Prevalence and determinants of hypertension and pre-hypertension among urban adolescent school students of the age group 13-17 years – A pilot study

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Abstract

Introduction: Hypertension among young children is receiving attention in the developed countries. Though it is increasingly becoming common in the developing countries, there are a very few studies focused on this rising epidemic. The emerging risk factors for raised blood pressure (BP) in this age group like rising levels of stress, unidentified mental health problems such as stress and anxiety remain unexplored. This study aims to assess the prevalence and determinants of hypertension and pre-hypertension among urban school students of age group 13-17 years.

Methodology: It was an observational study. The present analysis consists of the findings for the pilot study to assess feasibility and testing of the study tools for a larger study. An arbitrary sample of 200 students from two urban schools was assessed for the study. Hypertension was defined as mean blood pressure >95th but < 99th percentile and pre-hypertension as > 90th but less than 95th percentile for the age, gender and height. The risk factors taken into consideration were socio-demographic variables, Body Mass Index (BMI), anthropometry, dietary habits, physical activity and perceived stress.

Results: The mean blood pressure levels were 113 ± 16 mm/hg for systolic blood pressure (SBP) levels and 73 ± 12 mm/hg for diastolic blood pressure (DBP) levels. The prevalence of hypertension was 7.0% and that of pre-hypertension was 12.5% among the students of 13-17 years age group. The factors that significantly contributed to pre-hypertension and hypertension in this population were - higher age > 16 years (Risk ratios RR; (95% Confidence Interval (CI)) – (1.3 (1.0-1.4)), family history of hypertension 1.4 (1.1, 1.6), being overweight/obese (2.56 (2.12, 3.32)), additional salt consumption (1.72 (1.5, 1.9)), junk food consumption (1.4 (1.23, 1.56)), poor physical activity (1.3 (1.1, 1.5)), higher screen time (1.3 (1.12, 1.5)) and frequency of perceived stress episodes >5/week (2.3 (2.1, 2.68)).

Conclusion: It is seen thatthe adolescents are exhibiting an increasing susceptibility to the development of lifestyle related disorders. Detailed investigation of the emergent risk factors on a wider scale is needed among this age group.

Keywords *adolescent hypertension pre-hypertension perceived stress overweight obesity physical inactivity*

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1 Introduction

Hypertension, which was previously considered a disease of adulthood, is increasingly becoming common in the pediatric and adolescent population largely due to the obesity epidemic. **(Essouma, 2015 &Xi, 2016)** Hypertension in adolescents is associated with adverse health outcomes and may persist into adulthood, where it represents a significant personal and public health problem **(Lurbe, 2009)**. Screening asymptomatic adolescents has the potential to detect hypertension at earlier stages, so that interventions for reducing the adverse health effects of adolescent hypertension in adults can be developed and implemented. Hypertension is the biggest contributor to the global burden of disease **(Bromfield, 2013)** and is being recognized as a major modifiable risk factor for cardiovascular mortality. It has been established that the onset of hypertension is often early in life, which is mostly undiagnosed **(Edwald, 2016)**. Hypertension among young children and adolescent population is showing a secular trend in both the developed and developing countries. **(Muntner, 2004)** It is caused by a complex interplay of genetic, environmental and behavioural factors very few of This rising trend is attributable to the epidemiological transition from communicable to non-communicable diseases occurring in developing nations, which is further compounded by the obesity epidemic. Prevalence of Hypertension: Using the most current definition of hypertension in children, studies have found the prevalence to range between 3.0 and 19.4 % depending on a variety of factors such as age, sex, ethnicity, body mass index (BMI), parental hypertensive status, etc. **(Bromfield, 2013, Edwald, 2016 & Buch, 2011)** which have been studied extensively **(Anyaegbu, 2014, Amritanshu, 2015 &Sorof 2004)**. Hypertension among children and adolescents is defined as average SBP and/or diastolic BP (DBP) that is ≥95th percentile for gender, age, and height on ≥3 occasions. Prehypertension is defined as average SBP or DBP levels that are ≥90th percentile but 95th percentile but < 99th percentile for age, gender and height. Pre hypertension is considered as a precursor to hypertension and is equally important due to the risk of its progression to hypertension, if not intervened **(CDC, 1994)**. Early diagnosis of hypertension and pre hypertension in children and adolescents is required to reduce the prevalence of hypertension and its impact in the future adult population of our country **(Parati, 2005 & WHO, 2005)**. In spite of all these factors measurement of blood pressure (BP) in children and adolescents is often neglected in clinical practice **(Rao, 2016)**.

