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CONTENTS

Childhood obesity and its association with hypertension among school-going children of Dehradun, Uttarakhand

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ABSTRACT: Nutrition transition of India in last few decades has increased the problem of overweight and obesity in its population. This has created double burden of malnutrition and also increased the risk of NCDs not only in adults but children as well. One of them is hypertension, a silent killer associated with high morbidity and mortality. Present study was aimed to study the association between childhood obesity and hypertension among children. Sixty obese (exposed group) and sixty non-obese children (control group) of 6-15 year were selected through purposive and random selection, respectively from school setting. Overall, prevalence of hypertension among children (n=120) was 26.7% (12.5% girls and 14.2% boys). Obese children (43.3%) were more likely to be hypertensive than non-obese children (10%) [X^2 (2, N=120) =24.1, p= <0.01]. Compared to diastolic blood pressure, systolic blood pressure was affected more by various anthropometric measures with significant positive correlation (with body weight, height, BMI, WC, %BF and ΣSF4) ($p<0.01$) in both boys and girls of 6-15yrs. High BMI and waist circumference increases the risk of elevated BP in children. Childhood obesity and hypertension among children had a significant positive relationship, indicating the necessity for screening obese children for hypertension to avoid future risk of NCDs.

Key words: Anthropometry, childhood obesity, hypertension, obesity, prevalence

India accounting for one-fifth of world's population has undergone a nutrition transition in last few decades (Agrawal, 2002; Dandona, 2017). This shift from underweight to overweight population due to changes in diet and lifestyle patterns had led to increased risk of non-communicable diseases (NCDs) (MoHFW, 2019). These increases in prevalence of NCDs across all socio-economic strata contribute to premature mortality not only in India but globally (IHME, 2018). A dramatic transition in the economy, demography and nutrition of Indian population has led to increase in the prevalence of overweight and obesity in adults as well as children of India, posing greater risks of NCDs such as diabetes, cardiovascular diseases and hypertension (Kalra, 2012; MoHFW, 2019). The CNNS survey report by (MoHFW, 2019) classified 4% of school-age children and 5% of adolescents as overweight or obese (BMI-for-age >+1 SD) and prevalence of other biomarkers of NCDs among children. One of those indicators for the prevalence of hypertension among adolescents was a Systolic Blood Pressure (SBP) >139 mmHg or Diastolic Blood Pressure (DBP) >89 mmHg based on which 5% of adolescents (10-19 years) were classified as hypertensive.

Hypertension a silent threat to human health across the world and is associated with high morbidity and mortality (Veetus and Shivaprakash, 2014). Epidemiological evidence suggests that hypertension, a significant risk factor for cardiovascular diseases, increases in parallel with obesity in children and adolescents in low and middle-income countries (Dyson *et al.,* 2014). Usually, hypertension has been considered an uncommon problem in childhood and adolescence. According to Sundar *et al.* (2013) hypertension has its origin in childhood but goes undetected unless specifically looked for during this period. Keeping in mind the above, present cross-sectional study was carried out in Dehradun city of Uttarakhand to find the association between childhood obesity and

hypertension among school children (6-15 years).

MATERIALS AND METHODS

Study area and study population: School going children (6-15 years of age) of Dehradun, Uttarakhand

Sample Size: 120 children (64 boys and 56 girls)

Sample Selection: All the children (N=1823) enrolled in I to IX standard (6-15 year of age) studying in the participant schools (n=6) and present during investigation were screened for the prevalence of obesity based on age specific BMI cut-offs given by WHO (De Onis *et al.,* 2007). Among the screened children, 60 non-obese (selected randomly) and 60 obese children were enrolled into the study after obtaining oral and written consent from the children and the parents.

Anthropometric measurements: ***Height*** was measured using stadiometer (to the nearest 0.1 cm) while the subject stood erect with heels and toes close together. ***Body weight*** was measured (to the nearest 0.5 kg) with the subject standing erect and motionless on an analog weighing scale which was standardised regularly with a weight of 10 kg. ***Waist circumference*** (WC) and ***hip circumference*** (HC) were measured with a non-stretchable tape to the nearest 0.1 cm in a standing position. ***Skinfold thickness*** at triceps, biceps, subscapular and suprailiac were measured using Skinfold Calipers to the nearest 0.1cm.

Anthropometric indexes: BMI ***Per centiles*** were calculated subsequently for children of all age groups, to assess the prevalence of overweight and obesity as per BMI-for-age criteria (WHO, 2007) (De Onis *et al*., 2007). The age was determined by date of birth as given in the school registration records.

Per cent Body Fat **(%BF):** Based on the sum of two skin-fold measurements at triceps and subscapular sites, Per cent body fat was calculated using Slaughter's equations as given below: (Slaughter *et al*., 1988).

