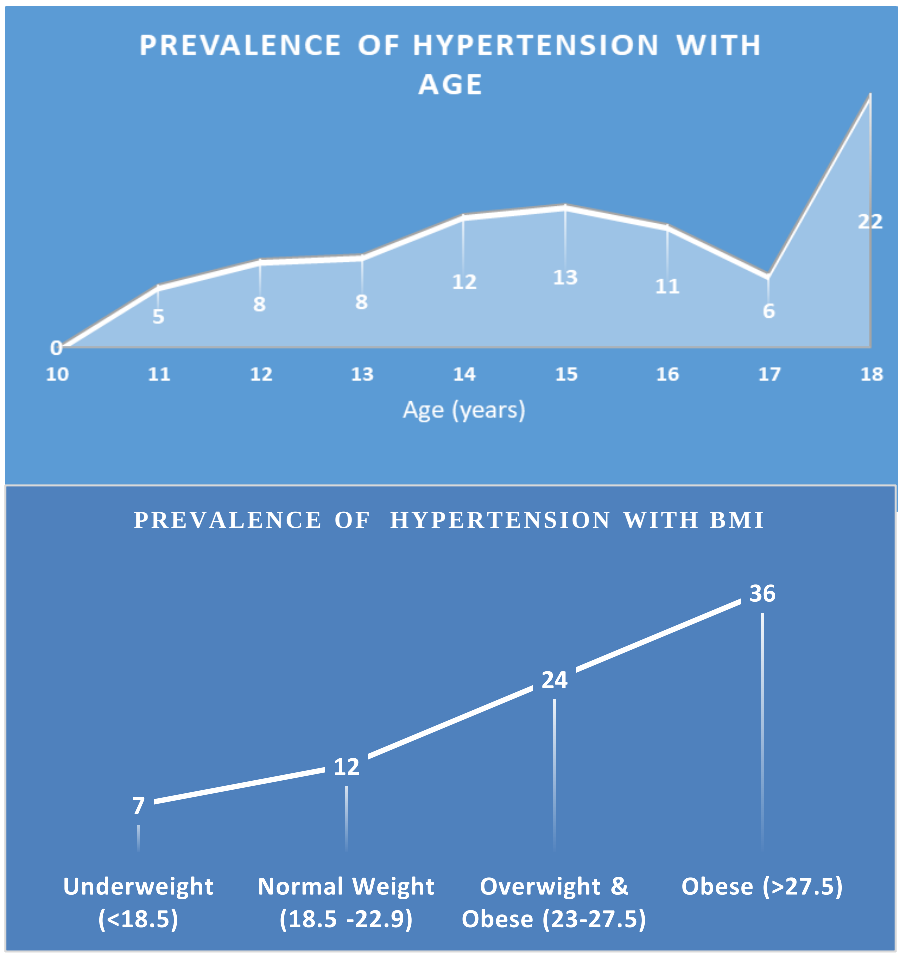

Fig. 1. Prevalence of Hypertension Among Adolescents Across Different Age and BMI Groups.

Statistical analysis revealed a highly significant difference in diastolic blood pressure (DBP) across all BMI categories, with the only non-significant difference in DBP observed among normal-weight adolescents. Among underweight adolescents, the proportion of normotensive subjects was higher (87%), whereas the prevalence of hypertension increased ninefold from underweight to obese (4% to 36 %), as highlighted in Table 3. Significant systolic blood pressure (SBP) differences were observed across all BMI categories. Among underweight adolescents, a higher proportion (70%) exhibited normotensive readings, with only a quarter experiencing prehypertension. In contrast, among overweight and obese adolescents, more than half suffered from prehypertension, and only 24% and 18% of them, respectively, were normotensive. Notably, the prevalence of systolic hypertension increased sevenfold from underweight to obese individuals (from 4% to 27%), as summarized in Table 3.

Table 3. Distribution of Diastolic and Systolic Blood Pressure in Various BMI Categories (n=600).

