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Vascular Ageing Influences Arterial Stiffness: A Cross-sectional Study of Different Age Groups with Special Reference to Blood Pressure and Obesity

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ABSTRACT

Introduction: Advanced Vascular age increases arterial stiffness which is a critical factor in cardiovascular risks such as high blood pressure (BP). The altered structural and functional changes in the blood vessels significantly contribute to increased arterial stiffness (AS). Ageing, increased BP and obesity are identified as the independent predictors of arterial stiffness. Current global scenarios make it need of the hour to establish a relationship between these factors.

Aim & Objectives: In this cross-sectional study, we aimed to explore the effect of vascular ageing on AS across two age groups and also find a correlation of obesity parameters and BP phenotypes.

Methodology: We determined the AS by measuring the arterial stiffness index (ASI) and pulse wave velocity (PWV) whereas the vascular ageing and BP were determined by oscillometric method in all the participants of our study. The obesity indices were measured by measuring body mass index (BMI) and waist circumference (WC). The obtained data was analyzed with Microsoft Excel and version-20 software of Statistical Package for Social Science (SPSS).

Results: The results obtained from our data were presented as mean ± SD and the correlation was conducted using Spearman's correlation. The values of $p < 0.05$ were considered as statistically significant in our results which make it evident that there is a positive correlation between obesity, AS, BP and vascular ageing.

Conclusion: These observations of our current study are indicative of an intricate relationship between vascular ageing, arterial stiffness, obesity and high blood pressure.

Keywords: *Arterial Stiffness, Obesity, Vascular Ageing, Blood Pressure*

1. INTRODUCTION

When we look upon the global causes of death due to non-communicable diseases (NCDs) and morbidities related to it, the cardiovascular diseases (CVDs) are renowned as the leader for it with a disproportionately high load of it in recent days are observed in India [1]. Advanced Vascular age increases arterial stiffness which is a critical factor in cardiovascular risks such as high blood pressure (BP). Vascular ageing, characterized by advancement in the vascular age which is often represented as a wide functional age difference (FAD), altered endothelial function, deposition of the collagen, reduced arterial elasticity due to degradation of the elastin, and structural remodeling of vessels plays a significant direct or indirect role in the pathogenesis of CVDs and its related sequel formations [2]. The altered structural and functional changes in the blood vessels significantly contribute to increased arterial stiffness (AS). Ageing, increased BP and obesity are identified as the

independent predictors of AS. Stiffness of the vessels, commonly measured by determining the Arterial Stiffness Index (ASI) of different limbs to reflect the functional and structural integrity of large vessels, play a crucial role in the advancement of the vascular age [3]. The relationships between the parameters of vascular ageing and AS are important due to associated factors like genetic predisposition [4]. A high BP predisposes an individual for future CVDs such as congestive heart failure, infarction of myocardium, stroke, etc. [5]. Advancement in the vascular age may precipitate this process as it is associated with oxidative stress related adversities [6]. Current global scenarios make it need of the hour to establish a relationship between these factors. Hence, in our study, we aimed to explore the effect of vascular ageing on AS across two age groups and also find a correlation of obesity parameters and BP phenotypes.

2. MATERIALS AND METHODS

The current study was conducted based on the guidelines of the Declaration of Helsinki. All participants in this study were enrolled voluntarily after they had given written informed consent following approval from the IEC, the institutional committee for ethics (Reference BLDE (DU)/IEC/581/2021-22).

The design of the current research: This cross-sectional study included 100 male participants aged 18 to 50 years, categorized into 2 age groups: young adults (18-35 years) were considered as participants of group-1 and middle-aged individuals (36-50 years) were considered as participants of group-2. We have included healthy individuals without pre-existing cardiovascular conditions, diabetes, or renal diseases. We have excluded females and individuals on antihypertensive or lipid-lowering therapies. We conducted the study at the Centre for Yoga and Exercise Science, Department of Physiology, between December 2021 and December 2022.

The total sample size of the current research: In our study the total size of the sample was calculated as 100, with 50 participants in both the study groups, to reach a minimum of 80% power level [4].

