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Original Article

Physiology Section

Correlation between Visceral Fat with Pulse Pressure in Young Offsprings of Hypertensive and Normotensive Parents: A Cross-sectional Observational Study

ARTI CHOUBEY[1], VIVEK VERMA[2], SUMIT KUMAR[3]

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ABSTRACT

Introduction: Increased Pulse Pressure (PP) and arterial stiffness are both associated with an elevated risk of Cardiovascular Disease (CVD). Raised PP is an independent prognostic marker for CVD not only in adults but also in young normotensive subjects. Normotensive Offspring of Hypertensive Parents (OHP) are more likely to develop future hypertension. Visceral obesity, closely tied to endocrine activity, magnifies susceptibility to hypertension and CVD development in young adults. Thus, understanding the association between visceral fat and PP assumes paramount importance in young adults.

Aim: To study the correlation between visceral fat and PP in young offspring of hypertensive and normotensive parents.

Materials and Methods: The cross-sectional study was conducted in the Department of Physiology, Government Medical College, Datia, Madhya Pradesh, India for eight months from June 2023 to January 2024 among 140 healthy young participants aged 18-25 years. The subjects were divided into two groups: Group-1 {Offspring of Normotensive Parents (ONP)} and Group-2 offsprings of Hypertensive Parents (OHPs). Body composition parameters and visceral fat levels were measured using a calibrated Karada scan. Detailed information regarding the history of hypertension in the family, alcohol intake, etc., was collected in a pre-defined proforma. Blood pressure measurements of subjects were taken using a standard electronic sphygmomanometer. Statistical analysis of the data was conducted using Statistical Package for Social Sciences (SPSS) Version 28.0 software. For correlational analysis, Pearson correlation test was used and a p-value <0.05 considered significant.

Results: The findings revealed a significant positive correlation between visceral fat levels and PP levels ($p<0.05$, $r=0.58$ and 0.57) in the two groups. Visceral fat levels were significantly higher in OHPs than in ONPs.

Conclusion: Visceral fat and PP showed a correlation within the young population, irrespective of hypertensive or normotensive parents. However, visceral fat and PP levels were higher in the OHPs. This study suggests that maintaining a healthy body fat composition rather than just body weight might be pivotal for long-term hypertension prevention.

Keywords: Hypertension, Obesity, Young adults

INTRODUCTION

Arterial PP is defined as the difference between Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP), which increases steeply after middle age due to decreased elasticity of larger arteries [1]. Various research studies have shown that increased PP is an independent prognostic marker for cardiovascular events not only in the elderly population but also in younger normotensive subjects and subjects with relatively low cardiovascular risk [2-4]. Increased PP damages the elastic components of the vascular wall, thereby increasing the risk of atherosclerosis [5]. It is also associated with increased stress on the left ventricle, leading to ventricular wall hypertrophy and failure [6]. Pre-hypertension and a family history of hypertension are considered important risk factors for the onset of CVDs [7]. The development of essential hypertension is the result of genetic and metabolic disorders, as well as the influence of many unhealthy lifestyle factors that are closely related to the occurrence of cardiovascular events. Normotensive OHP are more likely to develop future hypertension, and the risk is even greater when both parents are hypertensive [8].

The recognition of the clinical significance of obesity-related hypertension has increased over time, to the extent that obesity is now acknowledged as a major cause of high blood pressure, and the combination of obesity and hypertension is recognised as a leading cause of cardiovascular risk [9]. Despite the abundance of scientific literature on incident CVD and obesity, there are still un-answered questions. Could a measure of adipose distribution be more consistently associated with CVD risk than Body Mass Index (BMI) ?[10] Given the rising obesity epidemic, understanding body fat distribution and its clinical implications is crucial for timely treatment. Visceral adipose tissue is a hormonally active component of total body fat with unique biochemical characteristics that influence various normal and pathological processes in the human body. Several cross-sectional studies have shown that abdominal adiposity is more strongly linked to arterial stiffness than visceral fat levels due to general obesity [10,11].

There are statistically significant disparities in beat-to-beat SBP and mean blood pressure levels between normotensive OHPs and ONPs, indicating a heightened predisposition to hypertension among OHPs [12,13]. Given the increasing prevalence of CVD in young adults, it is crucial to study the correlation between family history of hypertension and visceral fat levels with PP. Therefore, the aim of this study was to determine any correlation between visceral fat and PP among the offspring of hypertensive and normotensive parents and to investigate any differences in visceral fat levels between the two groups.