In this context, the present study was planned as a pilot study to assess the prevalence of per-hypertension and hypertension as well as its determinants among the adolescent school students in an urban area in Eastern Maharashtra state. The study would also serve the purpose of reaffirming the sample size for a larger prevalence and intervention study that would be conducted in the future.

Aim and Objective:

To study the prevalence of hypertension and pre-hypertension among 13-17 years old high school and junior college students of an urban area of Maharashtra state and determine the psychosocial, dietary and behavioural determinants of hypertension and pre-hypertension among them.

2 Materials and Methods

The present study was a community based cross-sectional analytical study conducted in an urban area of Maharashtra State, from Central India. The study subjects were young children and adolescents in the age group 13-17 years attending high school (class 8-10) or higher secondary school (class 11-12) in the city corporation area. For the purpose of this pilot study 200 students were included from two selected schools.

Inclusion Criteria - The children with completed age between 13-17 years on the day of examination were included in the study if they had the written parental consent and provided their assent for participation.

Exclusion Criteria - Children diagnosed with hypertension and taking medications for the same were excluded at the outset. Also, the students who were consecutively absent on two days when the clinical examination and

BP measurement was scheduled were excluded from the study.

Methodology: After obtaining the Ethical approval from the institutional Ethics committee and seeking permissions from the school authorities, a baseline assessment of the eligible students was done. Written informed consents were obtained from the parents of the students who were invited to participate in the study. The assent of the students was recorded before filling the study questionnaire as well as before examination and blood pressure measurement. A pretested questionnaire was utilized to obtain information on the socio-demographic factors, dietary history, physical activity, stress, sleep patterns etc. They were examined on a pre-decided date in a private room at the school premises itself. The students who were diagnosed with hypertension were referred to Pediatrician for further assessment and management by informing and counselling their parents as needed. All the participant data was secured in a password protected computer in a locked room with restricted access to the study staff other than the principal investigator. Strict data confidentiality was maintained and the hypertensive status was neither revealed to the students or their class teachers. Only the parents were informed about the status of their child and counselled about their health and further referrals if needed were provided. This was helpful in preventing undue stress among the students and any biased behavior by teachers towards the students diagnosed with pre hypertension or hypertension. A random 5% cross verification of blood pressure levels of the students by the school physician was done as a data quality assurance measure.

Dependent and independent variables - The occurrence of hypertension and prehypertension that is normative blood pressure levels above the 95th percentile and between 90th to 95th percentile respectively for age, gender and height **(NHBPEP, 2004)**was the independent variable, whereas BMI, anthropometric indices, dietary patterns, physical activity, time spend viewing television, mobile use and other gadget use, stress, anxiety, depression, parental education, occupation and hypertensive status were the dependent factors.

Statistical Analysis plan: The data collected through the questionnaire was entered in MS Excel. Descriptive statistics were used for continuous variables and were summarized using means and standard deviation. Comparison of continuous parameters between the groups was performed using T-test. Categorical variables were summarized using frequencies and percentages and compared between the groups using Chi-Square or Fisher exact test. Risk estimates were made with the help of odds ratios, with 95% confidence intervals, by means of unconditional logistic regression of the variables like BMI, waist circumference, hip circumference, Waist hip ratio, waist height ratio, family history of arterial hypertension, dietary patterns, physical activity levels, stress levels, anxiety and depression scores with elevated arterial blood pressure (systolic or systolic and diastolic) as the dependent variable. Multivariate models were developed with the intention of verifying the associations of overweight, obesity, dietary habits, physical activity levels, stress, anxiety and depression (as continuous/categorical variables) adjusted for covariates and in relation to hypertension, in order to verify the relationship between hypertension and postulated risk factors. The software packages Epi-Info version 6.02, R version 3.4.4 and Stata 13.4 (STATA Corp. College Station, Texas, USA) were used for the statistical analysis. Detailed exploratory and sub group analysis was done according to the observations.

