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General And Neck Obesity Are Independent Determinants of Hypertension among Undergraduate Students: Evidence

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ABSTRACT:*Hypertension (HT) is a growing global public health problem. From a preventive point of view it is crucial to identify risk factors at an early stage. Obesity is a well –established risk factor for hypertension. Thus the aim of this study was to assess the association of general and neck obesity with hypertension (HT).This cross sectional survey was conducted among undergraduate students of West Bengal, India. The anthropometric and BP measurements were carried out on 1927 (males-732 and females-1195) students. General obesity was estimated from body mass index (BMI), and neck obesity from neck circumference (NC) and neck to height ratio (NHtR). Body height, weight, NC and BP were measured by standard methods. BMI and NHtR were estimated. The influence of BMI, NC and NHtR on blood pressure was estimated by logistic regression. P<0.05 values were considered as statistically significant. The prevalence of HT was greater in subjects with either overall obesity or neck obesity than non-obese counterpart. The each of the regressor (BMI, NC and NHtR) has positive influence on systolic blood pressure (SBP) and diastolic blood pressure (DBP) when they will be regressed separately. High BMI is significantly associated with systolic and diastolic hypertension irrespective of gender. Like BMI high NC is significantly associated with systolic hypertension of male and female and diastolic hypertension of male only. Impact of NHtR is insignificant on the development of hypertension in male and female. Moreover combination of neck obesity and general obesity may be preferable to either neck obesity or overweight/obesity for risk assessment of HT. The prevalence of HT was greater in subjects with overall obesity and neck obesity. Among Indian college students (18-22 years) the best indicator of the relationship between hypertension and obesity is BMI for female and NC for male students. Presence of combine (general and neck) obesity is a very potent risk factor for the development of HT in male and female students*

Keywords: *Hypertension, BMI, neck circumference, neck-to-height ratio.*

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I. Introduction

Hypertension (HT), also known as high blood pressure, is the commonest non communicable disease affecting both sexes in all races (1). It is defined as systolic blood pressure of 140 mm Hg or higher and/or diastolic blood pressure of 90 mm Hg or higher. It is the silent killer as it has no early significant symptoms but creates an extra load on heart and blood vessels. It is the single most significant risk factors for myocardial infarction, left ventricular hypertrophy, congestive heart failure, aneurysm, strokeand hypertensive nephropathy as well as hypertensive retinopathy (2). Around 26% adult world population was found to have HT in the year 2000 and this is expected to increase 29% by 2025 (3,4).The development of hypertension in younger age causes greater reduction of life expectancy if the blood pressure is left untreated (5). It has also been noted that even asymptomatic adolescents with blood pressure elevation can have target organ damage including left ventricular hypertrophy and pathological vascular changes (6, 7).

Obesity is rising to pandemic proportions and remains among the most neglected public health issues worldwide. It is associated with increasing risks of disability, illness and mortality from cardiovascular diseases. Cardiovascular disease particularly hypertension is the main illness associated with obesity (8). Different anthropometric measurements are commonly used worldwide to determine obesity. These include BMI, WC and waist-to-hip ratio (W/H). Overall obesity is measured by BMI but it restricted in screening regional body fat distribution. Waste circumference [WC] a clinical surrogate of visceral obesity, is superior to BMI in identifying central adiposity reflecting higher cardiovascular risk (9). The use of WC has certain limitations: i). it requires specific conditions such as unclothing and convenience of ambient temperature ii). It may vary throughout the day based on fasting-satiety status iii). It may vary in case of health problems which affect the abdominal wall (e.g. lipoabdominoplastyiv). Some people may not allow the measurement in light clothes due to sociocultural reasons (10).Neck circumference (NC) which is an easier and faster anthropometric measurement has been suggested as an index of upper body fat distribution (1) as well as good marker of central obesity like WC (10). Increase NC, a marker for upper body subcutaneous fat, surpasses WC as marker of visceral obesity (12). NC may be use as a simple screening measure to identify overweight and obesity (13). Obesity particularly when it occurs in upper part of the body is a major health problem (13).

The aim of the study was to assess the impact of general and neck obesity on the development of hypertension among undergraduate student.

