

Associations of obesity and serum leptin level with elevated blood pressure among urban secondary school students of a northeastern city of India: A baseline observation

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ABSTRACT

Background: Elevated blood pressure has been found to be associated with body mass index (BMI) and serum leptin levels among adults. But there is a paucity of reports regarding such associations among adolescents. **Objectives:** To estimate the prevalence of prehypertension and hypertension and its associations with BMI and serum leptin levels among the secondary school going students of the Agartala Municipal Corporation area. **Materials and Methods:** This school-based cross-sectional study was conducted from 1st April 2018 to 31st December 2018, among 1,000 students studying in different secondary level schools located in Agartala municipal corporation area chosen by multistage sampling ensuring proportionate representation in the sample. **Result:** Prevalence of prehypertension and hypertension were found to be 42.40% and 15.70%, respectively, 55.20% had normal, 22.80% had low, and 22.00% had high BMI. Serum leptin levels were found to be normal among 54.70% of the students, whereas, 36.70% had high and 8.60% had low levels, respectively. Logistic regression analysis has identified male sex (OR = 0.231, 95% CI = 0.172–0.310, $P = 0.000$) and high BMI (OR = 4.289, 95% CI = 2.857–6.440, $P = 0.000$) as the significant determinants of elevated blood pressure, but the effect of serum leptin level and family history of hypertension did not attain the level of statistical significance. **Conclusion:** Prevalence of prehypertension and hypertension among urban school-going adolescents were found to be 42.40% and 15.70%, respectively and were significantly associated with their sex and BMI and serum leptin level, but regression analysis failed to detect any significant effect of serum leptin level in determining the blood pressure of the study subjects.

Keywords: Body mass index, hypertension, leptin, obesity, prehypertension, Tripura

Introduction

The report indicates that noncommunicable diseases are the leading causes of death worldwide.^[1] Hypertension (HT) alone caused

more than 7 million deaths worldwide in 2010.^[2] The seventh joint national committee on prevention, detection, evaluation, and treatment of high blood pressure (BP) has introduced prehypertension (PHT) as a new category of BP, where systolic BP lies between 120 and 139 mmHg and/or diastolic BP between 80 and 89 mmHg.^[3] Though PHT has a strong familial predisposition, the pathophysiological mechanism that causes its progression has not yet been fully elucidated.^[4] Prevalence of PHT and HT were

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significantly greater in the south and west India as compared to northern and eastern India.^[5] In a study, the prevalence of PHT, HT, and optimum BP among the medical students of Agartala Government Medical College was found to be 45%, 4%, and 51% respectively.^[6] This huge chunk of prehypertensive young adults may develop HT in later life. Leptin is an adipose tissue-derived hormone that has been shown to be related to several metabolic, inflammatory, and hemostatic factors known to be involved in the development of HT and cardiovascular diseases.^[7] Only a few studies have examined the putative association between leptin and HT, and their results have not been consistent. Some studies detected a significant association between plasma leptin levels and HT only in men,^[8-10] others detected an association only in women,^[11,12] whereas some others reported a positive relationship in both men and women.^[13,14]

European Society of Hypertension strongly pointed out that overweight is the most influential factor in developing HT in childhood. From various studies, it has been observed that Indian children are more susceptible to obesity-mediated HT.^[15] Childhood high BP is also a risk for adult HT.^[16,17] The mechanisms underlying obesity-induced high BP are unclear. Leptin is known to play a role in the pathophysiology of obesity. Some studies suggest that leptin level is higher in hypertensive people comparing to their normotensive counterparts. There is a paucity of reports addressing BP status and its associations with serum leptin level and obesity among adolescents moreover there may be urban-rural variations, too.

Leptin is involved in the regulation of food intake and body weight, too.^[18] Various studies have demonstrated that plasma leptin concentration increases significantly in obesity in proportion to the degree of adiposity,^[19,20] which suggests the leptin resistance in obesity. Due to the potent multiple actions of leptin, hyperleptinemia may be involved in the pathogenesis of obesity and its related disorders. In this regard, one recent study has^[21] reported a significant correlation between BP and plasma leptin concentrations in patients having HT, suggesting that leptin may play some role in the pathogenesis of obesity-related HT.