3 Results and Discussions

The study was a pilot project conducted as a part of a larger intervention trial. It was conducted among 200 secondary and higher secondary school students in the age group of 13-17 years from two urban schools from eastern Maharashtra. The prevalence of hypertension was 7.0% and that of pre-hypertension was 12.5% among the students of 13-17 years age group **(Figure 1)**. The mean blood pressure levels were 113 ± 16 mm/hg for SBP and 73 ± 12 mm/hg for DBP levels. On

studying the corelates for hypertension and prehypertension, it was observed that older age > 16 years (1.3 (1.0-1.4); p<0.001), family history of hypertension (1.4 (1.1, 1.6);p= 0.0143), being overweight (2.56 (2.12, 3.32); p<0.001) or obese (1.32 (1.12, 2.43);p<0.001), added salt consumption (1.72 (1.5, 1.9);p<0.001), consumption of junk food for more that thrice per week (1.4 (1.23, 1.56);p=0.0432), experiencing stress (1.2 (0.98, 1.5); p=0.029) with more than five perceived stress episodes per week (2.3 (2.1, 2.68);p<0.001) and screen time of more than 6 hours per week (1.3 (1.12, 1.5);p<0.01) were observed to be associated with a significant risk of acquiring high blood pressure both prehypertension and hypertension **(Table 1)**.

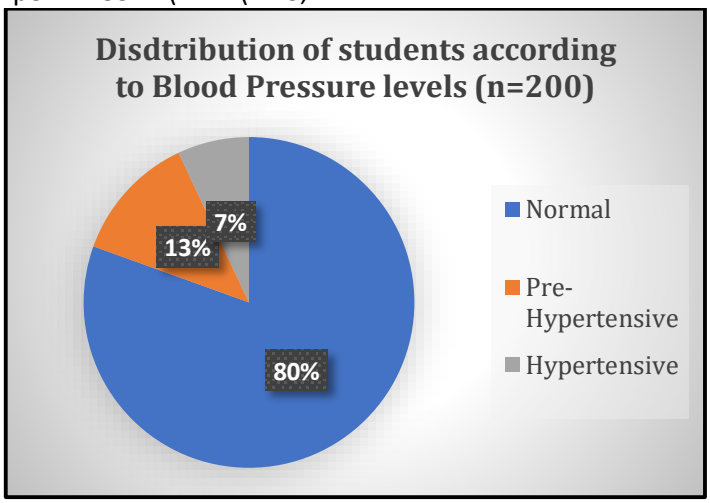

Figure 1: Distribution of students according to blood pressure levels (n=200)

Table 1: Multivariate logistic regression for examining the factors associated with hypertension and pre-hypertension among urban school students (n = 200)

Characteristic	Normotensive N (%)	Pre-hypertensive N (%)	Hypertensive N (%)	Adjusted risk ratios (95% CI)	p value
Age in Years					
13-14	68 (89.5)	7 (9.2)	1 (1.3)	1.0*	**< 0.001**
15-16	53 (82.9)	6 (9.3)	5 (7.8)	1.0 (0.9-1.1)	
>16	40 (66.7)	12 (20.0)	8 (13.3)	1.3 (1.0-1.4)	
Gender					
Male	80 (73.4)	19 (17.4)	10 (9.2)	1.1 (0.9-1.1)	0.842
Female	81 (89.0)	6 (6.6)	4 (4.4)	1.0*	
Socioeconomic Status					
Low	44 (84.6)	7 (13.5)	1 (1.9)	1.0*	0.351
Middle	113 (85.6)	8 (6.0)	11 (8.4)	1.0 (0.9, 1.1)	
High	4 (25.0)	10 (62.5)	2 (12.5)	0.9 (0.8, 0.9)	
Family history of HT					
Yes	12 (31.6)	17 (44.7)	9 (23.7)	1.4 (1.1, 1.6)	**0.0143**
No	149 (92.0)	8 (4.9)	5 (3.1)	1.0*	
BMI categories$					
Underweight (<16.5)	32 (68.0)	7 (14.9)	8 (17.1)	0.65 (0.33,0.71)	**<0.001**
Normal (16.6-24.9)	87 (90.6)	8 (8.3)	1 (1.1)	1.0*	
Overweight (25.0-29.9)	24 (72.7)	6 (18.2)	3 (9.1)	2.56 (2.12, 3.32)	
Obese (> 30.0)	18 (75.0)	4 (16.7)	2 (8.3)	1.32 (1.12, 2.43)	
Dietary practices					

