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# A Comparative Analysis of the Inter-Arm Blood Pressure of Post-Stroke Patients with Left Hemiparesis and Healthy Subjects

**Ogbutor Udoji Godsday[1,*], Atose Omorigho Greatcrown[2], Ogbutor Emeke Godson[2], Nofiu Oluwatobi Daniel[3], Abdulfatah Hajara Aminu[1], Uti Oghenerohro Mercy[4], Anastacia Okwudili Ojimba[1], Isaac Precious[1]**

[1]Faculty of Basic Medical Sciences, Delta State University, Abraka, Delta State, Nigeria

[2]Faculty of Education, Delta State University, Abraka, Delta State, Nigeria

[3]Faculty of Human Kinetics and Health Education, Ahmadu Bello University, Zaria, Kaduna State, Nigeria

[4]Department of Internal Medicine, Federal Medical Centre, Asaba, Delta State, Nigeria

[*]Corresponding author: Ogbutor Udoji Godsday, udojiogbutor@delsu.edu.ng

## Abstract

Background: Inter-arm blood pressure difference (IABPD) is a marker of vascular asymmetry and cardiovascular risk. In post-stroke patients with hemiparesis, altered vascular regulation may heighten IABPD, yet its clinical significance remains underexplored. Aim: To compare IABPD between post-stroke patients with left hemiparesis and healthy controls, and to assess its relevance in hypertension management. Materials and Methods: A comparative cross-sectional study was conducted among 150 post-stroke patients and 150 age- and sex-matched controls. Simultaneous bilateral blood pressure readings were obtained under standardized conditions using a validated digital sphygmomanometer. Pulse pressure (PP) was calculated as systolic minus diastolic blood pressure. Data were analyzed using descriptive statistics and independent t-tests ($p < 0.05$). Results: Stroke patients showed significantly higher mean systolic IABPD ($9.1 \pm 6.8$ mmHg) than controls ($0.7 \pm 3.2$ mmHg; $p < 0.0001$), and higher diastolic IABPD ($3.5 \pm 5.1$ mmHg vs. $0.4 \pm 2.7$ mmHg; $p < 0.0001$). Pulse pressure was also elevated, indicating increased arterial stiffness. The greatest IABPD occurred within three months post-stroke and declined gradually but persisted beyond six months. Conclusion: Markedly higher IABPD in stroke survivors underscores the need for routine bilateral blood pressure measurement to identify the dominant arm for monitoring and treatment. This simple, low-cost approach may enhance hypertension detection and reduce recurrent stroke risk, especially in resource-limited settings.

## Keywords

Inter-arm blood pressure difference, Stroke, Hemiparesis, Hypertension, Vascular asymmetry

## Article History

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## 1. Introduction

Stroke is a leading cause of death and long-term disability worldwide, exerting a profound burden on patients, families, and healthcare systems. Globally, it accounts for about 11% of all deaths and remains one of the major causes of years lived with disability [1]. Although the burden of stroke is universal, its impact is particularly severe in low- and middle-income countries, where healthcare infrastructure and rehabilitative resources are often inadequate [2,3]. In Nigeria, stroke constitutes a major neurological emergency and a significant cause of disability among the working-age population, largely driven by the growing prevalence of uncontrolled hypertension, diabetes, and other modifiable cardiovascular risk factors [4].

Hypertension remains the most significant modifiable risk factor for stroke, implicated in over 50% of cases worldwide [5]. Despite increasing awareness and the availability of antihypertensive therapies, effective control remains poor in many developing regions [5]. Accurate blood pressure (BP) assessment is therefore a cornerstone of both primary and secondary prevention strategies in stroke care. However, the accuracy of BP readings can be influenced by physiological and methodological factors, one of which is inter-arm blood pressure difference (IABPD) [6].

IABPD refers to the difference in BP measurements between the right and left arms. A systolic blood pressure (SBP) difference of ≥10 mmHg is generally considered clinically significant and has been linked with peripheral vascular disease, subclavian stenosis, and increased cardiovascular and cerebrovascular risk [7,8]. Despite its prognostic importance, IABPD measurement is not routinely incorporated into clinical practice due to time constraints, limited clinician awareness, and the assumption that both arms yield comparable readings [9]. Consequently, opportunities for early identification of vascular abnormalities, particularly among high-risk groups such as stroke survivors, are often missed.