MATERIALS AND METHODS

This cross-sectional study was conducted in the Department of Physiology, Government Medical College, Datia, Madhya Pradesh, India, from June 2023 to January 2024, after approval from the Institutional Ethics Committee (IEC), GMC, Datia (IECBMHR No: 29/2023). All participants were provided with information about the study, and their written informed consent was obtained.

Sample size calculation: The sample size for the study was calculated using the formula for comparing two means [14]. Data from a previous study conducted by Nadeema R et al., was used for calculations, with 85.64 as Group-A mean, μA; 80.21 as Group-B mean, μB; 9.42 as Group-A Standard Deviation, σA; 10.19 as Group-B Standard Deviation, σB; and 1 as the sampling ratio [15]. The formula for comparing two means was used as follows:

$$n_A = (\sigma_A^2 + \sigma_B^2/K)\left(\frac{z_{1-\alpha} + z_{1-\beta}}{\mu_A - \mu_B}\right)^2$$

$$n_B = Kn_A$$

$$1 - \beta = \Phi\left(\frac{|\mu_A - \mu_B|\sqrt{n_A}}{\sqrt{\sigma_A^2 + \sigma_B^2/K}} - z_{1-\alpha}\right)$$

Where,

κ.=nA/Nb is the matching ratio, σ is standard deviation, σ Ais standard deviation in Group-A, σ B is standard deviation in Group-B, Φ is the standard Normal distribution function, Φ-1 is the standard normal quantile function, α is Type I error, β is Type II error, meaning 1-β is power of study (80%)

The sample size calculated was 66 in each group, which was rounded up to 70 in each group.

Inclusion criteria: Normotensive, non-smoker, and non-alcoholic participants in the age group of 18-25 years were included in the study.

Exclusion criteria: Subjects with age < 18 years and > 25 years, as well as those suffering from hypertension or any serious ailments, were excluded from the study.

Procedure

A total of 140 healthy young volunteers, both male and female in equal ratio, between the age group of 18-25 years, were divided into two groups: Group-1 (ONPs) and Group-2 (OHPs), each consisting of 70 participants with an equal male and female ratio. All subjects were required to refrain from any activity during the last 24-hour period before the experiment that might influence their blood pressure, such as exercise, alcohol, medicine, coffee, etc. The test requirements were as follows:

1) No vigorous exercise or other physical activities were recommended within two hours before the test.
2) No bathing or toilet activity was allowed within two hours before the test.
3) The laboratory air conditioner temperature was set at 25°C.
4) Information regarding family history and any history of hypertension was collected from each participant using a predefined questionnaire.

Participants with arterial blood pressure lower than 130/85 mmHg on three different occasions were considered healthy normotensive, and those with 130-139 SBP and 85-89 mmHg DBP were considered high normal, as per the guidelines of the Indian Society of Hypertension (InSH) [16]. OHP was defined as having at least one parent who was hypertensive and undergoing treatment for the same. Height was recorded in an erect posture using a standard stadiometer to the nearest 0.1 cm in the research Laboratory. Body composition parameters including weight, BMI, fat percentage, and visceral fat were measured using a calibrated Karada scan (Omron Inc.). During the measurement, the individuals stood on the instrument barefoot to ensure that both feet were in full contact with the foot electrode position of the human body composition analyser and held the handles on both sides with both hands to ensure that all fingers were in full contact with the test electrode. Blood pressure measurements of the subjects were taken using a standard electronic sphygmomanometer (Omron Inc. HEM model 7120 Fully Automatic Digital BP Monitor) after 10-20 minutes of rest in a quiet environment. PP was calculated by subtracting DBP from SBP.

STATISTICAL ANALYSIS

Statistical analysis of the data was conducted using IBM SPSS software (Statistics for Windows) Version 28.0. Armonk, NY: IBM Corp; 2021. Continuous variables were checked for normality, and results were expressed as mean±standard deviation. Correlation was assessed using the Pearson correlation (r) test. A p-value <0.05 was considered significant.

RESULTS

The mean age of males and females in Group-1 (ONP) was 21.08±2.34 and 20.51±1.43 years, respectively, while in Group-2 offsprings of Hypertensive Parents (OHPs) it was 20.94±1.43 and 20.20±1.71 years which were not statistically significant [Table/Fig-1]. The mean weight in kilograms was 61.99±10.01 and 65.44±8.31 for the two groups Gp1 and Gp2 of males, and 48.84±10.89 and 51.53±9.21 for the two groups Gp1 and Gp2 of females, and was not statistically significant [Table/Fig-1].

