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Research Article

Association between Body Mass Index and Left Brachial-Ankle Pulse Wave Velocity in Young Adult Females: A Cross-Sectional Study

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ABSTRACT

Background: Pulse wave velocity (PWV) is a validated, non-invasive index of arterial stiffness, and obesity, commonly assessed using body mass index (BMI), is a recognised determinant of vascular stiffening and cardiovascular risk. Data describing this relationship in young, apparently healthy women from India remain limited.

Objective: To assess the association between BMI and left brachial-ankle pulse wave velocity (L-baPWV) in young adult females.

Methodology: A cross-sectional study was conducted among 200 healthy female students aged 18-25 years in the Department of Physiology, BPS Government Medical College for Women, Khanpur Kalan, Sonepat. Anthropometric parameters were recorded and BMI was calculated. L-baPWV was measured by a non-invasive periscope and categorised as ≤ 1056 cm/s and ≥ 1057 cm/s. The Chi-square test was used to test the association between BMI category and L-baPWV category.

Results: The mean age of participants was 21.33 ± 1.81 years and mean BMI was 22.20 ± 3.68 kg/m². Of the 200 participants, 28 (14%) were underweight, 127 (63.5%) had a normal BMI and 45 (22.5%) were overweight. Elevated L-baPWV (≥ 1057 cm/s) was present in 60.71% of underweight participants compared with 30.71% of those with normal BMI and 28.89% of overweight participants. This association between BMI and L-baPWV was statistically significant (x2 = 9.950, df = 2, p = 0.007).

Conclusion: A significant association was found between BMI and left brachial-ankle pulse wave velocity, with a higher proportion of underweight young women showing increased peripheral arterial stiffness. BMI, at both extremes, deserves attention as a correlate of early vascular changes even in apparently healthy young women.

Keyword: Body Mass Index, Pulse Wave Velocity, Arterial Stiffness, Periscopy, Young Adults.

INTRODUCTION

Pulse Wave Velocity (PWV) is the velocity at which pressure waves generated by systolic contraction of the heart propagate along the arterial tree, and it provides information about the elastic properties of the arterial system. A higher PWV corresponds to reduced vessel wall distensibility and compliance, and therefore to greater arterial stiffness.[1] Arterial stiffness is associated with the presence of cardiovascular risk factors and atherosclerotic disease.[2]

Obesity is a growing global problem, driven largely by physical inactivity and unhealthy dietary practices, and is considered a prime risk factor for cardiovascular disease, contributing to hypertension, heart failure, prothrombotic states and venous disease.[3,4] Body Mass Index (BMI), a simple and widely used anthropometric index of overall adiposity, has been variably associated with measures of arterial stiffness across different populations and age groups. While the relationship between obesity and cardiovascular disease is well established, the role of vascular dysfunction, particularly arterial stiffening, as a mechanistic link continues to be studied, and evidence regarding how BMI relates to peripheral arterial stiffness in young, apparently healthy women remains limited and inconsistent.[5,6]

Brachial-ankle pulse wave velocity (baPWV) is a simple, reproducible and non-invasive method of assessing arterial stiffness that can be recorded bilaterally, including the left brachial-ankle segment (L-baPWV).[7]Since early vascular changes may precede clinically overt cardiovascular disease by years, evaluating the association of BMI with L-baPWVin young women may help identify subjects at higher vascular risk at a stage when lifestyle modification is likely to be most effective. The present study was therefore undertaken to assess this association.

Objective

To assess the association between left brachial-ankle pulse wave velocity (L-baPWV) and Body Mass Index (BMI) in young adult females using a non-invasive periscope.

MATERIALS AND METHODS

Study design and setting: This was a cross-sectional, observational study conducted in the Department of Physiology, BPS Government Medical College for Women, Khanpur Kalan, Sonepat, Haryana, over a period of one year, after obtaining Institutional Ethics Committee (IEC) approval and written informed consent from all participants.

Study population and sample size: The study population comprised female students of the institute. Sample size was calculated by the regression method, using a correlation coefficient (r) of 0.89 for baPWV with arterial stiffness, 80% power and 5% alpha error, yielding a minimum requirement of 198 subjects; 200 subjects were finally enrolled using stratified random sampling.

Inclusion criteria: Young, healthy, female students aged 18–25 years.