II. Materials And Methods

Subject: The present study was conducted among normal healthy college students aged 18-20 years from two colleges in West Bengal, India during their college hours. Written consent from the students experimented in the study was obtained. Those not accepting to participate in the study, those with thyroid disease, those on medication for any reasons, body builders or professional or amateur athletes and physically handicapped person were excluded from the study.1927 students were included in this study. Every students in this study was given a predesigned questionnaire to obtain the information regarding age, last blood pressure readings, diabetes, kidney disease, congenital heart defect, myocardial infarction and/or stroke.

Measurement of blood pressure: Blood pressure was measured with a standard mercury sphygmomanometer. Before recording the blood pressure students were allowed to wait in separate room for 10 minutes to relieve their restlessness and anxiety. Systolic blood pressure (SBP) $\geq$ 140 mm Hg and diastolic blood pressure $\geq$ 90 mm Hg was considered as systolic and diastolic hypertension respectively (14).

Anthropometric measurements: Prior to the weight and height measurement subjects were asked to remove their shoes and heavy clothing. Body weight was measured using digital scale to the nearest 0.1kg. Height was measured using anthropometric rod. NC was measured just below the laryngeal prominence (Adam's apple) using calibrated plastic tape (10). Two measurements were recorded to the nearest 0.1 cm for each subject. BMI was calculated from the height and weight using following equation: BMI (kg/m^2) = weight (kg) / height^2 (m). NHtR was calculated by dividing NC with height. Overweight was defined as BMI 25-25.9kg/m2 and obesity as BMI $\geq$ 30 kg/m^2(15). Neck obesity was defined as NC $\geq$ 85th percentile value and NHtR$\geq$ 85th percentile value (16).

Statistical analysis

To examine the influence of BMI and neck obesity on blood pressure we run the generalized logistic regression. P<0.05 values were considered as statistically significant

Table 1: Variables included in the logistic regression of females

Dependent Variable: *i. SBP*: Dummy variable, having two categories viz. no systolic hypertension (SBP< 140mm Hg) and having systolic hypertension (SBP $\geq$ 140mm Hg). No systolic hypertension is taken as the reference category. *ii. DBP*: Dummy variable, having two categories viz. no Diastolic hypertension (DBP <90 mm Hg) and having Diastolic hypertension (DBP $\geq$ 90 mm Hg). No diastolic hypertension is taken as the reference category. **Independent Variables:** (i) *BMI*: Dummy variable, having two categories viz. below cutoff value (< 25.0kg/m^2) and above cutoff value ($\geq$ 25.0kg/m^2). BMI below cutoff value is taken as the reference category. (ii) *NC*: Dummy variable, having two categories viz. low NC (below 85th percentile) and high NC ($\geq$ 85th percentile value) (iii) *NHtR*: Dummy variable, having two categories viz. low NHtR (below 85th percentile) and high NHtR ($\geq$ 85th percentile value).

All of these regressor (BMI, NHtR and NC) are dummy variables having two values '0' (for reference categories) and '1' (for experimental categories).

III. Results

Sample characteristics

It is observed from Table 2 that more than one-third of males have high SBP and around 20 percent of females have high SBP. This disparity between males and females in the systolic blood pressure is partially disappeared in case of diastolic blood pressure. It can also be observed that there is no significantdifference in BMI, NC and NHtR between males and females.

Table 2: Sample characteristics

Categories of the variables	**Percentage of Population**	
	Males	**Females**
SBP		
No systolic hypertension	64.48	80.19
Having systolic hypertension	35.52	19.81
DBP:		
No diastolic hypertension	83.33	89.62
Having diastolic hypertension	16.67	10.38
Body Mass Index:		
Below cutoff value (< 25.0kg/m^2)	81.83	81.76
Above cutoff value ($\geq$ 25.0kg/m^2)	18.17	18.24
NC:		
Below cutoff value($\leq$85th percentile)	77.46	77.66
Above cutoff value (> 85th percentile)	22.54	22.34
NHtR:		
Below cutoff value($\leq$85th percentile)	84.43	85.59
Above cutoff value (> 85th percentile)	15.57	14.41

Bivariate analysis

Table 3 reports the bivariate analysis of systolic and diastolic hypertension with all independent variables. The percentages of individual's hypertension across male and female samples have been increased with the increase of BMI, NC and NHtR irrespective of gender.

