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Original Research Article

Prevalence and Significance of Inter-Arm Blood Pressure Differences in Young Adult Medical Students

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Abstract: ***Background***: Hypertension is a major global health concern and often begins in early adulthood. Inter-arm blood pressure difference (IAD), defined as a discrepancy in systolic or diastolic pressure between the right and left arms, has emerged as a marker of vascular stiffness, subclinical atherosclerosis, and increased cardiovascular risk. While most research has focused on middle-aged and elderly populations, limited data exist on the prevalence and clinical significance of IAD in younger adults, particularly medical students who face academic stress and lifestyle risk factors. ***Objectives:*** The primary aim of this study was to assess the prevalence of IAD in young adult medical students. Secondary objectives included evaluating gender differences in blood pressure, analyzing associations with anthropometric and physiological parameters, and examining the potential implications for early cardiovascular risk. ***Methods:*** A cross-sectional observational study was conducted among 191 medical students aged 17–25 years. Participants with cardiovascular, renal, or metabolic disorders or those on antihypertensive therapy were excluded. Anthropometric parameters (height, weight, BMI, waist circumference, hip circumference, and waist–hip ratio) and physiological variables (pulse, respiratory rate, and SpO_2) were recorded. Blood pressure was measured in both arms using a mercury sphygmomanometer, with duplicate readings averaged for analysis. An IAD of ≥10 mmHg in systolic or diastolic BP was considered clinically significant. Data were analyzed with SPSS v25.0, using t-tests, chi-square tests, and Pearson's correlations. A p-value <0.05 was considered statistically significant. ***Results:*** The mean age of participants was 18.8 ± 1.1 years; females comprised 55% of the cohort. The right arm showed higher systolic BP (118.4 ± 14.0 mmHg) compared with the left (114.3 ± 12.9 mmHg), yielding a mean systolic IAD of ~4 mmHg. Clinically significant systolic IAD (≥10 mmHg) was present in 26.7% (51/191) and diastolic IAD in 21.5% (41/191) of participants. Male students had significantly higher right arm systolic BP than females (126.4 vs. 111.8 mmHg, $p = 0.004$), while diastolic pressures did not differ by gender. Anthropometric indices including weight, BMI, waist circumference, and hip circumference correlated positively with both systolic and diastolic pressures ($p < 0.05$), whereas waist–hip ratio showed no significant association. Pulse rate was inversely correlated with right arm systolic BP ($r = –0.232$, $p = 0.001$). Respiratory rate and SpO_2 were not significantly associated with BP values. ***Conclusion:*** This study demonstrates that inter-arm blood pressure differences are not uncommon in young, apparently healthy medical students, with nearly one-fourth showing clinically significant systolic IAD. Male students exhibited higher systolic BP, and adiposity-related indices were strongly linked to BP measures, underscoring the role of body composition in early vascular changes. Routine bilateral BP measurement in young adults is recommended to prevent diagnostic errors and to enable early cardiovascular risk detection. Future multicentric longitudinal studies are warranted to explore the prognostic implications of IAD in predicting hypertension and cardiovascular disease over time.

Keywords: Inter-arm blood pressure difference; Young adults; Medical students; Anthropometry; Cardiovascular risk; Hypertension; Bilateral blood pressure measurement.

INTRODUCTION

Hypertension remains one of the most important modifiable risk factors for cardiovascular morbidity and mortality worldwide. According to the Global Burden of Disease (GBD) study, elevated blood pressure contributes to nearly 10.8 million deaths annually, primarily through ischemic heart disease, stroke, and chronic kidney disease (1). Although hypertension is more prevalent in middle-aged and elderly populations, its origins often trace back to early adulthood, where subtle alterations in vascular physiology, lifestyle risk factors, and undetected hemodynamic changes may already be present (2). Routine measurement of blood pressure (BP) is therefore not only critical for diagnosing hypertension but also for identifying young adults at risk of developing cardiovascular disease later in life.

In clinical practice, blood pressure measurement is typically performed in one arm, often without considering inter-arm differences. However, a difference in systolic or diastolic BP between the right and left arms, referred to as inter-arm blood pressure difference (IAD), has attracted increasing attention. Studies have shown that an IAD of ≥10 mmHg may be associated with peripheral arterial disease, increased arterial stiffness, and higher cardiovascular risk (3, 4). Pathophysiologically, IAD can reflect asymmetry in arterial compliance or subclinical atherosclerotic changes in the subclavian or brachial arteries. Clinically, failure to measure BP in both arms may result in misclassification of hypertensive status, with potential consequences for diagnosis, treatment, and prognosis.