Genderwise variables data	Basic characteristics of offsprings of hypertensive and normotensive parents (Total n=140)					
	Males (n=35) ONP group (1)	Males (n=35) OHP group (2)	p-value	Females (n=35) ONP group (1)	Females (n=35) OHP group (2)	p-value
Mean age (years)	21.08±2.34	20.94±1.43	0.759307	20.51±1.85	20.20±1.71	0.463596
Mean height (cm)	171.77±7.03	170.12±4.08	0.236417	156.55±6.74	156.04±7.77	0.768390
Mean weight (Kg)	61.99±10.01	65.44±8.31	0.121403	48.84±10.89	51.53±9.21	0.269834
Body Mass Index (BMI) (kg/m^2)	21.15±4.02	22.09±3.06	0.274344	19.92±3.20	20.97±3.33	0.181788
Fat%	22.34±5.79	24.70±4.73	0.065087	28.93±4.84	29.47±4.54	0.634074
Visceral fat	3.02±2.76	4.41±2.77	0.040621	2.4±1.96	2.88±2.18	0.332706
Systolic BP (mmHg)	117.71±11.39	120.22±10.78	0.34662	107.14±12.93	109.65±10.18	0.36941
Diastolic BP (mmHg)	78.34±5.58	76.0±7.11	0.129947	69.20±9.55	70.57±8.36	0.52514
Pulse pressure (PP) (mmHg)	38.85±10.20	44±8.40	0.02439	37.94±8.71	39.37±8.80	0.4974

[Table/Fig-1]: Basic characteristics of offsprings of hypertensive and normotensive parents.
BP:Blood Pressure; ONP: Offspring of Normotensive Patients; OHP: Offspring of hypertensive patients

[Table/Fig-2] illustrates the mean levels of visceral fat, SBP, DBP, and PP in Group-1 (ONP) and Group-2 (OHP). [Table/Fig-3] shows that the mean PP is moderately and positively correlated with visceral fat levels and statistically significant in Gp1 ($p<0.05$; $r=0.58$) and Gp2 ($p<0.05$; $r=0.57$). Visceral fat levels in Gp1 and Gp2 showed a statistically significant difference ($p<0.05$). The PP in Gp1 and Gp2 also showed a statistically significant difference ($p<0.05$) and was negatively correlated ($r= -0.10$), whereas SBP ($p<0.05$; $r=0.51$) and DBP ($p<0.05$; $r=0.16$) was positively correlated with visceral fat levels in Gp 1 subjects and was also statistically significant. SBP ($p<0.05$; $r=0.54$) and DBP ($p<0.05$; $r=0.13$) was also positively correlated with visceral fat levels and was statistically significant in Gp2 [Table/Fig-3].

Mean of offsprings of hypertensive and normotensive parents		
Variables	Group-1 (n=70) Offsprings of Normotensive Parents (ONP)	Group-2 (n=70) Offsprings of Hypertensive Parents (OHP)
Visceral fat	2.714±2.405	3.648±2.59
Systolic BP (mmHg)	112.42±13.22	114.94±11.69
Diastolic BP (mmHg)	73.77±9.03	73.385±8.17
Pulse Pressure (PP) (mmHg)	38.4±9.42	41.685±8.85

[Table/Fig-2]: Mean of Pulse Pressure (PP), Systolic BP, Diastolic BP and Visceral fat levels of offsprings of hypertensive and normotensive parents.

that the relationship between VAT and PP was modified by gender [20]. The accumulation of abdominal visceral fat in men, which is a strong independent predictor of mortality, appears to be mainly due to higher dietary fat uptake, higher production of chylomicrons, and a greater likelihood to accumulate abdominal visceral fat compared to pre-menopausal women [21]. A positive association was observed between the reduction in body visceral fat and improvements in both SBP and DBP in males in a 12-week meal replacement intervention, which is consistent with this study [22].

The gender difference in body fat distribution, with visceral fat being predominant in men and subcutaneous fat being predominant in women, may be explained by hormonal distribution, providing evidence for the existence of such a gender difference. However, Kuwabara J et al., showed a negative correlation between visceral fat adiposity and day-to-day blood pressure variability, concluding that the degree of obesity should be considered when evaluating the value of blood pressure variability [23]. A study by Jang S et al., showed that the risk of hypertension among offspring was approximately two times higher when one parent was hypertensive and over four times higher when both parents were hypertensive compared to controls whose parents were not hypertensive, indicating a potential genetic link [24].