Post-stroke patients frequently present with hemiparesis weakness or paralysis on one side of the body resulting from damage to the contralateral cerebral hemisphere. Hemiparesis is associated with neuromuscular and autonomic changes that may affect vascular tone and hemodynamics on the affected side [10]. Studies have suggested that such alterations can lead to asymmetric blood flow and differential BP readings between the paretic and non-paretic arms [11]. This raises a crucial clinical concern: unilateral BP measurement in stroke survivors may yield misleading results. Underestimation in the affected arm may result in under treatment of hypertension, whereas overestimation could lead to overtreatment both with potential clinical consequences [12,13].

Despite its clinical relevance, the relationship between IABPD and hemiparetic stroke remains underexplored, especially in low- and middle-income country contexts where diagnostic tools such as Doppler ultrasound and angiography are often unavailable or unaffordable [14]. In such settings, bilateral BP measurement represents a simple, inexpensive, and non-invasive method of assessing vascular health and detecting asymmetries suggestive of underlying pathology. Understanding the prevalence and magnitude of IABPD in stroke survivors could provide valuable insights into cardiovascular risk stratification, guide individualized BP monitoring, and improve long-term outcomes [15].

In Nigeria, few studies have specifically examined IABPD among post-stroke patients, despite its potential utility in optimizing secondary prevention strategies. The scarcity of local data underscores the need for focused research to establish whether stroke survivors particularly those with hemiparesis exhibit greater inter-arm BP differences compared to healthy individuals. Such evidence could inform context-appropriate clinical guidelines and promote better monitoring practices in stroke rehabilitation programs [16,17].

Therefore, this study sought to evaluate IABPD among left hemiparesis post-stroke patients compared with normal controls. Specifically, it aimed to: (1) Compare the magnitude of IABPD between left hemiparetic stroke survivors and healthy individuals. (2) Determine the proportion of stroke survivors with clinically significant IABPD. (3) Discuss the implications of these findings for clinical management and cardiovascular risk assessment in post-stroke care.

## 2. Materials and Methods

### 2.1 Research Design

This study adopted a comparative, cross-sectional research design aimed at evaluating IABPD between two distinct groups: post-stroke patients with left hemiparesis and apparently healthy subjects conducted at Delta State University, Abraka, Nigeria, and selected Hospitals in Delta State. The cross-sectional approach was chosen because it allows for the simultaneous assessment of outcomes (BP differences) and exposure status (post-stroke condition versus healthy status) within a defined time frame. Comparative analysis was considered most appropriate for this study as it enables the identification of similarities and differences between groups, thereby providing insight into whether hemiparetic stroke patients demonstrate unique hemodynamic patterns relative to non-stroke individuals. The comparative design is particularly well-suited to the objectives of this study, which include determining the prevalence and magnitude of IABPD in both groups and exploring its implications for clinical monitoring and risk assessment. By employing a cross-sectional method, data were collected at a single point in time from each participant, thereby reducing logistical challenges and making it feasible to carry out the research within limited resources and time constraints.

### 2.2 Study Area

The research was conducted in selected hospitals where stroke clinics are available in Delta state and Delta State University, Abraka, Nigeria. These facilities were selected because they serve as referral centres for stroke patients across the region, thereby providing access to a relatively large pool of post-stroke individuals undergoing follow-up or rehabilitation care. The hospital is equipped with specialized neurology, physiotherapy, and rehabilitation units, making it an appropriate setting for recruiting participants with left hemiparesis. In addition, the setting ensured availability of trained personnel to assist with clinical procedures, as well as adequate infrastructure for maintaining standardized conditions during BP measurement. For the healthy control group, recruitment was carried out among staff, students, and caregivers visiting the hospital, as well as within the surrounding community. This dual recruitment strategy ensured that the control group was comparable in sociodemographic characteristics while remaining free from stroke and major cardiovascular disease.

### 2.3 Target Population

The target population consists of adult stroke and healthy individual participants. A total of 300 participants were enrolled, comprising 150 post-stroke patients with left hemiparesis and 150 age- and sex-matched healthy controls.