BMI (Categories)	**Diastolic Blood Pressure**			**Chi-square df=2**
	Normotensive (n=496)	**Pre-hypertensive (n=68)**	**Hypertensive (n=36)**	
Underweight (n= 407)	354 (87%)	37 (9%)	16 (4%)	17.484 (p<0.001)**
Normal weight (n= 149)	115 (77.18%)	22 (14.76%)	12 (8%)	4.175 (p=0.124)
Overweight (n= 33)	22 (66.66%)	7 (21.21%)	4 (12.12%)	6.269 (p=0.044)*
Obese (n= 11)	5 (45.45%)	2 (18.18%)	4 (36.36%)	19.559 (p<0.001)**
Total (600)	496	68	36	
Chi-square	33.887 df=6 p<0.001**			
BMI (categories)	**Systolic Blood Pressure**			**Chi-square df=2**
	Normotensive (n=354)	**Pre-hypertensive (n=213)**	**Hypertensive (n=33)**	
Underweight (n= 407)	285 (70%)	107 (26%)	15 (4%)	63.873 (p<0.001)**
Normal weight (n= 149)	59 (39.59%)	81 (54.36%)	9 (6.04%)	32.620 (p<0.001) **
Overweight (n= 33)	8 (24.24%)	19 (57.57%)	6 (18.18%)	22.156 (p<0.001) **
Obese (n= 11)	2 (18.18%)	6 (54.54%)	3 (27.27%)	13.967(p< 0.001) **
Total (600)	354	213	33	
Chi-square	79.714 df=6 p<0.001**			

*P<0.05=Significant, **P<0.001=Highly Significant.

Fig. 2 illustrates the Pearson correlation coefficient of determination (R2), which quantifies the amount of variance in the dependent variables, SBP and DBP, explained by the independent variable, BMI. It was found that BMI explained 16% of the variance in SBP among adolescents (R2 = 0.157), while for DBP, BMI accounted for 6% of the variation (R2 = 0.06).