Vegetarian	90 (84.1)	10 (9.4)	7 (6.5)	1.0*	0.674
Eggetarian	20 (64.5)	7 (22.5)	4 (13.0)	1.1(0.92, 1.0)	
Mixed	54 (87.0)	5 (8.0)	3 (5.0)	1.2 (0.98, 1.3)	
Added salt consumption					
Yes	36 (60.0)	15 (25.0)	9 (15.0)	1.72 (1.5, 1.9)	**< 0.001**
No	125 (89.3)	10 (7.1)	5 (3.6)	1.0*	
Frequency of junk food consumption					
Never	22 (88.0)	2 (8.0)	1 (4.0)	1.0*	**0.0432**
< once per week	51 (78.5)	9 (13.8)	5 (7.7)	0.76 (0.65, 0.8)	
1-3 times a week	56 (88.9)	4 (6.3)	3 (4.8)	1.1 (0.92, 1.12)	
> 3 times a week	32 (68.0)	10 (21.3)	5 (10.7)	1.4 (1.23, 1.56)	
Physical Activity (hours/week)					
1-3 hours	39 (61.0)	18 (28.1)	7 (10.9)	1.3 (1.1, 1.5)	**<0.001**
4-6	62 (87.4)	4 (5.6)	5 (7.0)	1.1 (0.87, 1.3)	
> 6	60 (92.3)	3 (4.6)	2 (3.1)	1.0*	
Perceived stress					
Yes	48 (64.9)	16 (21.6)	10 (13.5)	1.2 (0.98, 1.5)	**0.029**
No	113 (89.7)	9 (7.1)	4 (3.2)	1.0*	
Frequency of stress episodes (per week)					
1-2	13 (48.1)	8 (29.6)	6 (22.2)	1.0*	**< 0.001**
3-4	19 (55.9)	14 (41.1)	1 (3.0)	1.4 (1.21, 1.6)	
> 5	3 (23.0)	3 (23.0)	7 (54.0)	2.3 (2.1, 2.68)	
Screen time (hours/week)					
1-3	162 (93.6)	8 (4.6)	3 (1.8)	1.0*	**< 0.001**
4-6	1 (7.7)	5 (38.5)	7 (53.8)	1.1 (0.89, 1.2)	
> 6	1 (7.1)	9 (64.3)	4 (28.6)	1.3 (1.12, 1.5)	

*Adjusted risk ratio = 1 for the reference category;

^ BP – National high BP education program working group 2004; percentiles for age, gender and height

$ BMI – classification as per WHO standards for BMI for age for 5-19 years boys and girls

^ BP – National high BP education program working group 2004; percentiles for age, gender and height

MLR model – adjusted for all listed co-variates; $p < 0.05$ was considered to be statistically significant

Discussion

This study assessed the prevalence and the risk factors of childhood and adolescent hypertension in urban school and junior college students in eastern Maharashtra region. The risk factors included in our study varied over a wide range of socio-demographic, psychosocial, behavioral and individual variables like diet, physical activity, anthropometry, stress, screen time etc. Prevalence of HT was 7.0% and that of pre-hypertension was 12.5% among the students of 13-17 years age group. The mean blood pressure levels were 113 ± 16 mm/hg for systolic blood pressure (SBP) levels and 73 ± 12 mm/hg for diastolic blood pressure (DBP) levels.

In view of the rising levels of childhood obesity globally, the developing nations like India are also experiencing the shift from communicable to non-communicable diseases. This has been evidenced by the steadily rising levels of blood pressure among the adolescents in both urban as well as the rural areas in India as demonstrated by several recently conducted studies **(Fadnis, 2020, Patel, 2019 & Srirama, 2020)**.

Similar prevalence of hypertension and prehypertension among adolescent population was reported by Soudarssanane et al from Puducherry (9.4%), by Sharma et al in

Shimla (7.1%) and by Borah et al from Dibrugarh, Assam of 7.6% **(Soudarssanane, 2008, Sharma, 2010 & Borah, 2015)**. Slightly higher prevalence was reported by Bala et al with the prevalence of hypertension to be 13% in a cohort of adolescent school students in Hyderabad **(Bala, 2017)**.

The prevalence of prehypertension in our study was 12.5%, however, other studies have reported somewhat higher prevalence of prehypertension as compared to our study. It was observed by Kar et in their study conducted at Gangtok, that the levels of prehypertension were 24.11% among the adolescents. In a study by Anand et al at Delhi, 30.1% of the adolescents reported prehypertension. As also by Srirama et al in Bangalore, where the prevalence of prehypertension was reported to be 21.6% **(Kar, 2015, Anand, 2014 & Srirama, 2020).** This variation in the prevalence could be explained by the differences in the age groups included in different studies, differential inclusion criteria and the standard criteria for defining hypertension, along with the regional variations in the dietary and cultural factors.