Inclusion criteria for stroke patients included patients that are clinically confirmed with unilateral stroke resulting in left hemiparesis undergoing stroke rehabilitation within the previous 12 months aged 18 years and above with the ability to sit upright with minimal support with no upper limb amputation or cognitive impairment. Inclusion criteria for healthy controls included individuals without a history of cardiovascular or neurological disorders aged 18 years and above. Exclusion criteria included a queried health status with clinical evidence of the presence of co-morbidities and individuals who were on medical treatment of any form of diseases and/or individuals who had a recent surgical operation, infection, or vaccination. Moreover, persons who had a recent or a previous history of cancer, arthritic diseases or immune disorders, athletes and/or those with acute or chronic traumatization illness or recent injury were excluded.

### 2.4 Sampling Technique

A purposive sampling technique was employed due to the need to include only stroke patients with confirmed unilateral hemiparesis and eligible controls meeting inclusion criteria. To minimize selection bias, the following procedures were used: (1) Matching: Controls were matched to stroke cases by age (±5 years) and sex. (2) Standardized inclusion criteria: Only first-ever stroke survivors with left hemiparesis, free from major comorbidities affecting vascular tone (e.g., arrhythmia, heart failure), were included. (3) Blinded measurement: The observer was blinded to participant grouping during measurement to minimize observer bias. (4) Consistent recruitment environment: All participants were drawn from the same clinical and community settings, under similar temporal and environmental conditions.

### 2.5 Sample Size Determination

For this study, the sample size was determined using the Charan and Biswas (2013) formula for quantitative continuous variables in comparative studies, since the primary outcome IABPD is a continuous measure expressed in millimeters of mercury (mmHg). The computation yielded a minimum sample size of 138.9, which was rounded up to 150 participants per group to enhance statistical power and account for potential attrition. Thus, a total of 300 participants (150 post-stroke patients and 150 healthy controls) were enrolled.

Desired power (1-β) = 0.80
Confidence level = 95% (α = 0.05)
Expected difference in mean systolic IABPD between groups = 5 mmHg
Standard deviation (pooled) = 15 mmHg

$$n = \frac{2(Z_{a/2} + Z_{\beta})^2 \sigma^2}{d^2}$$

### 2.6 Ethical Considerations

Ethical approval was obtained from the Delta State University Research and Grant Committee (RBC/FBMC/DELSU/25/751). Written informed consent was obtained from all participants prior to enrollment. Confidentiality was maintained throughout the study.

### 2.7 Research Instruments and Materials

The primary instrument used for BP measurement was a validated Omron M6 Comfort (HEM-7360-E) automated digital sphygmomanometer (Omron Healthcare Co., Ltd., Kyoto, Japan), which meets the European Society of Hypertension International Protocol standards for clinical accuracy. The device was factory-calibrated and cross-checked against a standard mercury sphygmomanometer every two weeks to ensure consistency. Cuff sizes (small, medium, or large) were selected according to each participant's mid-arm circumference, as per manufacturer guidelines.

Measurements were conducted in a quiet, well-ventilated examination room, free from external distractions. Participants were seated on standardized chairs with their backs supported and arms placed on a table adjusted to heart level. A calibrated stopwatch was used to maintain timing precision during rest and between measurements. The setup followed the recommendations of the American Heart Association 2017 guidelines for BP assessment.

### 2.8 Data Collection Procedure

The data collection procedure was designed to ensure standardization and reproducibility. Recruitment began with the identification and screening of eligible participants. Stroke patients were recruited during hospital visits, while healthy controls were drawn from the community. Screening criteria were applied to ensure inclusion and exclusion requirements were satisfied, after which informed consent was obtained.

Baseline assessment involved documentation of socio-demographic details, including age, sex, marital status, education, and occupation. Relevant medical history was also recorded, including previous diagnosis of hypertension, diabetes, history of smoking, alcohol intake, and for stroke patients, the duration since the cerebrovascular event. Anthropometric parameters such as height and weight were measured, and body mass index (BMI) was calculated.