Hence, to gather baseline data from the urban adolescents of Tripura, the present study was designed with the objectives to find out the prevalence of PHT and HT among the secondary school going students of Agartala Municipal Corporation area and to study its associations with body mass index (BMI), serum leptin level, and selected sociodemographic factors. The result of this study will generate baseline data regarding the magnitude of elevated BP, lifestyle, and associated risk factors among adolescents. It will help health administrators to formulate the incorporation of preventive measures such as prediction, screening, and early detection for these problems at primary health care level.

Materials and Methods

A school-based cross-sectional study was conducted from 1st April 2018 to 31st December 2018 among 1,000 adolescent students studying in different secondary level schools located in

the Agartala Municipal Corporation area chosen by multistage sampling ensuring proportionate representation in the sample. The objectives of this study were to estimate the prevalence of PHT and HT among secondary-level students enrolled in the schools located within Agartala Municipal area, which is an urban area and also to study the associations of elevated BP with obesity, serum leptin level, and selected sociodemographic profile of these students.

Minimum sample size requirement for this study was determined using the formula for calculating sample size in prevalence studies using proportion: $n = \left\{ \left[Z_{(1-\alpha/2)}^2 (p \times q) \right] / L^2 \right\}$, assuming 45% of the adolescents of Agartala are having elevated BP^[6] at 95% confidence interval (CI) and 10% relative precision and design effect of 2. It was found to be 978 and was rounded to 1,000 students.

PHT was defined as systolic BP between 120 to 139 mmHg and or diastolic BP of 80–89 mmHg. HT was defined as systolic BP ≥ 140 mmHg and or diastolic BP ≥ 90 mmHg (JNC-7) or on BP-lowering medications.^[22]

Special physical exercise for good health was defined as prescribed or recommended amount of walking, jogging, skipping, running, swimming, freehand exercises, gym-based exercises etc. aimed at achieving or maintaining health. Fast food items were considered as items which were available at restaurants or at roadside stalls and usually contain high fat and calorie. BG Prasad's socioeconomic status classification (2017) was used for classifying the socioeconomic status of the students.^[23]

A list of secondary level schools was collected from the Directorate of School Education. Agartala municipal area had four administrative zones. Separate sampling frames for each zone consisting of eligible schools of that particular zone were constructed. In the first stage of sampling, two schools were selected from each municipal zone by simple random sampling without replacement from the constructed sampling frames. In the second stage, students studying in classes IX to XII of the selected schools were chosen by simple random sampling without replacement using the attendance registers as sampling frames.

Prior permission from the Director of School Education, Govt. of Tripura and selected school authorities were obtained before conducting the study. Selected schools were visited on the prefixed dates and students fulfilling inclusion and exclusion criteria were approached for participating in this study. Informed written consent document for participation in this study was handed over to them for obtaining consent from their guardians and were instructed to attend school on a particular date in empty stomach (overnight fasting) if consented for participation. On the day of data collection, the consenting students were interviewed maintaining confidentiality using the pretested and validated interview schedule. Equal time was spent on interviewing each participant.

The interview schedule contained information regarding sociodemographics, lifestyle, measurement of BP, height, weight, hip, and waist circumference, body fat content, etc., face and content validity of the interview schedule was evaluated by piloting upon 30 secondary students and also examining by three epidemiologists. Digital weighing scale with a precision of 100 g, one stadiometer with a precision of 1 mm, one non-stretchable measuring tape with the precision of 1 mm, one sphygmomanometer, one automated body fat analyzer, and an ELISA reader for estimation of serum leptin level were used for collecting data in this study.

For measuring weight, the subjects were asked to stand erect and barefooted over the electronic bathroom weighing scale placed over even surface using minimum possible clothing. The weighing scale was calibrated daily before starting data collection by putting standard weight upon it.