Table-3: Bivariate analysis (contingency table)

Independent variables	SBP		DBP	
	No hypertension	Hypertension	No hypertension	Hypertension
Males				
BMI: Low (>25.0kg/m^2)	69.62	30.38	85.48	14.52
High ($\geq$ 25.0 kg/m^2)	41.35	58.35	73.68	26.32
NC: Low (< 85th percentile)	70.72	29.28	85.89	14.11
High (> 85th percentile)	43.03	56.97	74.55	25.45
NHtR: Low (< 85th percentile)	67.31	32.69	85.28	14.72
High (> 85th percentile)	49.12	50.88	72.81	27.19
Females				
BMI: Low (>25.0kg/m^2)	91.10	8.90	90.12	7.88
High ($\geq$ 25.0 kg/m^2)	64.22	35.78	78.44	21.56
NC: Low (< 85th percentile)	91.49	8.51	92.13	7.87
High (> 85th percentile)	67.79	32.21	80.90	19.10
NHtR: Low (< 85th percentile)	89.36	10.64	90.92	9.08
High (> 85th percentile)	67.25	32.75	81.87	18.13

Values are represented in percentage

Multivariate analysis:

Tables- 4 report the results of estimation of the logistic regressions of systolic and diastolic hypertension across the males and females. It is observed that high BMI has significant impact on the development of systolic and diastolic hypertension irrespective of gender. Like high BMI high NC has significant impact on the development of systolic hypertension of both sexes and diastolic hypertension of male student only. However, males are females having high NHtR are less likely to have high blood pressure, thus this influence is insignificant.

Table-4: Results of logistic regression by regressing SBP and DBP

Independent variables	Males			Females		
	Odds ratio	P value	Z value	Odds ratio	P value	Z value
SBP						
BMI: Low (>25.0kg/m^2)	Ref	Ref	Ref	Ref	Ref	Ref
High ($\geq$ 25.0 kg/m^2)	2.103**	0.00	3.09	5.27**	0.00	6.34

NC: Low (< 85th percentile)	Ref	Ref	Ref	Ref	Ref	Ref
High ($\geq$ 85th percentile)	2.656**	0.00	3.71	2.529**	0.00	2.58
NHtR:Low (< 85th percentile)	Ref	Ref	Ref	Ref	Ref	Ref
High ($\geq$ 85th percentile)	0.715	0.248	-1.16	1.280	0.331	0.98
DBP						
BMI: Low (>25.0kg/m^2)	Ref	Ref	Ref	Ref	Ref	Ref
High ($\geq$ 25.0 kg/m^2)	1.478**	0.00	4.758	2.610**	0.00	3.71
NC: Low (< 85th percentile)	Ref	Ref	Ref	Ref	Ref	Ref
High ($\geq$ 85th percentile)	1.382**	0.00	2.519	1.294	0.50	0.67
NHtR:Low (< 85th percentile)	Ref	Ref	Ref	Ref	Ref	Ref
High ($\geq$ 85th percentile)	1.396	0.309	1.443	1.141	0.733	0.34

Ref: implies reference category; ** implies p <0.01, * implies p <0.05.

Intersectional approach

Classifying the sample by two categories of each of the dummy variables BMI, NC and NHtR, we have already run the logistic regressions to estimate the impact of these variables on systolic and diastolic HT for males and females. However, all males and females having high BMI or low BMI are not identically affected by the NC, as well as by NHtR. For this reason, it will be more meaningful to classify the sample of males and females by combining the categories of BMI and NC, and the categories of BMI and NHtR together and run the logistic regressions to assess the influence of BMI and NC as well BMI and NHtR on the systolic and diastolic HT.

Each of the cases of classification of sample by BMI and NC, and four BMI and NHtR has four categories. The categories define by BMI and NC are 'low NC and low BMI', 'low NC and high BMI', 'high NC and low BMI', and 'high NC and high BMI', and the categories defined by BMI and NHtR are 'low NHtR and low BMI', 'low NHtR and high BMI', 'high NHtR and low BMI', and 'high NHtR and high BMI'. In case of running the logistic regressions we have taken either 'low NC or low BMI' as the reference category of the combined categorical variable defined by BMI and NC, or 'low NHtR and low BMI' as the reference category of the combined categorical variable defined by BMI and NHtR.