Several large-scale studies have investigated the prevalence and prognostic value of IAD in adults. Clark et al. (2016) demonstrated that inter-arm systolic differences of ≥10 mmHg were associated with an increased risk of all-cause mortality and cardiovascular events (3). Similarly, meta-analyses have confirmed that IAD is not a benign physiological variation but a marker of underlying vascular pathology (5). Importantly, guidelines from the European Society of Cardiology (ESC) and American Heart Association (AHA) recommend bilateral BP measurement at least at the initial visit, to detect such differences (6). Yet, despite these recommendations, the practice is often neglected in routine settings, especially in younger populations considered "low risk."

While most evidence links IAD with adverse outcomes in middle-aged and older adults, data in younger populations remain limited. Young adults, particularly those in stressful educational or occupational settings, may experience physiological fluctuations in BP that could mask or exaggerate inter-arm differences. Moreover, lifestyle patterns including poor sleep, academic stress, irregular diet, and reduced physical activity common among medical students can contribute to early vascular changes (7). Establishing baseline prevalence of IAD in young, apparently healthy adults is therefore essential. Such data not only enhance our understanding of vascular physiology in this age group but also provide opportunities for early cardiovascular risk stratification.

Anthropometric measures such as body mass index (BMI), waist circumference, and waist–hip ratio are established predictors of hypertension and cardiovascular disease (8). These indices reflect adiposity distribution, which influences vascular resistance, endothelial function, and arterial compliance. Correlating these parameters with inter-arm BP differences may uncover mechanistic pathways linking central adiposity with vascular asymmetry. Similarly, physiological variables such as heart rate, respiratory rate, and oxygen saturation can provide insights into autonomic regulation and cardiorespiratory health in young adults. Identifying associations between these variables and IAD adds value to screening practices. Despite international recognition of IAD as a cardiovascular risk marker, research among young adult cohorts, especially medical students in low- and middle-income countries such as India, is sparse. Most existing studies focus on high-risk or elderly populations, leaving a gap in understanding how prevalent and clinically significant IAD is in apparently healthy young individuals. Medical students constitute a unique group because they are not only future healthcare providers but also face academic stress, lifestyle disruptions, and irregular sleep patterns that can affect cardiovascular health. Early detection of inter-arm differences in this population can serve as both a preventive and educational strategy, encouraging routine bilateral BP measurement in clinical practice. The present study was conducted to determine the prevalence and significance of inter-arm blood pressure differences among young adult medical students. In addition, the study aimed to evaluate associations between IAD and anthropometric/physiological parameters, thereby identifying potential predictors of vascular asymmetry in this population.

Materials and Methods

This study was designed as a cross-sectional observational investigation and was conducted in the department of Physiology. The study targeted young adult medical students and was carried out over a defined duration after obtaining approval from the Institutional Ethics Committee (IEC). Ethical clearance was obtained in accordance with the principles of the Declaration of Helsinki (2013 revision), and written informed consent was secured from all participants before enrolment. A total of 191 medical students between the ages of 17 and 25 years were recruited. Participants were included if they were apparently healthy and willing to provide consent. Students with a known history of hypertension, cardiovascular disease, renal disorders, diabetes mellitus, or those taking antihypertensive or cardiovascular medications were excluded. Individuals with acute illness at the time of the study were also not considered eligible. All participants underwent a standardized set of anthropometric and physiological assessments. Height was measured using a stadiometer, while weight was obtained using a calibrated digital weighing machine. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters. Waist circumference was measured at the midpoint between the lower border of the last palpable rib and the iliac crest, and hip circumference was taken at the widest portion of the buttocks; waist–hip ratio (WHR) was subsequently derived. These anthropometric indices were chosen because of their established association with blood pressure variability and cardiovascular risk.

Blood pressure was measured bilaterally using a validated mercury sphygmomanometer. Participants were seated comfortably and allowed to rest for at least five minutes before measurement. The right arm was measured first, followed by the left arm after an interval of two to three minutes to minimize carryover effects. Both systolic and diastolic pressures were recorded at the first and fifth Korotkoff sounds, respectively. Each measurement was repeated twice in each arm, and the average of the two readings was taken for analysis. An inter-arm blood pressure difference (IAD) was defined as a discrepancy of at least 10 mmHg between the right and left arms, which was considered clinically significant.

Physiological parameters including pulse rate, respiratory rate, and oxygen saturation were also recorded. Pulse was measured at the radial artery for one full minute, respiratory rate was observed by counting chest excursions per minute, and peripheral oxygen saturation (SpO_2) was assessed with a calibrated digital pulse oximeter. The sample size was calculated based on existing literature, which reported that 10–20% of young adults might present with clinically significant IAD. Assuming a 95% confidence interval with a 5% margin of error, the minimum required sample size was estimated at 174. To account for potential attrition and incomplete records, 191 participants were finally included in the analysis.