BF% for children with triceps and subscapular skinfolds <35 mm:

Boys = 1.21 (sum of 2 skinfolds) – 0.008 (sum of 2 skinfolds2) – 1.7 …. (Eq 1)

Girls = 1.33 (sum of 2 skinfolds) – 0.013 (sum of 2 skinfolds2) – 2.5 …. (Eq 2)

BF% for children with triceps and subscapular skinfolds >35 mm:

Boys = 0.783 (sum of 2 skinfolds) – 1.7 …. (Eq 3)

Girls = 0.546 (sum of 2 skinfolds) + 9.7 …. (Eq 4)

Blood Pressure measurements: All BP measurements were carried out by a physician using a standard mercury sphygmomanometer. The average of three readings (taken over a period of 10 min) taken on the left arm was used to represent the individual's BP. The subject was seated at rest prior to measurements. Hypertension is defined as average systolic blood pressure (SBP) and/or diastolic blood pressure (DBP) $\geq$95th Per centile for sex, age, and height on three or more occasions (Bagga *et al.,* 2007).

Ethical consideration: School authorities were explained all the objectives and the methodology of study to seek their permission. For all the subjects the written consent was obtained from the school principal and their parents.

Statistical Analysis: Data was entered and analysed using Microsoft Excel 2007. Data was tabulated and presented as mean (standard deviations) for continuous variables and as counts and Per centages for categorical variables. To compare group means two-sample t-test was applied using SPSS Statistics 20 software. Pearson's Correlation coefficient was calculated to draw correlation matrix on blood pressure and various anthropometric parameters used in the study using Microsoft Excel 2007 and statistical significance of the results obtained was ascertained with SPSS Statistics 20 software.

RESULTS AND DISCUSSION

Results showed that out of 1823 children of age 6-

15 years who were screened for obesity, 11.9% children (73 girls and 143 boys) were underweight, 77.2% (614 girls and 794 boys) were normal, 7.6% (62 girls and 77 boys) were overweight and 3.3% (27 girls and 33 boys) were obese on applying BMI-for-age criteria given by WHO (2007) and were reported in detail by Belwal *et al.* (2020).

Distribution of non-obese and obese preschool children under age, gender and blood pressure classification is given in table 1. Overall, prevalence of hypertension among children of 6-15 years (n=120), irrespective of obese or non-obese was 24.2% for pre-hypertension and 26.7% for hypertension (12.5% girls and 14.2% boys). While prevalence of pre-hypertensive children was slightly higher in obese group (26.7%) compared to non-obese group (21.7%), Per centage of hypertensive children is 4 times higher in obese group (43.3%) compared to non-obese group (10%) and only 30% obese and 68.3% of non-obese children were normotensive.

The incidence of hypertension was quite high in both boys and girls who were obese, indicating that ~ 1 out 3 obese children to be hypertensive. There is a significant relationship between the obesity and hypertension. Obese children were more likely to be hypertensive [X^2 (2, N=120) =24.1, p= < .01] than non-obese children.

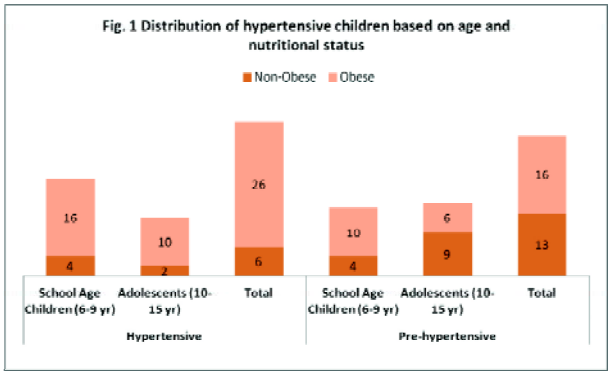

Fig. 1: Distribution of hypertensive and pre-hypertensive children based on their age and nutritional status

Average anthropometric measurements and blood pressure is given in table 2 for obese and non-obese

Table 2: Average anthropometric measurements of obese and non-obese children

Characteristics	Non-Obese children (mean ± SD)	Obese Children (mean ± SD)
Age	10.67 ±2.73	10.13 ±2.55
Height	141.20 ±15.03	142.05 ±13.90
Weight**	35.65 ±17.38	50.87 ±16.59
BMI**	17.38 ±1.74	24.43 ±3.87
SBP **	103.8 ±10.4	115.8 ±12.4
DBP*	68.2 ±7.5	75 ±7.4
WC**	65.57 ±8.41	79.19±10.44
Σ SF4**	38.55 ±12.02	82.70 ±22.39
% BF**	20.28 ±3.90	30.12 ±3.68