The rising levels of blood pressure at an early age predispose the individual to develop cardiovascular problems in the future which are the common cause of mortality in younger population and hypertension being one of the leading risk factors for cardiovascular morbidity and mortality needs to be assessed and managed promptly. In addition to the rising levels of obesity among children and adolescents, the commonly prevalent behaviors among them such as unhealthy eating habits, sedentary lifestyle, addictions, excessive use of electronic media, competitive atmosphere that heightens stress levels as also their risk acquiring high blood pressure and its resultant complications **(Kumar, 2017 &Matjuda 2020)**.

When the determinants of hypertension and prehypertension were studied, it was observed that older children above the age of 16 years were at a greater risk (Risk ratios RR; (95% Confidence Interval (CI)) – (1.3 (1.0-1.4; p<0.001)), as compared to the younger students.

Similar findings of higher prevalence of hypertension among the older adolescents was reported by other studies **(Sharma, 2020, Bala & Kumar, 2017)**. The higher prevalence among older adolescents' might be a reflection of their choices that tends to be similar to adult lifestyles like venturing into smoking and alcoholism. The preponderance among older ages also partially indicates their predisposition to stressful circumstances like study pressures for faring well in completive exams for securing admissions to professional courses.

Though, the prevalence of hypertension was higher among males in this study as compared to females but the difference was not statistically significant. The male preponderance in raised blood pressure levels was also observed in other studies **(Goharian 2015 & Srirama, 2020)**. The male preponderance may be attributable to the hormonal changes as observed by their indulgence in activities that stimulates adrenaline release as well as due to the higher prevalence of personal habits like smoking and alcoholism among them.

In our study, family history of hypertension 1.4 (1.1, 1.6;p=0.0143)) emerged as a significant risk factor for raised blood pressure among the adolescent. The familial connect was similarly observed in several other studies like the one conducted at Brazil, which concluded that both the SBP and DBP were raised among the students who had either of a parent who was previously diagnosed hypertensive or had an unfavorable lipid profile **(Elias, 2004)**. Another study from Canada found significant evidence of familial aggregation of hypertension. In addition to the familial component, these studies also emphasize the importance of environmental factors like similar dietary and physical activity patterns in the family that may additionally contribute to the development of hypertension **(Jomini &Barlassina, 2002)**.

In our study, it was observed that another significant contributor for the development of high blood pressure among adolescent population was being overweight or obese which nearly doubled the risk (2.56 (2.12, 3.32; p<0.001)). The corelation of higher BMI

and hypertension has been described in several studies (Patil, 2014, Uwaezuoke, 2016 & Aronow, 2017). Another study observed that each unit gain of BMI increases the risk of developing hypertension by 14% (MadhavikuttyAmma, 2015). Similarly, a study by Berenson et al. also reported high BMI as one of the strongest risk factors of hypertension (Berenson, 1998). Higher adiposity in people with raised BMI, leads to loss of elasticity of the blood vessels and also promotes atherosclerosis at an early age, thereby predisposing them to hypertension. Childhood obesity has also been shown to be associated with the development of hypertension later in life. Obesity predisposes to arterial stiffness that increases the peripheral vascular resistance and also leads to various hemodynamic changes that may contribute to the development of hypertension.

Our study also showed that, the risk of acquiring hypertension was greater among the students who had poor physical activity (1.3 (1.1, 1.5; p<0.001)) as compared to those who performed any kind of physical activity for > 6 hours per week. The findings from our study were similar to those observed by Bala et al who reported insufficient levels of physical activity in 62% of the participants (Bala, 2017). It has been recommended by the WHO that the adolescents should undergo atleast 60 minutes of moderate to vigorous physical activity per day for 5-6 days a week (WHO, 2003). Globally, there was high prevalence (81.0%) of insufficient physical activity among school going adolescents (WHO, 2003). The results of our study also resonate with other Indian studies that have reported a much lower prevalence of physical activity among adolescent populations (Singh, Kumar J 2012, Borah, 2015 & Singh, 2006). Varying levels of prevalence of physical activity may be attributed to the different methods of assessment and criteria used. The assessment was subjective as the present study used a self-reported tool to assess physical activity duration. However, a directly observed structured study would have given much accurate results but was beyond the purview of this study.