Measurements: All the participants when reported between 9 AM to 11 AM, their chronological age was asked and the values were expressed in years, following which the measurement of their weight was conducted by using a calibrated digital weighing machine and the values were expressed as Kg. The height was measured by using a calibrated stadiometer and the values were expressed as cm. The body mass index (BMI) of all the participants was calculated and expressed as Kg/m^2. Waist circumference (WC) was measured by using a measuring tape and expressed as cm. All the participants were evaluated for their AS, BP and vascular age by using a Periscope, Genesis Medical System, a noninvasive automated device that works on the oscillometric method. We obtained different parameters of AS such as Right Brachial Arterial Stiffness Index (ASI_{RB}), Left Brachial Arterial Stiffness Index (ASI_{LB}), Right Ankle Arterial Stiffness Index (ASI_{RA}), and Left Ankle Arterial Stiffness Index (ASI_{LA}), Right Brachial-Ankle Pulse Wave Velocity (Right PWV_{b-a}), and Left Brachial-Ankle Pulse Wave Velocity (Left PWV_{b-a}). For calculating the Functional Age Difference (FAD), we have deducted the value of the chronological age from the vascular age and the obtained values were expressed as ±years.

Statistical Analysis: The obtained data from our study was stored in a Microsoft Excel sheet and was analyzed using SPSS software version 20. The results obtained from the comparative analysis of our data were presented as mean ± SD whereas the correlation was established using Spearman's correlation. A paired student t-test was applied to compare the variables of both groups which was two-tailed. We considered the values of $p < 0.05$ as statistically significant for our obtained results.

3. RESULTS

Out of the 100 participants, we observed a significant difference in maximum parameters of obesity between our study groups such as weight and WC. Although we found an increased BMI in group 2 when compared with group 1 participants, the difference was not significant. We also found a significant increase in all the measured parameters of AS in group 2 participants when compared with group 1 participants along with a significant increase in BP in group 2 participants when compared with group 1 participants. We observed a significant difference in the chronological age between our study groups which indicates that the proposed study design was properly followed. All these observations are depicted in Table 1 which also makes it evident that there is an increased FAD in group 2 participants when compared with group 1 participants. The correlation between all the variables of AS and vascular ageing in our study participants is depicted in Table 2 and the correlation between variables of vascular ageing and obesity indices is depicted in Table 3 whereas Table 4 depicts the correlation between variables of AS and obesity indices. It is evident from these tables that AS is positively correlated with vascular ageing and obesity. The correlation between BP and AS is depicted in Table 5 and the correlation between BP and vascular ageing is depicted in Table 6 whereas Table 7 depicts the correlation between BP and obesity indices.

Table 1: Comparison of all the variables of both groups

Variables	Group 1, Age group 18-35 years (n = 50)	Group 2, Age group 36-50 years (n = 50)	p - value
Weight (kg)	62.06 ± 6.13	74.72 ± 10.71	p<0.001
BMI (kg/m^2)	21.13 ± 2.05	24.91 ± 3.72	NS
WC (cm)	83.06 ± 6.13	95.72 ± 10.71	p<0.001
SBP (mmHg)	116.64 ± 6.73	125.21 ± 12.07	0.0031
DBP (mmHg)	76.64 ± 7.01	79.61 ± 8.74	0.0353
PP (mmHg)	40.01 ± 5.47	45.61 ± 7.65	0.0206
MAP (mmHg)	89.97 ± 6.42	94.81 ± 9.31	0.0032
ASI_{RB} (mmHg)	24.03 ± 3.63	29.72 ± 8.12	p<0.001
ASI_{LB} (mmHg)	25.24 ± 3.91	28.61 ± 8.19	0.0101
ASI_{RA} (mmHg)	34.23 ± 3.63	36.21 ± 8.19	p<0.001
ASI_{LA} (mmHg)	34.54 ± 3.91	38.52 ± 8.12	0.0023
Right PWV_{b-a} (cm/sec)	1063.81 ± 110.02	1208.75 ± 172.01	0.0022
Left PWV_{b-a} (cm/sec)	1066.35 ± 120.04	1192.02 ± 163.17	0.0339
Vascular Age (years)	23.9 ± 5.84	46.96 ± 8.25	p<0.001
FAD (±years)	-1.18 ± 3.64	2.84 ± 6.23	p<0.001

Data represented in the form of mean ± SD; p<0.05 is considered statistically significant; BMI, body mass index; WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure; PP, pulse pressure; MAP, mean arterial pressure; ASI_{RA}, Right Ankle Arterial Stiffness Index; ASI_{LA}, Left Ankle Arterial Stiffness Index; Right PWV_{b-a}, Right Brachial-Ankle Pulse Wave Velocity; Left PWV_{b-a}, Left Brachial-Ankle Pulse Wave Velocity; FAD, functional age difference; NS, Not significant