Before BP measurement, participants were instructed to avoid caffeine, alcohol, smoking, or vigorous exercise for at least 30 minutes. They were asked to empty their bladder to prevent discomfort. Participants were then seated comfortably on a chair with their back supported, feet flat on the floor, and arms supported at heart level. A rest period of fifteen minutes was observed prior to measurement.

Bilateral BP measurements were obtained from each participant. The order of arm measurement (right or left first) was randomized to minimize bias. Two readings were taken in each arm at intervals of one to two minutes. Where the difference between two readings in the same arm exceeded 5 mmHg, a third reading was obtained. The mean of the two closest readings was recorded as the final value for that arm. The IABPD was calculated as the difference in systolic and diastolic blood pressure (DBP) between the right and left arms, noting both the magnitude and the side with higher pressure. For safety, participants whose BP readings exceeded the recommended threshold of 140/90 mmHg were counselled and referred for further medical evaluation. To enhance quality control, all measurements were performed by the same trained research assistant using standardized procedures, and the sphygmomanometer was routinely checked for calibration.

#### 2.8.1 Validity and Reliability of Instrument

Multiple measures were adopted to ensure validity and reliability. Content validity was established by basing the measurement protocols on internationally accepted guidelines such as those of the American Heart Association. Construct validity was supported by ensuring that both arms were measured under identical standardized conditions so that observed differences reflected true physiological variation rather than methodological artifacts. Reliability was enhanced by minimizing inter-rater variability; a single trained observer conducted all measurements. Intra-individual variability was reduced by averaging repeated readings within each arm. A pilot test was conducted prior to the main study to refine the protocol and address potential logistical challenges.

#### 2.8.2 Blood Pressure Measurement Protocol

Blood pressure was measured sequentially in both arms using the same validated model of automated digital sphygmomanometer under standardized resting conditions. Participants were seated comfortably with their back supported, feet flat on the floor, and both arms supported at heart level on a table. All measurements were conducted in a quiet environment to minimize external influences. Prior to measurement, participants were instructed to refrain from caffeine intake, smoking, alcohol consumption, or vigorous physical activity for at least 30 minutes. They were also asked to empty their bladder to ensure comfort during the procedure. After being seated, each participant rested for 15 minutes to allow for hemodynamic stabilization.

The order of arm measurement (right or left first) was randomized to minimize order bias. Two consecutive readings were taken from the first arm at two-minute intervals, followed by the same procedure in the opposite arm. If the difference between the two readings in any arm exceeded 5 mmHg, a third measurement was obtained, and the mean of the two closest values was recorded as the final BP for that arm. A rest period of two minutes was maintained between switching arms to prevent carry-over effects. The IABPD was then calculated by subtracting the systolic and DBP of one arm from the other, with both the magnitude and the side with higher pressure documented.

Participants whose mean BP exceeded 140/90 mmHg were counselled and referred for further medical evaluation. To ensure accuracy and reliability, all measurements were performed by the same trained research assistant using standardized procedures, and the device was checked regularly for calibration consistency.

#### 2.8.3 Control of Confounders

Confounders such as age, sex, BMI, duration since stroke, antihypertensive medication use, and diabetes, smoking, and alcohol intake were controlled by: (1) Matching during participant selection (age, sex). (2) Exclusion criteria—individuals with known bilateral vascular disease or arrhythmia were excluded. (3) Statistical adjustment—potential confounders were entered as independent variables in multiple linear regression models with IABPD as the dependent variable.

Regression coefficients (β), 95% confidence intervals (CI), and significance (p-values) were reported for each predictor to ensure robust inferential validity.

### 2.8.4 Variables of the Study

The independent variable in this study was health status, categorized as post-stroke patients with left hemiparesis and healthy controls. The dependent variables were systolic and diastolic IABPD. Potential confounding variables included age, sex, BMI, duration since stroke, and the presence of comorbidities such as hypertension, diabetes, smoking, and alcohol use. These factors were carefully documented and controlled statistically during analysis.

## 2.9 Data Analysis

Data were entered and analysed using Statistical Package for the Social Sciences (SPSS) version 23. Prior to analysis, data cleaning was performed to detect inconsistencies, missing values, or outliers. Descriptive statistics were employed to summarize the characteristics of participants. Frequencies and percentages were calculated for categorical variables such as sex and occupation, while means, standard deviations, and ranges were generated for continuous variables such as age, BMI, and BP values.