All data were entered into Microsoft Excel and analyzed using the Statistical Package for the Social Sciences (SPSS) version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean with standard deviation, while categorical variables were represented as frequencies and percentages. Differences between male and female participants were assessed using independent sample t-tests for continuous variables and chi-square tests for categorical data. Pearson's correlation coefficients were used to explore the association between anthropometric measures and blood pressure values. A p-value less than 0.05 was considered statistically significant for all analyses

RESULTS

A total of 191 medical students participated in the study, with a mean age of 18.8 ± 1.1 years (range 17–25 years). The gender distribution was balanced, with a slight predominance of females (n = 105, 55%) compared with males (n = 86, 45%). Dietary habits were nearly equally split between vegetarian and non-vegetarian groups. Overall, the participants represented a young and healthy cohort with no history of hypertension or cardiovascular disease (Figure-1).

Figure-1 Distribution of Gender and Dietary Habits among Study Participants (n = 191)

Anthropometric and Demographic Characteristics

The average height of the study population was 163.9 ± 8.9 cm, and the mean weight was 62.9 ± 13.3 kg, corresponding to an average body mass index (BMI) of 23.4 ± 4.2 kg/m². Waist and hip circumferences were 33.6 ± 5.1 cm and 38.4 ± 4.8 cm, respectively, with a mean waist–hip ratio of 0.88 ± 0.12. Gender-specific analysis showed that males were significantly taller and heavier than females and also had a higher waist–hip ratio. While BMI did not differ significantly between genders, waist circumference was higher among males, reflecting greater central adiposity. The differences in weight (p = 0.002) and waist–hip ratio (p = 0.028) were statistically significant, indicating gender-specific variations in body fat distribution (Table-1).

Table 1. Descriptive Statistics of Anthropometric, Blood Pressure and Physiological Parameters (n = 191)

Variable	Minimum	Maximum	Mean	Std. Deviation
Age (years)	17	25	18.80	1.087
Height (cm)	145	189	163.90	8.850
Weight (kg)	40.0	105.0	62.95	13.26
BMI	15.59	35.86	23.37	4.17
Waist circumference (cm)	24.0	59.0	33.57	5.11
Hip circumference (cm)	21.0	49.0	38.40	4.75
Waist-Hip Ratio	0.65	1.55	0.88	0.12
Right Systolic BP (mmHg)	86	181	118.35	13.98
Right Diastolic BP (mmHg)	50	114	69.90	11.45
Left Systolic BP (mmHg)	86	150	114.27	12.88
Left Diastolic BP (mmHg)	47	99	68.81	9.26
Pulse (beats/min)	60.0	130.0	97.71	13.70
Respiratory Rate (/min)	9	19	11.15	1.46
SpO_2 (%)	90	100	97.75	1.52

Blood Pressure Measurements

The mean right arm systolic blood pressure (SBP) across the cohort was 118.4 ± 14.0 mmHg, while the mean left arm SBP was 114.3 ± 12.9 mmHg. Thecorresponding diastolic values were 69.9 ± 11.5 mmHg for the right arm and 68.8 ± 9.3 mmHg for the left arm. On average, the right arm demonstrated slightly higher systolic values than the left arm, resulting in a mean inter-arm systolic difference of approximately 4 mmHg. Inter-arm diastolic differences were smaller and less consistent. Males exhibited significantly higher right arm systolic BP compared with females (126.4 ± 14.3 vs. 111.8 ± 9.6 mmHg, p = 0.004), while other BP parameters, including left arm SBP and both diastolic measures, did not differ significantly by gender (Table-2).

Table 2. Blood Pressure and Physiological Parameters by Gender (n = 191)

Variable	Female (n=105)	Male (n=86)	p-value
Right Systolic BP (mmHg)	111.78 ± 9.62	126.37 ± 14.33	0.004
Right Diastolic BP (mmHg)	67.50 ± 11.07	72.81 ± 11.28	0.257
Left Systolic BP (mmHg)	109.04 ± 10.95	120.66 ± 12.21	0.444
Left Diastolic BP (mmHg)	66.98 ± 8.88	71.03 ± 9.27	0.321
Pulse (beats/min)	100.98 ± 13.54	93.72 ± 12.88	0.339
Respiratory Rate (/min)	11.27 ± 1.44	11.01 ± 1.47	0.495
SpO_2 (%)	97.87 ± 1.65	97.60 ± 1.34	0.893