Table 2: Correlation between variables of arterial stiffness and vascular ageing (n = 100)

Variable	Chronological Age (years)	Vascular Age (years)	FAD (±years)
ASI_{RB} (mmHg)	r = 0.44*	r = 0.68*	r = 0.82*
ASI_{LB} (mmHg)	r = 0.28*	r = 0.51*	r = 0.72*
ASI_{RA} (mmHg)	r = 0.21*	r = 0.46*	r = 0.74*
ASI_{LA} (mmHg)	r = 0.33*	r = 0.56*	r = 0.75*
Right PWV_{b-a} (cm/sec)	r = 0.46*	r = 0.68*	r = 0.82*
Left PWV_{b-a} (cm/sec)	r = 0.44*	r = 0.66*	r = 0.81*

r, correlation coefficient; ASI_{RB}, Right Brachial Arterial Stiffness Index; ASI_{LB}, Left Brachial Arterial Stiffness Index; ASI_{RA}, Right Ankle Arterial Stiffness Index; ASI_{LA}, Left Ankle Arterial Stiffness Index; Right PWV_{b-a}, Right Brachial-Ankle Pulse Wave Velocity; Left PWV_{b-a}, Left Brachial-Ankle Pulse Wave Velocity; FAD, functional age difference

* p value was <0.05 and it was considered as statistically significant

Table 3: Correlation between variables of vascular ageing and obesity indices (n = 100)

Variable	Chronological Age (years)	Vascular Age (years)	FAD (±years)
BMI (kg/m^2)	r = 0.55*	r = 0.75*	r = 0.81*
WC (cm)	r = 0.61*	r = 0.79*	r = 0.79*
r, correlation coefficient; BMI, body mass index; WC, waist circumference; FAD, functional age difference			

* p value was <0.05 and it was considered as statistically significant

Table 4: Correlation between variables of arterial stiffness and obesity indices (n = 100)

Variable	BMI (kg/m^2)	WC (cm)
ASI_{RB} (mmHg)	r = 0.81*	r = 0.77*
ASI_{LB} (mmHg)	r = 0.73*	r = 0.66*
ASI_{RA} (mmHg)	r = 0.70*	r = 0.63*
ASI_{LA} (mmHg)	r = 0.77*	r = 0.70*
Right PWV_{b-a} (cm/sec)	r = 0.73*	r = 0.73*
Left PWV_{b-a} (cm/sec)	r = 0.72*	r = 0.68*
r, correlation coefficient; ASI_{RB}, Right Brachial Arterial Stiffness Index; ASI_{LB}, Left Brachial Arterial Stiffness Index; ASI_{RA}, Right Ankle Arterial Stiffness Index; ASI_{LA}, Left Ankle Arterial Stiffness Index; Right PWV_{b-a}, Right Brachial-Ankle Pulse Wave Velocity; Left PWV_{b-a}, Left Brachial-Ankle Pulse Wave Velocity; BMI, body mass index; WC, waist circumference		

* p value was <0.05 and it was considered as statistically significant

Table 5: Correlation between BP phenotypes and arterial stiffness (n = 100)

Variable	SBP (mmHg)	DBP (mmHg)	PP (mmHg)	MAP (mmHg)
ASI_{RB} (mmHg)	r = 0.79	r = 0.57	r = 0.54	r = 0.70
ASI_{LB} (mmHg)	r = 0.70	r = 0.52	r = 0.45	r = 0.63
ASI_{RA} (mmHg)	r = 0.72	r = 0.57	r = 0.41	r = 0.68
ASI_{LA} (mmHg)	r = 0.73	r = 0.52	r = 0.50	r = 0.64
Right PWV_{b-a} (cm/sec)	r = 0.77	r = 0.54	r = 0.54	r = 0.68
Left PWV_{b-a} (cm/sec)	r = 0.70	r = 0.52	r = 0.47	r = 0.64
r, correlation coefficient; SBP, systolic blood pressure; DBP, diastolic blood pressure; PP, pulse pressure; MAP, mean arterial pressure; ASI_{RA}, Right Ankle Arterial Stiffness Index; ASI_{LA}, Left Ankle Arterial Stiffness Index; Right PWV_{b-a}, Right Brachial-Ankle Pulse Wave Velocity; Left PWV_{b-a}, Left Brachial-Ankle Pulse Wave Velocity				

* p value was <0.05 and it was considered as statistically significant

Table 6: Correlation between BP phenotypes and vascular ageing (n = 100)