When the dietary factors that might have been associated with risk of hypertension were studied, it was observed that increased salt intake in the form of added salt to cooked food items was associated with a risk of hypertension (1.72 (1.5, 1.9; p<0.001)). Similarly, the study by Srirama et al showed a prevalence of 17.5% for intake of salted food items (Srirama, 2020). In another study by Kumar et al in Patna, it was observed that about 22.3% of the adolescents were taking extra salts (Kumar 2012). In yet another study by Soudarssanane et al among adolescents and young adults in Puducherry, it was observed that dietary salt intake significantly affects the mean DBP but has little or no effect on the mean SBP (Soudarssanane, 2008). Sodium plays an important role in the causation of hypertension through water retention, increase in systemic peripheral resistance, alterations in the endothelial function, changes in the structure and function of large elastic arteries, modification in sympathetic activity, and in the autonomic neuronal modulation of the cardiovascular system. Therefore, prompt assertive action for creating awareness among parents is needed to educate them about the hazards of high added salt consumption.

Another risk factor observed in our study, that was associated with hypertension was junk food consumption (1.4 (1.23, 1.56; p=0.0432)) among the adolescents. This was similarly reported by Fadnis et al in their study observed that increased frequency of junk food intake was strongly related to hypertension. In their study, about 6 (23.07%) of the 26 participants who were habituated to consumption of junk food for more than 6 times a week were shown to have significantly higher blood pressure levels as compared to the 12 (5.21%) out of the 230 people who had lower frequency of junk food intake of less than 2 times in a week (Fadnis, 2020). Similar findings were put forth by a study conducted in Bihar, among adolescents of the age group of 5-19 years by Kumar et al, which showed that hypertension was significantly associated with diet containing processed and salty food items (p<0.001) (Kumar, 2015). Another study

conducted in Kerala also had similar associations between junk food consumption with pre-hypertension and hypertension **(Amma, 2015)**.Junk food consumption corelates with lesser probability of selecting healthier options as they are readily available, palatable and addicting for younger age groups. Lower consumption of fruits and vegetables was linked to higher consumption of junk food among adolescents in some of the studies **(Kumar & Amma 2015)**.

Another risk factor observed in the present study that was found to be associated with a significantly higher incidence of hypertension and prehypertension was a higher screen time (1.3 (1.12, 1.5; p<0.001)) of > 6 hours per week. In a study by Otinwa et al. it was similarly observed that children who were accustomed to watching television for > 5 hours per day were 4.6 times more likely to be overweight than children who watched it for 0–1 hour per day **(Otinwa, 2017)**. The time spend in sedentary activities mostly in the form of gadget use and watching TV screen limit the time that can be utilized for outdoor activities, this has been successfully proved in a prospective study designed to reduce children's TV use, that found significant improvement in body mass index (BMI), body fat percentage, and other obesity-related indices. This evidence led the U.S. Task Force on Community Preventive Services to recommend behavior-change programs focusing on reducing screen time by promoting physical activity **(Grontved& Hu, 2011, Wyszynska, 2017)**.

Lastly, our study showed that frequency of perceived stress episodes >5/week (2.3 (2.1, 2.68; p<0.001)) was significantly associated with prehypertension and prehypertension. Previous studies have also emphasized that stress is linked with elevated blood pressure. These have shown that high perceived stress scores were at 1.7 times higher risk of having raised blood pressure. There was a significant positive correlation between systolic BP and perceived stress score among those with elevated blood pressure, whereas a significant negative correlation was observed between diastolic BP and perceived stress score **(Lu, 2019, Richardson & Logan 2012)**. Stress induces a fight or flight reaction and is known to release cortisol in its response that stimulates adrenaline release, which inturn causes vasoconstriction and a rise in blood pressure. Indirect evidence indicates that coping strategies designed to reduce stress also subsequently cause a fall in the blood pressure levels.

4 Conclusion

Adolescent population is exhibiting an increased susceptibility to lifestyle disorders. The prevalence of hypertension (7.0%) and pre hypertension (12.5%) was alarmingly high among the adolescents and therefore necessitates urgent interventions focusing on life-style modification. Higher age, positive family history of hypertension, obesity, unhealthy eating habits, poor physical activity, higher screen time and high stress levels were found to be the major risk factors for predisposing the adolescents to hypertension and prehypertension in our study.

Recommendations:

Detailed investigation of the emerging risk factors is warranted in this age group for designing effective prevention strategies targeting the identified risk factors School health programs should incorporate regular blood pressure screening for early identification and effective management of adolescent prehypertension and hypertension.

In view of the rising prevalence of non-communicable diseases at an early age, sensitization of the school students towards adopting a healthier lifestyle should be done through awareness campaigns and implementing healthy nutrition and age-appropriate physical activity schedules at the schools.

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Conflicts of interest: None

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