*Significant at 5% level (p< .05), **Significant at 1% level (p< .01), %BF: Body fat Per centage ΣSF4: Sum of skinfold thickness at 4 sites (triceps, biceps, subscapular and supra-iliac)

Table 1: Distribution of non-obese and obese preschool children under different age group, gender and blood pressure classification

Age (years)		Non-Obese Children				Obese Children		
		Total (N=120)	Boys (n=30)	Girls (n=30)	Total (N_1=60)	Boys (n=34)	Girls (n=26)	Total (N_2=60)
School age children (6-9 yr)	Normotensive	24(20.0%)	8 (26.7%)	9 (30.0%)	17 (28.3%)	4 (11.8%)	3 (11.5%)	7 (11.7%)
	Prehypertensive	14(11.7%)	1 (3.3%)	3 (10.0%)	4 (6.7%)	9 (26.5%)	1 (3.8%)	10 (16.7%)
	Hypertensive	20(16.7%)	3 (10.0%)	1 (3.3%)	4 (6.7%)	9 (23.5%)	8 (30.8%)	16 (26.7%)
Adolescents (10-15yr)	Normotensive	35(29.2%)	13 (43.3%)	11 (36.7%)	24 (40.0%)	3 (8.8%)	8 (30.8%)	11 (18.3%)
	Prehypertensive	15(12.5%)	5 (16.7%)	4 (13.3%)	9 (15%)	4 (11.8%)	2 (7.7%)	6 (10.0%)
	Hypertensive	12(10%)	-	2 (6.7%)	2 (3.3%)	6 (17.6%)	4 (15.4%)	10 (16.7%)
Total (6-15 year)	**Normotensive****	**59(49.2%)**	**21 (70%)**	**20 (66.7%)**	**41(68.3%)**	**7 (20.6%)**	**11 (42.3%)**	**18 (30%)**
	Prehypertensive*	**29(24.2%)**	**6(20%)**	**7(23.3%)**	**13(21.7%)**	**13 (38.2%)**	**3(11.5%)**	**16 (26.7%)**
	Hypertensive***	**32(26.7%)**	**3(10%)**	**3(10%)**	**6(10%)**	**14 (41.2%)**	**12 (46.2%)**	**26 (43.3%)**

*Pre-hypertensive= SBP or DBP ≥90th Per centile but <95th Per centile ***Hypertensive= SBP or DBP ≥95th Per centile **Normotensive= SBP or DBP <90th Per centile

Table 3: Correlation matrix on blood pressure and anthropometric parameters for obese and non-obese children

	Obese Children (n=60)								
	SBP	**DBP**	**Weight**	**Height**	**BMI**	**WC**	**HC**	**BF%**	**Σ SF4**
SBP	1								
DBP	0.65**	1							
Weight	0.57**	0.12	1						
Height	0.51**	0.07	0.94**	1					
BMI	0.49**	0.12	0.91**	0.74**	1				
WC	0.56**	0.12	0.92**	0.83**	0.91**	1			
HC	0.52**	0.18	0.86**	0.80**	0.85**	0.93**	1		
BF%	0.36**	0.32*	0.46**	0.40**	0.48**	0.50**	0.50**	1	
ΣSF4	0.55**	0.36**	0.76**	0.68**	0.78**	0.83**	0.81**	0.75**	1
	Non- Obese Children (n=60)								
	SBP	**DBP**	**Weight**	**Height**	**BMI**	**WC**	**HC**	**BF%**	**Σ SF4**
SBP	1								
DBP	0.66**	1							
Weight	0.31*	0.14	1						
Height	0.35**	0.18	0.98**	1					
BMI	0.20	0.06	0.92**	0.84**	1				
WC	0.19	0.02	0.68**	0.65**	0.65**	1			
HC	0.17	0.02	0.84**	0.80**	0.86**	0.78**	1		
BF%	0.08	0.09	0.50**	0.49**	0.52**	0.36**	0.58**	1	
ΣSF4	-0.05	0.01	0.49**	0.46**	0.56**	0.30*	0.57**	0.90**	1

*Significant at 5% level (p< .05) **Significant at 1% level (p< .01) ΣSF4 = sum of skinfold thickness at 4 sites (triceps, biceps, subscapular and supra-iliac)

Table 4: Correlation matrix on blood pressure and anthropometric parameters for boys and girls