It can be observed from the results of logistic regressions by taking into account the intersection between BMI and NC that the females having 'high NC and low BMI', or 'low NC and high BMI', or 'high NC and high BMI' are more likely to have higher prevalence of systolic HT in compared to the females having 'low NC and low BMI'. However, for males this results deviate to some extent, as there is no significant difference in prevalence of Systolic HT between males having 'low NC & high BMI' and 'low NC and low BMI'. Though the males having 'high NC and low BMI' and 'high NC and high BMI' are more likely to have high systolic blood pressure compared to the males having 'low NC and low BMI'(table-5).

Table 5: Result of Logistic Regression by regressing of SBP in intersectional approach

Variables	Males			Females		
	Odds ratio	P value	Z-value	Odds ratio	P value	Z-value
NC and BMI						
Low NC and low BMI	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Low NC and high BMI	1.42	0.325	0.98	4.53**	0.000	4.95
High NC and low BMI	2.18**	0.008	2.64	3.27**	0.000	4.13
High NC and high BMI	6.45**	0.000	5.99	7.58**	0.000	7.76
NHtR and BMI						
Low NHtR and low BMI	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Low NHtR and high BMI	1.98	0.422	1.36	3.70**	0.000	5.05
High NHtR and low BMI	0.97	0.151	-1.15	1.72	0.13	1.52
High NHtR and high BMI	3.17*	0.045	2.08	3.91**	0.000	4.28

Ref: implies reference category; ** implies p <0.01, * implies p <0.05

In case diastolic blood pressure, the results are quite different from the case of systolic blood pressure. In case of the intersection between NHtR and BMI irrespective of gender high NHtR and high BMI are more likely to have diastolic HT. All other combination of NHtR and BMI have insignificant impact on the development of diastolic HT (table-6).

Table 6: Result of Logistic Regression by regressing of DBP in intersectional approach

Variables	Males			Females		
	Odds ratio	P value	Z-value	Odds ratio	P value	Z-value
NC and BMI						
Low NC and low BMI	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Low NC and high BMI	1.78	0.170	1.37	1.86	0.091	1.68
High NC and low BMI	1.52	0.238	1.18	1.57	0.195	1.30
High NC and high BMI	1.95*	0.049	1.97	4.37**	0.000	5.14

NHtR and BMI						
Low NHtR and low BMI	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Low NHtR and high BMI	1.64	0.091	1.69	1.93*	0.03	2.20
High NHtR and low BMI	0.99	0.072	-1.80	0.64	0.36	-0.91
High NHtR and high BMI	1.76*	0.034	2.12	2.29*	0.021	2.31

** implies $p < 0.01$, * implies $p < 0.05$

On the basis of odds ratio out of two indicators of upper body subcutaneous fat impact of NC has more significant than NHtR on the development of hypertension.

Prevalence of Hypertension on the basis of NC and BMI:

The prevalence of HT was significantly greater in subjects with either overall obesity or neck obesity than non-obese counterpart. But combination high NC with high BMI was associated with more significant increased risk of hypertension (Fig.1).