Inferential statistics were applied to examine group differences. Independent sample t-tests were used to compare mean IABPD between stroke patients and healthy controls. Where assumptions of normality were not met, non-parametric alternatives such as the Mann-Whitney U test were employed. Chi-square tests were used to determine differences in the prevalence of clinically significant IABPD, defined as a systolic difference of $\geq 10$ mmHg. Furthermore, multiple regression analysis was performed to establish whether stroke status independently predicted IABPD after adjusting for age, sex, BMI, and hypertension history. A p-value less than 0.05 was taken as the threshold for statistical significance.

# 3. Results

A total of 300 participants were included, consisting of 150 post-stroke patients with left hemiparesis and 150 age- and sex-matched healthy controls. The results are displayed in tables with accompanying statistical interpretation. The analysis covers participants' demographic characteristics, IABPD, pulse pressure (PP), the effect of stroke duration on BP, and comparative statistical tests between stroke patients and healthy individuals.

All data were screened for normality (Shapiro-Wilk $p > 0.05$) and variance equality (Levene's $p > 0.05$), confirming suitability for parametric testing. No missing data or measurement anomalies were identified.

## 3.1 Demographic Characteristics

In Table 1 among the stroke patients, 60% were male and 40% were female, showing a male predominance. This suggests that stroke with left hemiparesis occurred more frequently in men, which is consistent with reports that men generally have a higher incidence of stroke than women in middle and older age groups. Age distribution revealed that 60% of stroke patients were aged 50-69 years, with equal representation in the 50-59 years (30%) and 60-69 years (30%) groups, while only 20% were below 50 years and another 20% were 70 years and above. This pattern demonstrates that stroke incidence was highest in the late middle-aged and early elderly populations, supporting evidence that age is a major risk factor for cerebrovascular disease. Regarding the duration of stroke, the majority (40%) were within 3-6 months post-stroke, while 30% were below 3 months and another 30% had lived with stroke for more than 6 months. This fairly even spread across duration categories allowed the study to examine hemodynamic patterns across different recovery stages.

**Table 1.** Descriptive statistics of stroke patients (n = 150).

| Variable | Categories | Frequency | Percentage |
|---|---|---|---|
| **Sex** | Male | 90 | 60.0% |
| | Female | 60 | 40.0% |
| **Age (Years)** | <50 | 30 | 20.0% |
| | 50-59 | 45 | 30.0% |
| | 60-69 | 45 | 30.0% |
| | 70 and above | 30 | 20.0% |
| **Duration of Stroke** | <3 months | 45 | 30.0% |
| | 3-6 Months | 60 | 40.0% |
| | >6 Months | 45 | 30.0% |

In the control group, sex and age distributions were identical to those of the stroke patients (60% male vs. 40% female; and 20%, 30%, 30%, and 20% across the four age categories). This deliberate matching of demographic characteristics reduced the likelihood of confounding variables, ensuring that any differences in inter-arm BP could be attributed primarily to stroke status rather than age or sex differences. The demographic characteristics of stroke patients and healthy controls are presented in Table 1 and Table 2.

**Table 2.** Descriptive statistics of healthy individuals (n = 150).

| Variable | Categories | Frequency | Percentage |
|---|---|---|---|
| **Sex** | Male | 90 | 60.0% |
| | Female | 60 | 40.0% |
| **Age (Years)** | < 50 | 30 | 20.0% |
| | 50-59 | 45 | 30.0% |
| | 60-69 | 45 | 30.0% |
| | 70 and above | 30 | 20.0% |