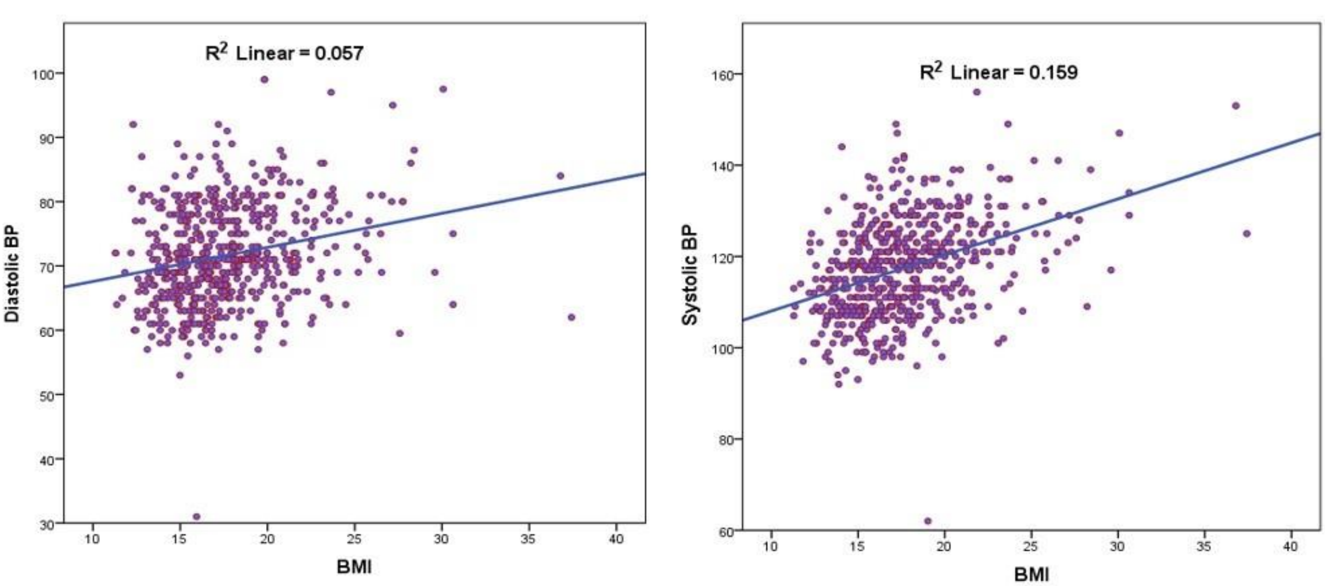

Fig. 2. Correlation of Systolic and Diastolic Blood Pressure with BMI.

Significantly, a positive correlation was observed between blood pressure (SBP, DBP) and BMI, with p-values indicating statistical significance ($p<0.001$). Furthermore, the unstandardized coefficient value was nearly twice as high for SBP compared to DBP, suggesting that SBP increases about twice as much as DBP with an increase in BMI, as summarized in Table 4.

Table 4. Regression Analysis of Blood Pressure in Relation to BMI Among Adolescents (n=600).

Independent variable	Dependent variables (Blood pressure)	Constant (A)†	Unstandardized Coefficient (B) ††	Standardized coefficient (Beta) ‡	Significance (p-value)	R2	Regression Line D=A+(B x I)
BMI	SBP	95.765	1.229	0.398	<0.001*	0.159	SBP=95.765+(1.229 x BMI))
	DBP	62.29	0.530	0.238	<0.001*	0.057	DBP=62.29+(0.53 x BMI)

†A=Constant, ††B= Unstandardized Coefficient, ‡Beta=Correlation value, *Highly Significant, D= Dependent variable, I= Independent.

4. Discussion

In the present study, it was found that the prevalence of hypertension increased with age, and it is relatively low in underweight adolescents, with 87% having normal DBP and 70% having normal SBP. In contrast, among obese adolescents, normotensive is only 18%, and the majority of them either fall into the pre-hypertensive (55%) or hypertensive (27%) categories for SBP. The present study also found that the prevalence of hypertension increases significantly with each progressive BMI category, surging nine and sevenfold from underweight to obese for DBP and SBP, respectively. The present study findings highlight a strong association between BMI and blood pressure. Numerous prior studies, both international and national, have consistently reported a higher prevalence of hypertension among obese adolescents compared to their normal-weight counterparts.[26] For instance, a multicentric study conducted in China involving 42,025 adolescents identified several risk factors associated with hypertension, including parental history of hypertension, higher heart rate, greater waist circumference, and increased adiposity.[10]

Similarly, research in the United States involving 21,062 adolescents aged 10-19 years highlighted obesity as the leading predictor of early hypertension.[27] Furthermore, a comprehensive review and meta-analysis of 64 research studies in India revealed that 7% of school-aged children in the country are hypertensive, with higher prevalence rates among urban and overweight children.[28] The present study findings are consistent with various Indian studies on comparable age groups, including Vasudevan et al.,[29] Mohan.,[30] and Banerjee.,[31]

However, it is essential to note that most studies relied on World Health Organization (WHO) recommendations for BMI, defining overweight as a BMI greater than 25 kg/m^2 and obesity as a BMI exceeding 30 kg/m^2. Adopting Indian consensus criteria for defining overweight (BMI 23–27.5 kg/m^2) and obesity (BMI > 27.5 kg/m^2) is crucial for precision in quantifying the disease burden and tailoring context-specific preventive and treatment strategies for this growing non-communicable disease in the country. More extensive research employing Indian consensus recommendations for overweight is warranted. Obesity is thought to promote hypertension through various mechanisms, including insulin resistance and leptin production, both of which activate the sympathetic nervous system and contribute to obesity-induced hypertension.[32-34] Additionally, high sodium and fat consumption in children and adolescents have been linked to excess adiposity and elevated blood pressure.[35]

Limitations

While BMI is a commonly used tool for assessing body fat in adolescents, its limitations must be acknowledged, as it may not accurately indicate health for all individuals. Factors such as muscle mass, body composition, and the distribution of body fat can also play a role in the development of hypertension. They should be considered when evaluating an adolescent's risk for high blood pressure. To prevent the development of hypertension and related disorders in adolescents, it is imperative to regularly monitor blood pressure and implement lifestyle modifications, including increased physical activity and a balanced diet. These measures can contribute significantly to mitigating the risk of hypertension in adolescents.