For measuring height, the study subjects were asked to stand erect, bare and close footed over the footplate of the stadiometer in such a way that the occiput, back, hip, and the heels lie in contact with the stadiometer stand. Then, the head plate of the stadiometer was gradually brought down upon the head to place firmly. In this position, height readings were taken.

After finishing the interview and anthropometry, venous blood samples were collected from the respondents and transported to the “Multidisciplinary Research Unit” (MRU) located at Agartala Government Medical College (AGMC) following standard guidelines^[24] for analysis and the participants were offered packed lunch. A team consisting of trained research scientist-II, scientist-I, laboratory technicians and laboratory assistant both male and female from the MRU, AGMC accompanied the authors for conducting the interview, anthropometry, and blood sample collection, etc.

Data entry and analysis were performed with a computer using ‘Statistical Package for the Social Sciences’ (SPSS) software for Windows version 15.0. Chi-square test with Yates’ correction was used for studying the association between categorical variables. Binary logistic regression analysis was used to predict the development of elevated BP by using significant independent variables. Probability value <0.05 was considered statistically significant. This study was approved by the institutional ethics committee of Agartala Government Medical College.

Result

Majority (58.90%) of the study subjects were female, 41.00% belonged to general community, 23.30% of the respondents had family history of HT, 74.10% said that their guardians were educated up to either secondary level or above and 31.70% subjects belonged to upper socioeconomic class as per BG Prasad’s socioeconomic classification.

Among the study subjects, 95.60% were nonvegetarians and out of the nonvegetarians, 37.34% used to take meat more than

twice in a week and 13.70% of subjects used to take fast food from outside regularly. Regular consumption of table salt was reported by 34.50% and regular physical exercise by 36.80% of the subjects. History of smoking and occasional alcohol consumption was revealed by only 0.40% and 0.05% of the students, respectively.

Prevalence of PHT and HT were found to be 42.40% and 15.70%, respectively. Among the study subjects, 55.20% had normal, 22.80% had low, and 22.00% had high BMI. Among the study subjects, 54.70% had normal, 36.70% had high and 8.60% had low serum leptin levels. The serum leptin level of the students was significantly associated with their BMI ($P < 0.05$).

Discussion

In India, the prevalence of HT in children is high in comparison with developed countries like the USA where the prevalence of elevated BP was found to be 2.7–3.7% in different surveys.^[25] Similarly, the prevalence of childhood HT varied between 5.9 and 7.6% among different populations within India.^[26-30]

This study evaluated and explored different factors affecting the prevalence of PHT among the urban adolescents of one northeastern state of India. In this baseline study from Agartala, the capital of Tripura, we observed that the prevalence of PHT and HT among the urban school-going adolescents was 42.40% and 15.70%, respectively.

In a study done by Senthil *et al.*, it was observed that the frequency of males with PHT was significantly higher (for systolic PHT $P < 0.0001$ and for diastolic PHT $P < 0.022$) compared to females which support present study result.^[31] Studies done by Percy *et al.* and Sugarman *et al.* have reported that males are having higher BP than females during adolescence and early adulthood.^[32,33] This study also supports the observation made by these authors. Lack of endogenous estrogens may be the reason behind the raised levels of BP in young men compared to women. Earlier evidence suggests that estrogen may modulate vascular endothelial function, causing vasodilatation. Mostly due to this women are having low BP compared to men.^[34]

In a population-based cross-sectional study done by Aldiab *et al.* from Saudi Arabia,^[35] it was found that the prevalence of PHT was 66.1% in males and 48.1% in females. The prevalence of HT was 6.0% in males and 4.2% in females. A similar result has been observed in our study in which 52.8% male and 35.1% female are having PHT whereas 23.4% male and 10.4% female adolescents are having HT.

One school-based Indian study done by Amma *et al.*^[36] showed that overall prevalence of PHT and HT was 24.5% (male-30.5%, females-20.3%) and 0.6% (male-0.98%, females 0.34%), respectively which also supports our present study result. In our study, PHT was significantly more prevalent among students having higher BMI and higher serum leptin levels, but regression

analysis failed to detect any significant effect of serum leptin levels in determining BP of the study subjects.