Variable	SBP (mmHg)	DBP (mmHg)	PP (mmHg)	MAP (mmHg)
Chronological Age (years)	r = 0.42	r = 0.27	r = 0.32	r = 0.34
Vascular Age (years)	r = 0.68	r = 0.47	r = 0.48	r = 0.59
FAD (±years)	r = 0.88	r = 0.68	r = 0.57	r = 0.81
r, correlation coefficient; FAD, functional age difference; SBP, systolic blood pressure; DBP, diastolic blood pressure; PP, pulse pressure; MAP, mean arterial pressure				

* p value was <0.05 and it was considered as statistically significant

Table 7: Correlation between BP phenotypes and obesity indices (n = 100)

Variable	SBP (mmHg)	DBP (mmHg)	PP (mmHg)	MAP (mmHg)
BMI (kg/m^2)	r = 0.79	r = 0.57	r = 0.52	r = 0.72
WC (cm)	r = 0.73	r = 0.52	r = 0.50	r = 0.65
r, correlation coefficient; BMI, body mass index; WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure; PP, pulse pressure; MAP, mean arterial pressure				

* p value was <0.05 and it was considered as statistically significant

Our results it evident that vascular ageing is positively correlated with arterial stiffness, high BP and obesity and FAD is the most sensitive parameter to assess vascular ageing.

4. DISCUSSION

The current research was conducted to assess the progression of arterial stiffness across different age groups to provide insights into age-related cardiovascular risks. Our results are indicative of a positive correlation between arterial stiffness, vascular ageing, obesity and increased blood pressure. The mechanistic pathways [7, 8, 9] which may serve as the possible explanations for the observed results are depicted below in Figure 1.

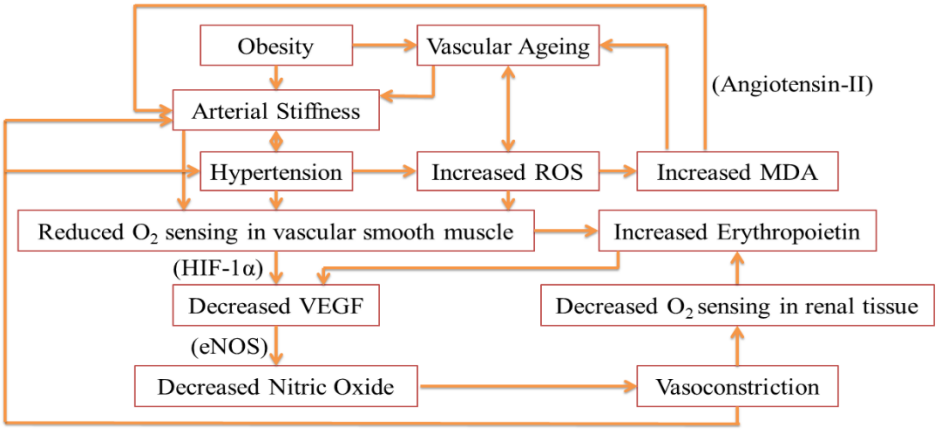

Figure 1: Mechanistic pathways depicting the intricate relationship of vascular ageing, obesity, arterial stiffness and hypertension

5. CONCLUSION

We conclude our study by establishing a positive relationship between arterial stiffness with vascular ageing which advances as an individual enters middle age from a young age. Lifestyle modifications may act as preventive measures to avoid the risk of future cardiovascular risks in Indian populations independent of their chronological age. Our study is also suggestive of preventing obesity to decelerate the progress of the pathogenesis related to arterial stiffness and advanced vascular age. Future research comprising a larger sample size is required in this direction with a special focus on the molecular mechanisms

involved within it.

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Informed Consent statement: The informed consent was obtained for experimentation and that it conforms to the standards currently applied in the country of origin

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Authors Contribution: Each author mentioned has significantly and directly contributed intellectually to the project and has given their approval for its publication.

Ashwani Sharma: Conceptualization, Methodology, Writing – Original Draft, Supervision, Project Administration, Resources, Supervision.

Jyoti P Khodnapur: Conceptualization, Methodology, Writing – Original Draft.

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Sumangala M Patil: Data Collection, Analysis, Writing – Review & Editing.

Jayballabh Kumar: Data Collection, Analysis, Writing – Review & Editing.

Sariya Nazim: Conceptualization, Methodology, Writing – Original Draft, Visualization.

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