5. Conclusion

This study revealed several noteworthy findings regarding the prevalence of hypertension and its association with Body Mass Index (BMI) among adolescents. Firstly, there was a clear age-related trend, with the highest prevalence of hypertension occurring among adolescents aged 18 years, underscoring the importance of monitoring blood pressure in older adolescents. Secondly, we observed a strong correlation between BMI and hypertension, with the lowest prevalence among underweight individuals (7%) and the highest among obese adolescents (36%). Normal-weight adolescents fell in between, with a prevalence of 12%. This highlights the critical role of weight management and healthy lifestyle choices in preventing hypertension among adolescents. Statistical analysis demonstrated significant differences in diastolic blood pressure (DBP) across all BMI categories except for normal-weight adolescents. The prevalence of hypertension increased dramatically from underweight to obese adolescents, emphasizing the importance of early intervention and health education programs.

Furthermore, our findings indicated that BMI explained 16% of the variance in systolic blood pressure (SBP) and 6% of the variation in DBP among adolescents. The positive correlation between blood pressure and BMI was statistically significant, with SBP showing a stronger association with BMI than DBP. Overall, these findings underscore the need for comprehensive healthcare strategies targeting BMI management and blood pressure control in adolescents, with particular attention to older age groups and those at risk of obesity. Promoting healthy lifestyles and regular blood pressure monitoring can be crucial in preventing hypertension in this vulnerable population.

Conflict of Interest

The authors declared that there is no conflict of interest.

Acknowledgements

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

References

[1] Mills KT, Stefanescu A, He J. The global epidemiology of hypertension. Nature Reviews Nephrology. 2020;16(4):223-37. https://doi.org/10.1038/s41581-019-0244-2.

[2] Song P, Zhang Y, Yu J, Zha M, Zhu Y, Rahimi K, et al. Global prevalence of hypertension in children: a systematic review and meta-analysis. JAMA pediatrics. 2019;173(12):1154-63. https://doi.org/10.1001/jamapediatrics.2019.3310.

[3] Awasthi N, Kashyap A. Adolescent Health-RKSK Perspective. Indian Journal of Youth and Adolescent Health (E-ISSN: 2349-2880). 2020;7(1):27-31. https://doi.org/10.24321/2349.2880.202005.

[4] Dhar SK, Hoque MA, Islam MN, Akhtaruzzaman M, Saha BK, Yesmin A, et al. Study on Blood Pressure Profile in School Children of Mymensingh City. Mymensingh medical journal: MMJ. 2023;32(2):320-9.

[5] Sundar JS, Adaikalam JM, Parameswari S, Valarmarthi S, Kalpana S, Shantharam D. Prevalence and determinants of hypertension among urban school children in the age group of 13-17 years in, Chennai, Tamilnadu. IOSR Journal of Dental and Medical Sciences. 2013;8(3):14-20.

[6] Ewald DR, Haldeman LA. Risk factors in adolescent hypertension. Global pediatric health. 2016;3:2333794X15625159. https://doi.org/10.1177/2333794X15625159.

[7] Murphy MO, Huang H, Bauer JA, Schadler A, Makhoul M, Clasey JL, et al. Impact of pediatric obesity on diurnal blood pressure assessment and cardiovascular risk markers. Frontiers in Pediatrics. 2021;9:596142. https://doi.org/10.3389/fped.2021.596142.