Exclusion criteria: Subjects with a history of hypertension, known cardiovascular disease, malignancy, liver, gastrointestinal or renal disease, autoimmune vasculitis, tuberculosis, diabetes mellitus or any other chronic illness, those on antihypertensive drugs, and those who did not consent, were excluded.

Anthropometric assessment: Height and weight were measured using a stadiometer and calibrated weighing scale, and BMI was calculated as weight (kg)/height² (m²). Participants were classified as underweight (BMI < 18.5 kg/m²), normal (BMI 18.5–24.9 kg/m²) or overweight (BMI ≥ 25 kg/m²) as per WHO classification.[8]

Measurement of pulse wave velocity: L-baPWV was measured using a non-invasive periscope (Recorders & Medicare Systems Pvt. Ltd., Panchkula). Participants abstained from caffeine for at least 12 hours before testing and rested supine for 5 minutes prior to recording. Four-limb blood pressure cuffs and a four-lead ECG cable were connected to the device, and baPWV was derived automatically from the time delay between waveforms recorded at the brachial and ankle sites along with the estimated path length between these sites. The reference (normal) value of baPWV was taken as 1056 cm/s; accordingly, L-baPWV was categorised as ≤ 1056 cm/s (normal) or ≥ 1057 cm/s (elevated) for the purpose of this analysis.

Statistical analysis: Data were entered in Microsoft Excel and analysed using SPSS version 25. Quantitative data are expressed as mean ± standard deviation; categorical data are expressed as frequencies and percentages. The Chi-square ($\chi 2$) test was used to assess the association between BMI category and L-baPWV category. A p-value < 0.05 was considered statistically significant.Student's t-test was used to determine the mean difference between groups for normally distributed (parametric) data, whereas the Mann–Whitney test was applied for non-parametric data.

RESULTS

A total of 200 healthy young adult females aged 18–25 years were studied. The sociodemographic and baseline profile of the study population is presented below, followed by the association between BMI and L-baPWV.

Table 1: Sociodemographic (Age-Wise) Distribution of Study Participants (N = 200)

Age Group (Years)	Number Of Participants	Percentage (%)
18–21	100	50.0
22–25	100	50.0
Total	**200**	**100.0**

As shown in Table 1, the study population was equally distributed across the two age strata, with 100 participants (50%) each in the 18–21-year and 22–25-year age groups; all subjects were female.

Table 2: Mean and Standard Deviation of Anthropometric and Cardiovascular Parameters of Study Participants (N = 200)

Parameter	Mean ± SD
Age (Years)	21.33 ± 1.81
Weight (Kg)	56.36 ± 9.85
Height (Cm)	159.55 ± 6.05
BMI (Kg/M²)	22.20 ± 3.68
Waist Circumference (Cm)	74.49 ± 8.63
Hip Circumference (Cm)	93.91 ± 7.68
Waist/Hip Ratio	0.78 ± 0.05
Heart Rate (Bpm)	78.35 ± 12.71
Systolic BP (Mmhg)	115.13 ± 12.71
Diastolic BP (Mmhg)	63.75 ± 6.99
Pulse Pressure (Mmhg)	51.45 ± 7.64
L-Bapwv (Cm/S)	1018.08 ± 114.94

Table 2 depicts the overall sociodemographic and physical profile of the study population. The mean BMI of the study population was 22.20 ± 3.68 kg/m², within the normal range, and the mean L-baPWV was 1018.08 ± 114.94 cm/s.

Table 3: Association between BMI and Left Brachial-Ankle Pulse Wave Velocity (L-Bapwv) (N = 200)

BMI Category (Kg/M²)	L-Bapwv ≤ 1056 Cm/S N (%)	L-Bapwv ≥ 1057 Cm/S N (%)	Total N (%)	Test Of Significance
Underweight (0–18.50)	11 (39.29)	17 (60.71)	28 (100)	X^2 = 9.950
Normal (18.6–24.99)	88 (69.29)	39 (30.71)	127 (100)	Df = 2
Overweight (≥ 25.00)	32 (71.11)	13 (28.89)	45 (100)	**P = 0.007**
Total	**131 (65.5)**	**69 (34.5)**	**200 (100)**	

On comparing L-baPWV values across BMI categories, a significantly higher proportion of underweight participants (60.71%) showed elevated L-baPWV (≥ 1057 cm/s) compared with those having a normal BMI (30.71%) or an overweight BMI (28.89%). Participants with normal and overweight BMI showed a comparatively lower and similar percentage of elevated L-baPWV. This association between BMI and L-baPWV was statistically significant (χ^2 = 9.950, df = 2, p = 0.007).