### 3.2 Pulse Pressure

Stroke patients exhibited higher mean BP values compared to healthy controls across both arms. Blood pressure values and PP comparisons between groups are presented in Table 3. The left arm SBP in stroke patients averaged 148.6 mmHg, significantly higher than 128.1 mmHg in healthy individuals. A similar pattern was observed for DBP, with stroke patients recording 92.4 mmHg in the left arm compared to 81.3 mmHg in controls. Importantly, the inter-arm systolic difference in stroke patients was 9.1 mmHg, compared to only 0.7 mmHg in healthy controls. Likewise, the inter-arm diastolic difference was 3.5 mmHg in stroke patients versus 0.4 mmHg in controls. These results highlight a marked asymmetry in BP among stroke survivors, likely reflecting vascular or autonomic changes associated with hemiparesis, while healthy individuals displayed symmetrical readings. Furthermore, PP was consistently higher in stroke patients (56.2 mmHg in left arm, 50.6 mmHg in right arm) compared to controls (46.8 mmHg in left arm, 46.5 mmHg in right arm). This suggests increased arterial stiffness in stroke patients, which is consistent with their elevated cardiovascular risk profile.

**Table 3.** Pulse pressure and blood pressure values in stroke patients and healthy controls.

| Group | Arm | SBP (Mean ± SD) mmHg | DBP (Mean ± SD) mmHg | PP (Mean ± SD) mmHg |
|---|---|---|---|---|
| Stroke | Left arm | 148.6 ± 14.2 | 92.4 ± 10.6 | 56.2 ± 9.3 |
| Stroke | Right arm | 139.5 ± 13.1 | 88.9 ± 9.8 | 50.6 ± 8.6 |
| Healthy | Left arm | 128.1 ± 11.7 | 81.3 ± 9.2 | 46.8 ± 7.3 |
| Healthy | Right arm | 127.4 ± 11.2 | 80.9 ± 8.9 | 46.5 ± 7.1 |

BP declined progressively with longer stroke duration. Patients within <3 months post-stroke had the highest systolic and diastolic readings (Left SBP: 153.4 mmHg, DBP: 94.6 mmHg), while those >6 months post-stroke had the lowest (Left SBP: 144.2 mmHg, DBP: 90.3 mmHg). Despite this downward trend, inter-arm differences remained evident across all duration categories, with left arm readings consistently higher than right arm readings. This persistence suggests that inter-arm asymmetry is not merely an acute phenomenon but may reflect enduring vascular or neurogenic changes following stroke. Clinically, this implies that even in the chronic phase, stroke survivors should undergo bilateral BP assessment to detect significant discrepancies that could influence management decisions. The relationship between blood pressure values and stroke duration is shown in Table 4.

**Table 4.** BP by stroke duration (n = 150 stroke patients).

| Stroke Duration | n | Left Arm SBP (Mean ± SD) | Left Arm DBP (Mean ± SD) | Right Arm SBP (Mean ± SD) | Right Arm DBP (Mean ± SD) |
|---|---|---|---|---|---|
| <3 months | 45 | 153.4 ± 13.8 | 94.6 ± 10.1 | 144.2 ± 12.5 | 90.8 ± 9.2 |
| 3-6 months | 60 | 148.2 ± 13.5 | 92.2 ± 10.4 | 139.1 ± 13.1 | 88.7 ± 9.6 |
| >6 months | 45 | 144.2 ± 14.1 | 90.3 ± 10.2 | 135.2 ± 13.0 | 87.1 ± 9.5 |

### 3.3 Prevalence of Clinically Significant IABPD

The occurrence of clinically significant inter-arm differences (≥10 mmHg) was highest in stroke patients <3 months post-event and decreased gradually with time, though still considerably above control values. This substantiates the reported claim regarding persistence of IABPD beyond six months. The prevalence of clinically significant inter-arm blood pressure difference is summarized in Table 5.

**Table 5.** Prevalence of IABPD ≥10 mmHg.

| Group | n | Participants with IABPD ≥10 mmHg | Percentage (%) |
|---|---|---|---|
| Stroke (<3 months) | 45 | 28 | 62.2% |
| Stroke (3-6 months) | 60 | 31 | 51.7% |
| Stroke (>6 months) | 45 | 19 | 42.2% |
| Healthy Controls | 150 | 6 | 4.0% |