In this study, both groups, offspring of hypertensive and normotensive parents, showed a positive correlation between PP and visceral

Correlation Chart	Visceral fat GP1 (n=70) (ONP)	Visceral fat GP2 (n=70) (OHP)	Pulse Pressure (PP) GP 1 (n=70) (ONP)	Pulse Pressure (PP) GP 2 (n=70) (OHP)	Systolic BP GP 2(n=70) (OHP)	Diastolic BP GP 2(n=70) (OHP)
Visceral fat GP1 (ONP)	-	r= 0.035 **p=0.008**	**p<0.001** (1.64406E-63) r=0.58	-	-	-
Visceral fat GP2 (OHP)	r=0.035 **p=0.008**	-	-	r= 0.575 **p<0.001** (1.08328E-69)	r=0.547 **p<0.05**	r=0.139 **p<0.05**
Pulse Pressure (PP) GP1 (ONP)	r=0.58 **p<0.001** (1.64406E-63)	-	-	r=-0.107 **p=0.035**	-	-
Pulse Pressure (PP) GP2 (OHP)	-	r = 0.575 **p<0.001** (1.08328E-69)	r=-0.107 **p=0.035**	-	-	-
Systolic BP GP1 (ONP)	r=0.51 **p<0.05**	-	-	-	r=0.179 p=0.23	-
Diastolic BP GP1 (ONP)	r=0.161 **p<0.05**	-	-	-	-	r=0.118 p=0.73

[Table/Fig-3]: Correaltion of Pulse Pressure (PP), Systolic BP, Diastolic BP and Visceral fat levels in offsprings of hypertensive and normotensive parents.
Group-1: Offspring of normotensive parents (ONP); Group-2: Offspring of Hypertensive Parents (OHP).
PP: Pulse pressure in mm of Hg; SBP and DBP as Systolic and Diastolic blood pressure in mm of Hg; Test applied: Pearson correlation test; $p<0.05$ is considered significant

DISCUSSION

In this cross-sectional observational study, the relationship between visceral fat and PP in offspring of hypertensive and normotensive parents revealed a notable positive correlation between visceral fat and PP across both normotensive and hypertensive parental backgrounds. Elevated PP, a marker of cardiovascular risk, in conjunction with increased visceral fat, underscores the necessity for early cardiovascular risk assessment and targeted preventive strategies in individuals with a familial history of hypertension. Furthermore, it showed a significant difference in visceral fat levels ($p<0.05$) between offspring groups, with notably elevated levels among those with hypertensive parents.

In a previous study by Parikh SM et al., excessive visceral body fat was found to be positively associated with blood pressure in Indian adolescents [17]. Regarding fat distribution, De Pergola G et al., reported that visceral fat had the most significant impact on the elevation of blood pressure [18]. Wang Z et al., also found that excess visceral body fat was strongly associated with a higher risk of hypertension ($p<0.0001$), consistent with the findings in this study [19]. Sung HH et al., suggested that visceral adipose tissue (VAT) was associated with PP in Korean adults, but subgroup analysis revealed fat, but values of visceral fat were significantly higher in OHPs. The differences observed in the study might be attributed to variability in genetic factors. Therefore, the distribution of visceral fat in the body may be an important indicator that needs to be monitored and targeted in the management of overweight and obese adolescents to prevent future hypertension.

Limitation(s)

The age range of the study participants was 18-25 years, which limits the generalisation of the results to other age groups. This study emphasises the need for more extensive, ethnic- and gender-specific research on the potential significance of visceral fat and its role in the pathophysiology of cardiovascular morbidity and mortality.

CONCLUSION(S)

Visceral fat levels in OHPs exhibit slightly elevated levels compared to ONPs, with a positive correlation observed between visceral fat and PP. Thus, for prevention of hypertension, reducing body visceral fat (rather than only body weight) might become an important modality to prevent hypertension in long-term. Establishment of this association could help in arterial stiffness risk stratification in

normotensive young population with increased visceral fat levels, who were frequently overlooked in preventing CVDs.

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PARTICULARS OF CONTRIBUTORS:

1. Resident 2nd Year, Department of Physiology, Government Medical College, Datia, Madhya Pradesh, India.
2. Professor and Head, Department of Physiology, Government Medical College, Datia, Madhya Pradesh, India.
3. Assistant Professor, Department of Physiology, Government Medical College, Datia, Madhya Pradesh, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Sumit Kumar,
Assistant Professor, Department of Physiology, Government Medical College, Datia-475661, Madhya Pradesh, India.
E-mail: docsumitkumar27@gmail.com

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