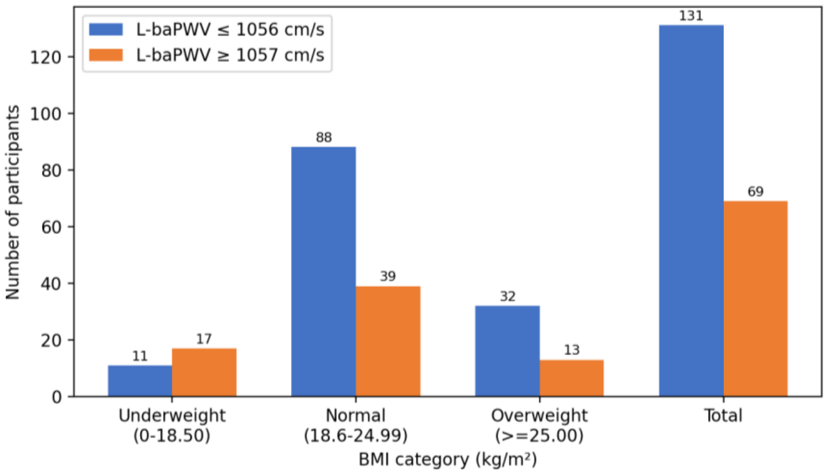

Figure 1: Association between BMI and Left Brachial-Ankle Pulse Wave Velocity (L-Bapwv)

DISCUSSION

Arterial stiffening is an early pathological vascular change that precedes clinically overt cardiovascular disease, and non-invasive tools capable of detecting this change in young, apparently healthy individuals are of growing interest.[9]In the present study of 200 healthy young women, a significant association was found between BMI and L-baPWV (p = 0.007), with the highest prevalence of elevated arterial stiffness observed, unexpectedly, in the underweight group (60.71%) rather than in the overweight group (28.89%).

This finding contrasts with the conventional expectation of a positive, linear relationship between adiposity and arterial stiffness. Kim HL et al[10] found no significant correlation between baPWV and BMI in their study population, while Hu F et al[11] reported a negative relationship between BMI and baPWV values in both sexes, findings that are broadly in keeping with the pattern of higher L-baPWV among leaner participants observed in the present study. On the other hand, Pizzi OL et al[12]and Tang B et al[13] reported a significant positive association between BMI and PWV, and Ruiz-Moreno MI et al[14]similarly observed a positive relationship between arterial stiffness and obesity parameters, including BMI, in a paediatric population. These discrepancies across studies suggest that the relationship between generalised adiposity, as reflected by BMI, and peripheral arterial stiffness may be influenced by age, sex, ethnicity, body composition and the specific arterial segment being assessed, and may not always follow a simple linear pattern, particularly in young, lean populations where low BMI may itself reflect factors such as poor nutritional status rather than favourable vascular health.

A possible explanation for the higher L-baPWV noted among underweight participants in this study is that a low BMI in young women may sometimes be a marker of undernutrition rather than physical fitness, and nutritional deficiency has itself been linked to altered vascular compliance in some populations.[15]Alternatively, small sample sizes within BMI subgroups, particularly the underweight category (n = 28), may have contributed to this finding, and the result warrants confirmation in larger, well-nourished cohorts.

The strengths of this study include a reasonably large, homogeneous sample of young, healthy women and the use of a standardised, automated, non-invasive device for PWV assessment. Limitations include the cross-sectional design, which precludes causal inference, the single-centre nature of the study population, and the relatively small number of participants in the underweight subgroup.

CONCLUSION

In this cross-sectional study of 200 healthy young adult females, a statistically significant association was observed between BMI and left brachial-ankle pulse wave velocity (p = 0.007), with a higher proportion of underweight participants showing elevated arterial stiffness compared with those having normal or elevated BMI. These findings suggest that both low and high BMI may be relevant correlates of early peripheral vascular changes in young women, and that BMI screening, combined with non-invasive arterial stiffness assessment, could help identify young women who may benefit from nutritional and lifestyle counselling. Larger, multi-centric, longitudinal studies are recommended to confirm this association and to clarify its underlying mechanisms.

Conflict of Interest

None.

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