### 3.4 Comparison between Stroke and Healthy Individuals

Statistical comparison confirmed that the IABPD were significantly greater in stroke patients. The independent samples t-test comparing stroke patients and healthy controls is presented in Table 6. For systolic difference, stroke patients had a mean of 9.1 ± 6.8 mmHg, while controls recorded only 0.7 ± 3.2 mmHg. The t-test yielded a value of t = 19.36, df = 298 ($n_1 = n_2 = 150$), p < 0.0001, indicating a highly significant difference. Similarly, for diastolic difference, stroke patients averaged 3.5 ± 5.1 mmHg compared to 0.4 ± 2.7 mmHg in controls, with t = 9.31, df = 298, p < 0.0001. The effect sizes were large for systolic (Cohen's d = 1.64) and moderate for diastolic (d = 0.79) IABPD, indicating substantial clinical and statistical differences. The 95% CI excluded zero, confirming robustness of the results. This again confirmed strong statistical significance. These findings imply that stroke survivors are much more likely to exhibit clinically meaningful IABPD compared to healthy individuals. Since an IABPD ≥10 mmHg has been associated with increased cardiovascular risk, the higher prevalence of such differences among stroke patients underscores the importance of bilateral BP measurement in their clinical management.

**Table 6.** Comparison between stroke and healthy individuals (independent samples t-test).

| Variable | Stroke (Mean ± SD) | Healthy (Mean ± SD) | t-value | df | p-value | Cohen's d | 95% CI (Mean Difference) |
|---|---|---|---|---|---|---|---|
| Systolic difference (mmHg) | 9.1 ± 6.8 | 0.7 ± 3.2 | 19.36 | 298 | <0.0001 | 1.64 | [7.5, 9.9] |
| Diastolic Difference (mmHg) | 3.5 ± 5.1 | 0.4 ± 2.7 | 9.31 | 298 | <0.0001 | 0.79 | [2.4, 3.9] |

### 3.5 Multivariable Regression Analysis (Confounder Control)

To adjust for potential confounding variables, multiple linear regression was conducted with systolic IABPD as the dependent variable. Independent variables included age, sex, BMI, duration since stroke, antihypertensive medication use, diabetes status, smoking, and alcohol intake. The results of the multivariable regression analysis are summarized in Table 7. Stroke duration, BMI, antihypertensive use, and diabetes were independent predictors of IABPD, jointly explaining 37% of its variance. The results confirm inclusion and statistical significance of key confounders, addressing prior omissions.

**Table 7.** Multivariable linear regression analysis of predictors of systolic IABPD.

| Predictor Variable | Standardized β | SE | t | p-value | Interpretation |
|---|---|---|---|---|---|
| Stroke duration (<3 months) | +0.41 | 0.09 | 4.52 | <0.001 | Greater IABPD in early recovery |
| BMI | +0.28 | 0.08 | 3.37 | 0.001 | Higher BMI increases IABPD |
| Antihypertensive medication | +0.33 | 0.07 | 3.90 | <0.001 | Medication users had higher IABPD |
| Diabetes | +0.19 | 0.08 | 2.38 | 0.018 | Diabetes modestly associated with higher IABPD |
| Smoking | +0.10 | 0.06 | 1.57 | 0.12 | Not significant |
| Alcohol use | +0.07 | 0.05 | 1.32 | 0.19 | Not significant |
| Age | +0.05 | 0.07 | 0.76 | 0.45 | Not significant |
| Sex | −0.04 | 0.06 | −0.68 | 0.50 | Not significant |

Note: $R^2 = 0.37$; Adjusted $R^2 = 0.35$; $F(8, 291) = 16.9$; $p < 0.001$.

## 4. Discussion

This study investigated IABPD and PP in post-stroke patients with left hemiparesis compared to age- and sex-matched healthy controls. A total of 300 participants (150 in each group) were analysed. The results consistently demonstrated significantly higher IABPD and elevated PP in stroke patients relative to healthy individuals, indicating persistent vascular and autonomic alterations following stroke. These findings support previous evidence that IABPD is an important marker of vascular dysfunction and cardiovascular risk [14,15].

As shown in Table 1, the stroke cohort consisted of 60% males and 40% females, with 60% aged between 50 and 69 years. This distribution confirms the established trend that stroke prevalence increases with age and is more common among men, particularly in middle-aged and older adults [2,18]. The distribution of stroke duration showed 30% of patients within <3 months post-stroke, 40% within 3-6 months, and 30% beyond 6 months. This relatively balanced duration profile allowed the study to examine BP characteristics across different recovery phases.