[8] Yan Y, Hou D, Liu J, Zhao X, Cheng H, Xi B, et al. Childhood body mass index and blood pressure in prediction of subclinical vascular damage in adulthood: Beijing blood pressure cohort. Journal of Hypertension. 2017;35(1):47-54. https://doi.org/10.1097/HJH.0000000000001118.

[9] Li Y, Haseler E, Chowienczyk P, Sinha MD. Haemodynamics of hypertension in children. Current Hypertension Reports. 2020;22:1-8. https://doi.org/10.1007/s11906-020-01044-2.

[10] Liu K, Li C, Gong H, Guo Y, Hou B, Chen L, et al. Prevalence and risk factors for hypertension in adolescents aged 12 to 17 years: a school-based study in China. Hypertension. 2021;78(5):1577-85. https://doi.org/10.1161/HYPERTENSIONAHA.121.17300.

[11] Franks PW, Hanson RL, Knowler WC, Sievers ML, Bennett PH, Looker HC. Childhood obesity, other cardiovascular risk factors, and premature death. New England Journal of Medicine. 2010;362(6):485-93. https://doi.org/10.1056/NEJMoa0904130.

[12] Bao W, Threefoot SA, Srinivasan SR, Berenson GS. Essential hypertension predicted by tracking of elevated blood pressure from childhood to adulthood: the Bogalusa Heart Study. American journal of hypertension. 1995;8(7):657-65. https://doi.org/10.1016/0895-7061(95)00116-7.

[13] Dong Y, Song Y, Zou Z, Ma J, Dong B, Prochaska JJ. Updates to pediatric hypertension guidelines: influence on classification of high blood pressure in children and adolescents. Journal of hypertension. 2019;37(2):297-306. https://doi.org/10.1097/HJH.0000000000001903.

[14] Chen X, Wang Y. Tracking of blood pressure from childhood to adulthood: a systematic review and meta–regression analysis. Circulation. 2008;117(25):3171-80. https://doi.org/10.1161/CIRCULATIONAHA.107.730366.

[15] Jiang SZ, Lu W, Zong XF, Ruan HY, Liu Y. Obesity and hypertension. Experimental and therapeutic medicine. 2016;12(4):2395-9. https://doi.org/10.3892/etm.2016.3667.

[16] Wang Y, Min C, Song X, Zhang H, Yuan C, Chen L, et al. The dose-response relationship between BMI and hypertension based on restricted cubic spline functions in children and adolescents: A cross-sectional study. Frontiers in Public Health. 2022;10:870568. https://doi.org/10.3389/fpubh.2022.870568.

[17] Zhao W, Mo L, Pang Y. Hypertension in adolescents: The role of obesity and family history. The Journal of Clinical Hypertension. 2021;23(12):2065-70. https://doi.org/10.1111/jch.14381.

[18] Cheung EL, Bell CS, Samuel JP, Poffenbarger T, Redwine KM, Samuels JA. Race and obesity in adolescent hypertension. Pediatrics. 2017;139(5):e20161433. https://doi.org/10.1542/peds.2016-1433.

[19] Korczak DJ, Cleverley K, Birken CS, Pignatiello T, Mahmud FH, McCrindle BW. Cardiovascular disease risk factors among children and adolescents with depression. Frontiers in Psychiatry. 2021;12:702737. https://doi.org/10.3389/fpsyt.2021.702737.

[20] Tomáš S, Terezie Š, Stella S. Masked Hypertension in Healthy Children and Adolescents: Who Should Be Screened?. Current Hypertension Reports. 2023;25(9):231-42. https://doi.org/10.1007/s11906-023-01260-6.

[21] Ejike CE, Ugwu C. Hyperbolic relationship between blood pressure and body mass index in a Nigerian adolescent population. 2010;1(10):WMC00797. https://doi.org/10.9754/journal.wmc.2010.00797.

[22] Jackson LV, Thalange NK, Cole TJ. Blood pressure centiles for Great Britain. Archives of Disease in Childhood. 2007;92(4):298-303. http://dx.doi.org/10.1136/adc.2005.081216.