Similar results were found in an Iranian school-based study done by Fakhrazadeh *et al.*, where there were significant correlations between BMI and serum leptin levels, age, systolic and diastolic BP.^[37] BMI was independently associated with leptin levels among obese children. In these studies, systolic BP and diastolic BP had no association with serum leptin levels in multivariate linear regression analysis.

We observed that serum leptin level of the students was significantly associated with their sex, BMI, and family history of HT in our study [Table 1]. In a recent study done by Pirsean *et al.*,^[38] it was found that in case of overweight and obese children, the salivary level of the leptin was significantly increased ($40.4 \text{ ng/mL} \pm 28.8$) comparing to nonobese (Leptin: 9.58 ± 3.1) which supports the finding of present study.

A similar result was found by Falorni *et al.* where female adolescents had higher leptin concentrations than males.^[39] In adolescent girls and boys, leptin concentrations increased slowly with age and body-fat mass. But, in boys, this increase

was normally interrupted in early puberty when testosterone and lean body mass increased. Whereas, in girls, leptin, along with the body-fat mass, continued to increase during puberty.

In our study, BMI was strongly associated with PHT which was also seen by Gratz *et al.*^[40] and many other studies like in one Indian study by Shaziya *et al.*^[41] But, as per our study, the BP status of the students had no significant associations with their family history of HT and literacy status of guardians [Table 2]. This might be due to the fact that students studying in the schools of urban areas were from better socioeconomic backgrounds and hence family history or literacy status were overshadowed by other contributory factors such as food habits, lack of physical exercises, etc.

Normally, adolescent's food habits are important determinants of both their present and future health.^[42,43] Our study showed that higher proportions of the subjects performing regular physical exercise had normal BP. Those who used to consume table salt regularly had significantly elevated BP. A higher proportion of nonvegetarians, subjects consuming meat in more number of days, and consumers of fast food had elevated BP though statistically, these were not significant [Table 3].

Table 1: Serum leptin levels by sex, BMI, and family history of hypertension

		Serum leptin level			Significance
		Low, n (%)	Normal, n (%)	High, n (%)	
Sex	Male	59 (14.40)	213 (51.80)	139 (33.80)	$\chi^2=29.507$ $P=0.000$
	Female	27 (4.60)	334 (56.70)	228 (38.70)	
BMI	Low	32 (37.20)	161 (29.40)	35 (9.50)	$\chi^2=152.282$ $P=0.000$
	Normal	42 (48.80)	330 (60.30)	180 (49.00)	
	High	12 (14.00)	56 (10.20)	152 (41.40)	
Family history of hypertension (HTN)	Present	14 (6.0)	118 (50.6)	101 (43.3)	$\chi^2=13.955$ $P=0.007$
	Absent	49 (11.0)	258 (57.7)	140 (31.3)	
	Unknown	23 (7.2)	171 (53.4)	126 (39.4)	

Serum leptin level of the students was significantly associated with their sex, BMI and family history of hypertension

Table 2: Blood pressure level by BMI, serum leptin level, sex, family history of hypertension, and guardian's literacy of the study subjects

Variables		Blood pressure status			Significance
		Normotensive n (%)	Prehypertensive n (%)	Hypertensive n (%)	
BMI	Low	151 (66.20)	50 (21.90)	27 (11.80)	$\chi^2=112.080$ $P=0.000$
	Normal	229 (41.50)	246 (44.60)	77 (13.90)	
	High	39 (17.70)	128 (58.20)	53 (24.10)	
Serum Leptin	Low	29 (33.70)	45 (52.30)	12 (14.00)	$\chi^2=27.974$ $P=0.000$
	Normal	268 (49.00)	195 (35.60)	84 (15.40)	
	High	122 (33.20)	184 (50.10)	61 (16.60)	
Sex	Male	98 (23.8)	217 (52.8)	96 (23.4)	$\chi^2=98.145$ $P=0.000$
	Female	321 (54.5)	207 (35.1)	61 (10.4)	
Family history of HTN	Present	89 (21.20)	100 (23.60)	44 (28.00)	$\chi^2=3.817$ $P=0.431$
	Absent	198 (47.30)	183 (43.20)	66 (42.00)	
	Unknown	132 (31.50)	141 (33.3)	47 (29.90)	
Guardians literacy	Illiterate	08 (47.10)	09 (52.90)	00 (0.0)	$\chi^2=7.785$ $P=0.100$
	Primary	115 (47.50)	90 (37.20)	37 (15.30)	
	Secondary & above	296 (39.90)	325 (43.90)	120 (16.20)	