Prevalence of Inter-Arm Differences

In the present study, inter-arm blood pressure differences were observed between the right and left arms. The mean systolic blood pressure was higher in the right arm (118.35 ± 13.98 mmHg) compared with the left arm (114.27 ± 12.88 mmHg), while the mean diastolic pressure showed a minimal difference (right: 69.90 ± 11.45 mmHg; left: 68.81 ± 9.26 mmHg). When analyzed categorically, systolic IAD ≥10 mmHg was found in 26.7% (51/191) participants, whereas diastolic IAD ≥10 mmHg was present in 21.5% (41/191) participants. These findings indicate that systolic inter-arm variation was more frequent than diastolic variation in this young adult cohort.

Physiological Parameters

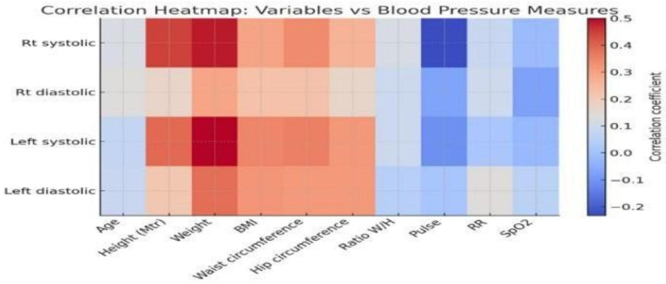
The mean pulse rate was 97.7 ± 13.7 beats per minute, while the mean respiratory rate was 11.2 ± 1.5 breaths per minute. Oxygen saturation (SpO_2) values were uniformly high across the cohort, averaging 97.8 ± 1.5%, reflecting normal baseline oxygenation in this young population. Gender analysis showed no significant differences in respiratory rate or SpO_2. Pulse rate, however, tended to be higher in females compared with males, although the difference did not reach statistical significance.

Correlation Analysis

Pearson's correlation analysis revealed strong and significant positive associations between anthropometric parameters and blood pressure values. Height, weight, BMI, waist circumference, and hip circumference all demonstrated significant positive correlations with both systolic and diastolic BP in both arms ($p < 0.05$). Among these, body weight exhibited the strongest correlation with systolic BP. In contrast, waist–hip ratio did not correlate significantly with any BP measurement. Pulse rate was negatively correlated with right arm systolic BP ($r = -0.232$, $p = 0.001$), suggesting that higher heart rates were associated with lower systolic pressure in the right arm. Respiratory rate and oxygen saturation showed no significant correlations with blood pressure values.

Figure-2 Correlation heatmap: Variables vs blood pressure measures

Discussion



DISCUSSION

This study examined the prevalence and significance of inter-arm blood pressure differences (IAD) among 191 young adult medical students. The findings demonstrate that, although the mean inter-arm systolic difference was modest (~4 mmHg), a subset of participants exhibited clinically significant IAD (≥10 mmHg). Males showed significantly higher right arm systolic blood pressure compared with females, while other blood pressure parameters did not differ substantially between genders. Anthropometric variables including weight, BMI, waist circumference, and hip circumference showed significant positive correlations with systolic and diastolic BP values, whereas waist–hip ratio was not associated with blood pressure measures. Pulse rate was inversely correlated with right arm systolic BP, while respiratory rate and SpO_2 showed no meaningful associations.

The present study revealed that systolic IAD ≥10 mmHg was found in 26.7% of participants, while diastolic IAD ≥10 mmHg was observed in 21.5%. These values are considerably higher than the prevalence reported in some community-based studies of young adults, which typically range from 5% to 15% (4, 9, 10). Our findings highlight that even in apparently healthy, young, and normotensive individuals, clinically significant inter-arm variation exists and warrants attention. Clark et al. (2012) demonstrated that systolic IAD ≥10 mmHg is associated with increased risk of peripheral arterial disease and cardiovascular mortality (9). Similarly, Aboyans et al. (2018) emphasized that inter-arm BP measurement is a simple, non-invasive tool that improves cardiovascular risk prediction (4). Clark et al. (2012) further linked IAD with arterial stiffness and coronary artery calcification, underscoring its role as an early vascular marker (11). The right-arm predominance observed in this study is consistent with anatomical variations in the brachiocephalic artery and differences in peripheral vascular resistance. Clinically, this finding reinforces the recommendation that BP should be measured in both arms during initial evaluation to avoid misclassification of hypertension and to identify individuals at higher cardiovascular risk. Early detection of IAD in young populations may serve as a valuable opportunity for preventive interventions and long-term monitoring.