[23] Black HR, Sica D, editors. Hypertension primer: the essentials of high blood pressure. American Heart Association. 2008:273–275

[24] Tan KC. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. The lancet. 2004;363(9403):157-163. http://dx.doi.org/10.1016/S0140-6736(03)15268-3.

[25] Falkner B, Daniels SR, Flynn JT, Gidding S, Green LA, Ingelfinger JR, et al. National high blood pressure education program working group on high blood pressure in children and adolescents. The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. Pediatrics. 2004;114(2):555-76. https://doi.org/10.1542/peds.114.S2.iv.

[26] Bloch KV, Cardoso MA, Sichieri R. Study of Cardiovascular Risk Factors in Adolescents (ERICA): results and potentiality. Revista de Saúde Pública. 2016;50(suppl 1):2s. https://doi.org/10.1590/S01518-8787.201605000SUPL1AP.

[27] Cheung EL, Bell CS, Samuel JP, Poffenbarger T, Redwine KM, Samuels JA. Race and obesity in adolescent hypertension. Pediatrics. 2017;139(5):e20161433. https://doi.org/10.1542/peds.2016-1433.

[28] Meena J, Singh M, Agarwal A, Chauhan A, Jaiswal N. Prevalence of hypertension among children and adolescents in India: a systematic review and meta-analysis. Indian journal of pediatrics. 2021;88:1107-14. https://doi.org/10.1007/s12098-021-03686-9.

[29] Vasudevan A, Thomas T, Kurpad A, Sachdev HS. Prevalence of and factors associated with high blood pressure among adolescents in India. JAMA Network Open. 2022;5(10):e2239282. https://doi.org/10.1001/jamanetworkopen.2022.3928.

[30] Mohan B, Verma A, Singh K, Singh K, Sharma S, Bansal R, et al. Prevalence of sustained hypertension and obesity among urban and rural adolescents: a school-based, cross-sectional study in North India. BMJ open. 2019;9(9):e027134. http://dx.doi.org/10.1136/bmjopen-2018-027134.

[31] Banerjee D, Winocour P, Chowdhury TA, De P, Wahba M, Montero R, et al. Management of hypertension in patients with diabetic kidney disease: summary of the Joint Association of British Clinical Diabetologists and UK Kidney Association (ABCD-UKKA) Guideline 2021. Kidney international reports. 2022;7(4):681-7. https://doi.org/10.1016/j.ekir.2022.01.004.

[32] MM JZ, MM FH, Lu S, MM FZ, Xu M. Adolescent Hypertension Induced by Obesity and the Efficacy of Comprehensive Intervention. Alternative Therapies in Health and Medicine. 2023;29(5):6-11.

[33] Russo B, Menduni M, Borboni P, Picconi F, Frontoni S. Autonomic nervous system in obesity and insulin-resistance—The complex interplay between leptin and central nervous system. International Journal of Molecular Sciences. 2021;22(10):5187. https://doi.org/10.3390/ijms22105187.

[34] Kalil GZ, Haynes WG. Sympathetic nervous system in obesity-related hypertension: mechanisms and clinical implications. Hypertension Research. 2012;35(1):4-16. https://doi.org/10.1038/hr.2011.173.

[35] Leyvraz M, Mizéhoun-Adissoda C, Houinato D, Moussa Baldé N, Damasceno A, Viswanathan B, et al. Food consumption, knowledge, attitudes, and practices related to salt in urban areas in five sub-saharan African countries. nutrients. 2018;10(8):1028. https://doi.org/10.3390/nu10081028.

How to Cite this Article: Pradhan B, Punjabi P, Sankhla M, Yadav A, Yadav K, Guar KL. Association Between Hypertension Risk in Adolescents and Body Mass Index: A Cross-Sectional Study. International Journal of Scientific Research in Dental and Medical Sciences. 2023;5(4):194-200. https://doi.org/10.30485/IJSRDMS.2023.422714.1544.