Prehypertension was significantly more prevalent among males, students having higher BMI and higher serum leptin levels ($P<0.05$). The blood pressure status of the students had no significant associations with their family history of hypertension and the literacy of guardians

Table 3: Blood pressure status by the practice of the study subjects

Practices	Types	Blood pressure		Significance
		Normal, n (%)	Elevated, n (%)	
Physical exercise	Regularly	236 (64.10)	132 (35.90)	$\chi^2=8.311$ $P=0.003$
	Occasionally	345 (54.60)	287 (45.4)	
Type of diet	Vegetarian	22 (50.00)	22 (50.00)	$\chi^2=0.917$ $P=0.338$
	Nonvegetarian	397 (41.50)	559 (58.50)	
Meat consumption	Twice or less per week	154 (43.10)	203 (56.90)	$\chi^2=0.507$ $P=0.476$
	More than twice per week	243 (40.60)	356 (59.40)	
Fast food consumption	Regularly	58 (42.30)	79 (57.70)	$\chi^2=1.192$ $P=0.551$
	Occasionally	470 (58.60)	331 (41.30)	
	Never	32 (51.60)	30 (48.40)	
Consumption of table salt	Regularly	117 (33.91)	228 (66.09)	$\chi^2=91.842$ $P=0.000$
	Occasionally	301 (61.80)	186 (38.20)	
	Never	121 (72.89)	45 (27.11)	

Significantly higher proportions of the subjects performing regular physical exercise had normal blood pressure. Those who used to consume table salt regularly had significantly elevated blood pressure. A higher proportion of nonvegetarians, subjects consuming meat in more number of days and consumers of fast food had elevated blood pressure though statistically these were not significant

Table 4: Binary logistic regression analysis for developing elevated blood pressure.

Variables	Subgroup	OR (95% CI)	Significance
Sex	Male	0.231 (0.172-0.310)	0.000
	Female	1	
BMI	High	4.289 (2.857-6.440)	0.000
	Low and normal	1	
Serum leptin	High	1.354 (0.994-1.844)	0.055
	Low and normal	1	
Income		1.000 (1.000-1.000)	0.055
Family history of HTN	Present	1.111 (.795-1.552)	0.537
	Absent and unknown	1	

Binary logistic regression analysis has identified male sex (OR=0.231, 95% CI=0.172-0.310, $P=0.000$) and BMI (OR=4.289, 95% CI=2.857-6.440, $P=0.000$) as the significant predictors of elevated blood pressure among the students. The effect of serum leptin level, income of the parents, family history of hypertension, etc., in developing hypertension did not attain the level of statistical significance

In our study, binary logistic regression analysis has identified that male sex and BMI as the significant predictors of elevated BP among the students. But, the effect of serum leptin level, income of the parents, family history of HT, etc. in developing HT did not attain the level of statistical significance [Table 4].

Conclusion

The prevalence of PHT and HT among urban school-going adolescents were found to be 42.40% and 15.70%, respectively and it was significantly associated with their sex and BMI, and serum leptin level, but regression analysis failed to detect any significant effect of serum leptin level in determining BP of the study subjects.

Declaration of informed consent

The authors certify that they have obtained written informed consent from all the study subjects and their guardians. The participants and their guardians have consented for their images and other clinical information to be reported in the journal. They understood that their names and initials will not be published and due efforts will be made to conceal their identity and anonymity.

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Conflicts of interest

There is no conflict of interest.

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