The present study also revealed that males had significantly higher right arm systolic BP compared with females, a finding consistent with known sex differences in vascular physiology. Prior studies have attributed such differences to greater arterial stiffness, higher sympathetic tone, and larger body size in men (12). Interestingly, diastolic BP values did not differ significantly by gender, suggesting that systolic parameters may be more sensitive markers of sex-related vascular variation in young adults. Our results resonate with global observations showing that young men tend to develop higher systolic values earlier in life, contributing to their greater lifetime cardiovascular risk compared with women (13).

Consistent positive correlations between anthropometric measures and blood pressure observed in our study reinforce the well-established link between adiposity and elevated vascular resistance. Among these parameters, body weight exhibited the strongest correlation with systolic BP, followed by BMI and waist circumference. This is in line with the work of Leggio et al. (2017), who demonstrated that higher BMI is directly associated with increased systolic and diastolic pressures in young adults (8). Our finding that waist–hip ratio was not significantly correlated with BP is noteworthy, as it may reflect the relatively homogenous and non-obese status of our cohort compared with older or more heterogeneous populations where WHR is a stronger predictor (7). These associations suggest that even modest variations in body composition can influence blood pressure regulation in young adults, highlighting the importance of early lifestyle interventions.

We also observed an inverse correlation between pulse rate and right arm systolic BP. This contrasts with certain studies in older populations where tachycardia has been linked to higher systolic pressure due to increased sympathetic activation (9). The negative correlation in our cohort could reflect a physiological phenomenon in young adults where elevated heart rates, often associated with lower stroke volume, lead to relatively reduced systolic pressure. The lack of significant association between respiratory rate or SpO_2 and blood pressure is consistent with prior reports that these parameters remain stable in healthy individuals without cardiorespiratory disease (14-17).

Our findings carry important implications for clinical practice. First, they reinforce the necessity of measuring BP in both arms during initial clinical assessments, even in young populations traditionally considered low risk. Failure to detect significant IAD may result in misclassification of hypertensive status and missed opportunities for early intervention. Second, the associations between anthropometric indices and BP highlight the contribution of adiposity to vascular changes at a young age. This underscores the need for early lifestyle modifications such as weight control, balanced diet, and physical activity to prevent progression toward sustained hypertension. Finally, the detection of clinically significant IAD in otherwise healthy students suggests that vascular asymmetry may represent an early subclinical marker of cardiovascular risk, warranting periodic follow-up.

Most previous research has focused on middle-aged or high-risk populations, with relatively few studies examining IAD in young cohorts. A study from China reported that 7.2% of university students exhibited systolic IAD ≥10 mmHg, findings comparable to our observations (18). In contrast, community-based studies in older adults have reported prevalence rates as high as 15% (3). The lower prevalence in young adults may reflect preserved arterial compliance and absence of advanced atherosclerosis, but the presence of any clinically significant IAD should still raise clinical awareness.

A strength of this study lies in its focus on young medical students, a relatively under-researched group, providing baseline prevalence data on IAD in early adulthood. The standardized measurement protocol with repeated bilateral readings enhanced the reliability of BP data. However, several limitations must be acknowledged. First, this was a single-center study with a modest sample size, which may limit generalizability. Second, vascular imaging such as Doppler ultrasound was not employed to confirm arterial asymmetry, restricting mechanistic interpretation. Third, the cross-sectional design precludes causal inferences regarding the relationship between anthropometric variables and BP. Finally, potential confounders such as stress, caffeine intake, or circadian variation in BP were not controlled. Future research should focus on larger multicentric cohorts to validate these findings and investigate longitudinal trajectories of IAD in young adults. Incorporating vascular imaging and biomarkers of endothelial function could elucidate the underlying mechanisms. Additionally, exploring the predictive value of IAD for later development of hypertension or cardiovascular disease in young populations would provide important evidence for preventive strategies.

Conclusion

The present study highlights that inter-arm blood pressure differences are not confined to older or high-risk populations but are also prevalent among young, apparently healthy medical students. In our cohort, more than one-fourth of participants demonstrated systolic inter-arm differences ≥10 mmHg, while over one-fifth showed similar diastolic variation, underscoring that clinically significant asymmetry exists even in early adulthood. These findings emphasize the importance of incorporating bilateral blood pressure measurement into routine clinical practice to avoid misclassification of hypertension and to identify individuals at potential risk of future cardiovascular disease. Early recognition of such vascular asymmetry, coupled with lifestyle modification and periodic monitoring, may serve as a valuable preventive strategy to reduce the long-term cardiovascular burden.

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