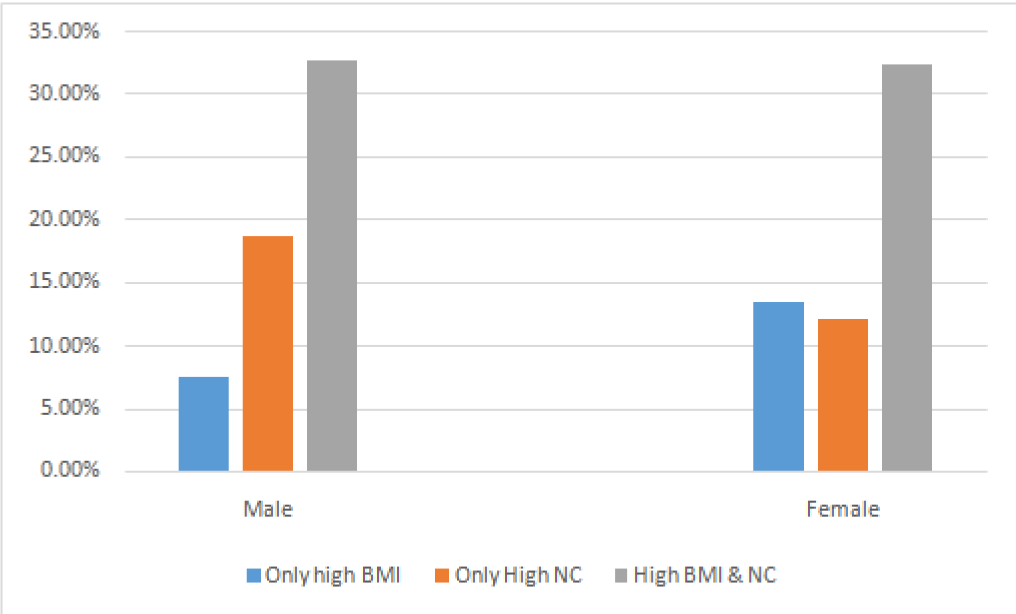

Fig.-1:Distribution of male and female hypertensive students on the basis of obesity

Prevalence of HT increases with the increase of NC for male and female students (table-7). Similarly prevalence of hypertension was more in over weight and obese students than students with normal weight.

Table-7: Prevalence of hypertension on the basis of percentile of Neck circumference and BMI

Gender	NC percentile				BMI (kg/m²)		
	≤ 85th	> 85th	> 90th	> 95th	< 25.0	25.0 – 29.9	≥ 30.0
Male	10.06%	30.84%	35.87%	60.00%	13.69%	28.57%	56.00%
Female	4.51%	15.91%	17.92%	30.23%	4.26%	9.52%	26.31%

IV. Discussion

The goal of this study was to evaluate the association between overall obesity and neck obesity with HT. Findings can be summarised as follows: i). Obesity either measured in general or neck was associated with greater prevalence of HT. ii). The occurance of HT was even greater when obesity coexisted in overall and neck region. iii). According to odd ratio in female students impact of overweight and obesity is more than neck obesity in the development of HT however, no such difference was noted in male students. iv. On the basis of odds ratio out of two indicators of upper body subcutaneous fat impact of NC has more significant than NHtR on the development of hypertension. v. combination overweight / obese and high NC is has positive impact on the development of HT in college student.

Obesity is a well-established risk factor for HT. Epidemiological studies have demonstrated that overweight predicts future development of HT and the relationship between BMI and HT is almost lenear (17). According to third National Health And Nutrition Survey the risk of HT increased significanly with overweight and it was much higher for subject with obesity (18). Our results also suggest general obesity as risk factor to develop HT.

Obesity, particularly upper body obesity is a major contributor of chronic diseases and disability including HT (19). We also noted similar results where upper body obesity is one of the determinant of HT. Upper body fat is more lipolytically active than lower body fat in both man and woman. Upper body subcutaneous fat is the dominant contributor to circulating FFAs and source of excess fatty acid released in upper body obesity (20). Thus upper body adeposity is associated with increase circulating FFA which increase VLDL and triglyceride production (21) and causes cardiovascular disease (22). Excess upper body subcutaneous fat is associated with oxidative stress, endothelial cell dysfunction, HT and vascular injury (23). In recent years use of NC as obesity marker is increasing gradually (24). NC is surrogate marker of upper body subcutaneous fat (25).Thus higher bioavailibility of FFAs can be suggested as a pathway in the relationship between high NC and HT. NC measurements have very good inter and intra-rater reliability and consequently they do not require multiple repeated measurements for precision and reliability (26). The NC measurement is cheaper and easier to perform. It is applicable to everyone and in every environment without being affected by fasting-satiety, garments and ambient temperature (10).Thus NC may be used as reliable marker of HT.

Both SBP and DBP were significantly positively correlated with NC and BMI (16). Bivariate logistic regression analysis of this study showed significant association between upper body subcutaneous fat and the risk to develop HT among college students. Like high NC, overweight and obesity was also associated with development of HT.

V. Conclusion

The results of this study indicated a high prevalence of HT among college students. High NC ($\geq$ 85th percentile)and high BMI (> 25.0kg/m^2)were significantly associated with hypertension. Moreover combination of high NC and overweight/obesity may be preferable to either high NC or overweight/obesity for risk assessment of HT among Indian college students. Once the obesity- related hypertension has developed, the complete normalization of blood pressure is difficult. Thus the early diagnosis of obesity and hypertension together with the change in lifestyle can lead to early intervention and thereby can improve the cardiovascular health of the whole population.

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