	Boys (n=64)								
	SBP	**DBP**	**Weight**	**Height**	**BMI**	**WC**	**HC**	**BF%**	**ΣSF4**
SBP	1								
DBP	0.74**	1							
Weight	0.66**	0.36**	1						
Height	0.44**	0.14	0.86**	1					
BMI	0.65**	0.46**	0.84**	0.47**	1				
WC	0.62**	0.36**	0.90**	0.70**	0.86**	1			
BF%	0.54**	0.50**	0.63**	0.29*	0.84**	0.74**	1		
ΣSF4	0.60**	0.53**	0.68**	0.32*	0.87**	0.78**	0.97**	1	
	Girls (n=56)								
	SBP	**DBP**	**Weight**	**Height**	**BMI**	**WC**	**HC**	**BF%**	**ΣSF4**
SBP	1								
DBP	0.68**	1							
Weight	0.53**	0.24	1						
Height	0.36**	0.13	0.78**	1					
BMI	0.54**	0.30*	0.93**	0.51**	1				
WC	0.52**	0.25	0.86**	0.55**	0.88**	1			
BF%	0.55**	0.37**	0.83**	0.51**	0.89**	0.78**	1		
ΣSF4	0.54**	0.36**	0.85**	0.46**	0.93**	0.82**	0.98**	1	1

*Significant at 5% level (p< .05) **Significant at 1% level (p< .01), ΣSF4 = sum of skinfold thickness at 4 sites (triceps, biceps, subscapular and supra-iliac)

children. While the average age and height of the children in two groups are similar with no significant difference, the average blood pressure and anthropometric measurements other than height were

significantly higher for obese children compared to non-obese children.

The correlation matrix of blood pressure (SBP and DBP) and anthropometric parameters for obese and non-obese children (Table 3) was drawn and the results showed that SBP of obese children had a significant correlation ($p<0.01$) with DBP and all anthropometric parameters like weight, height, BMI, waist circumference, hip circumference and Σ SF4 and %BF. DBP had a significant correlation ($p<0.01$) only with SBP, Σ SF4 and %BF. In case of non-obese children only SBP showed some significant correlation that too with DBP, weight and height.

Correlation of blood pressure (systolic and diastolic) with various anthropometric parameters for boys and girls (obese and non-obese together) is given in table 4. A significant positive correlation was observed for SBP (with body weight, height, BMI, WC, %BF and Σ SF4 ($p<0.01$) in both boys and girls of 6-15yrs. While, anthropometric measurements such as weight, BMI, WC, %BF and Σ SF4 had a positive and significant correlation ($p<0.01$) with DBP in case of boys, for girls DBP had significant positive correlation $p<0.05$) only with BMI, %BF and ΣSF4.

Results showed that among all the children of 6-15years who were screened for obesity (BMI for age) 7.6% children were overweight and 3.3% were obese. The subsample of obese and no-obese children drawn from this population showed (Fig 1) that while prevalence of hypertension in obese children was four times higher (48.3%) than their counterpart (10% in non-obese children), pre-hypertension seemed to prevail in non-obese children (21.7% v/s 26.7%) almost on par with that in obese children (Shah *et al.*, 2013; Verma *et al.,* 1994). Dyson *et al.* (2014) also reported that obese children were 3.5-5.5 times more likely to show hypertension than those of normal weight, which indicated increased bodyweight as a significant risk factor for hypertension. Similar observations were reported by Badi *et al.* (2012) in Aden, Yemen for school children of age 6–16 years.

Overall, prevalence of pre-hypertension and hypertension among children of 6-15 years (n=120), was 24.2% and 26.7% respectively. The prevalence rates of hypertension for the present study were quiet high compared to the findings of some previous studies (Dyson *et al.,* 2014 and Kaur *et al.,* 2013) for the children in the age group 5-16 years, which is mostly likely because of low sample size of the present study. Present study was a part of study determining obesity prevalence and finding the association between hypertension and obesity rather than prevalence of hypertension among children.

The results indicated that anthropometric measures were inter dependent on each other, and that SBP was more positively affected by anthropometric measures compared to DBP. Unlike SBP, DBP gets more influenced by body composition factors rather than growth indicators in obese children. It can be inferred that children with high measures of body weight, BMI, WC, fat fold thickness and body fat are likely to develop high blood pressure as there are enough evidences from the previous studies also (Taksande *et al.,* 2008; Kaur *et al.*, 2013 and Colin-Ramirez *et al*., 2009)

Traditionally, hypertension has been considered an uncommon problem in childhood and adolescence, especially the essential hypertension but, essential hypertension is now emerging as a hidden problem in children and adolescents which should be detected by not avoiding blood pressure measurement at the health checkup of such population. There could be other reasons for primary hypertension (Patel and Walker, 2016), but the effect of obesity among children can't be ignored as it has significant correlation with blood pressure. Therefore, appropriate and timely measures should be taken to address the problem of obesity and related hypertension among children.

CONCLUSION

Childhood obesity and hypertension among children had a significant relationship. Systolic blood pressure is affected by most of the anthropometric measurements compared to Diastolic blood pressure. High waist circumference other than high BMI

increases the risk of hypertension among children. Study results support the importance of monitoring blood pressure among children also so that timely actions could be taken to prevent hypertension and its progression to later stages of life.

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