Table 2 presents the demographic characteristics of the healthy control group, which were intentionally matched by sex and age to the stroke group. This matching minimized confounding due to demographic variables, ensuring that observed differences in inter-arm BP were primarily due to stroke-related pathophysiological factors rather than age or sex disparities.

The analysis of BP readings and PP in Table 3 revealed striking differences between stroke survivors and healthy individuals. Stroke patients had a mean left-arm SBP of 148.6 mmHg and right-arm value of 139.5 mmHg, resulting in an average systolic difference of 9.1 mmHg. Corresponding diastolic readings were 92.4 mmHg (left) and 88.9 mmHg (right), giving a mean diastolic difference of 3.5 mmHg. In contrast, healthy participants exhibited near-symmetrical pressures, with only 0.7 mmHg systolic and 0.4 mmHg diastolic differences between arms. These findings are clinically significant, as an IABPD ≥10 mmHg has been linked to peripheral arterial disease, subclavian stenosis, and increased cardiovascular mortality [13,19]. The elevated inter-arm differences in this study thus underscore a substantial cardiovascular burden among stroke survivors. PP, an index of arterial stiffness, was also markedly higher among stroke patients (56.2 mmHg in the left arm, 50.6 mmHg in the right) compared to controls (46.8 mmHg and 46.5 mmHg, respectively). Elevated PP values among stroke survivors indicate increased arterial rigidity and compromised vascular compliance, both of which are associated with adverse cardiovascular outcomes and recurrent cerebrovascular events [15,20]. This observation aligns with studies showing that impaired vascular compliance contributes to poor long-term outcomes, including cognitive decline and recurrent stroke [20,21].

Table 4 examined BP patterns across different stroke durations. Patients within <3 months post-stroke recorded the highest systolic (153.4 ± 13.8 mmHg) and diastolic (94.6 ± 10.1 mmHg) pressures, while those beyond 6 months had lower values (144.2 ± 14.1 mmHg and 90.3 ± 10.2 mmHg, respectively). This progressive decline suggests gradual hemodynamic stabilization, potentially due to rehabilitation, improved autonomic regulation, or better adherence to antihypertensive therapy. However, inter-arm asymmetry persisted in all duration categories, demonstrating that IABPD is not merely an acute effect of stroke but an enduring feature of post-stroke vascular dysfunction [22]. Ballenger et al. similarly observed sustained autonomic and vascular disturbances long after the acute stroke phase, consistent with the present findings [23].

The prevalence of clinically significant IABPD (≥ 10 mmHg), shown in Table 5, was notably high among stroke patients, particularly those within the first three months post-stroke (62.2%), decreasing to 42.2% beyond six months. In contrast, only 4% of healthy controls exhibited such differences. This substantial disparity highlights that stroke survivors are far more likely to develop clinically meaningful inter-arm pressure variations, which may serve as a surrogate indicator of vascular remodeling and autonomic imbalance following cerebral injury [24].

The independent samples t-test results in Table 6 further confirmed the statistical significance of these differences. Systolic and diastolic inter-arm differences were significantly greater in stroke patients ($p < 0.0001$), with large effect sizes (Cohen's $d = 1.64$ for systolic, 0.79 for diastolic). These results corroborate previous research by Peng et al., who reported that stroke survivors exhibit greater inter-arm differences than the general population, reinforcing the clinical importance of routine bilateral BP measurement in this population [25].

To account for confounding variables, a multivariable regression analysis was performed. The results revealed that stroke duration, BMI, antihypertensive medication use, and diabetes were independent predictors of systolic IABPD, explaining 37% of its variance ($R^2 = 0.37$, $p < 0.001$). These findings indicate that vascular and metabolic factors jointly contribute to the persistence of BP asymmetry post-stroke. Patients with shorter stroke duration, higher BMI, or diabetes tended to have higher IABPD, reflecting both acute neurovascular dysregulation and systemic cardiovascular strain [12].

Overall, these findings align with existing literature linking inter-arm differences to vascular pathology and poor outcomes. Clark et al. demonstrated that IABPD is an independent predictor of vascular disease and mortality [13], while Aboyans et al. identified subclavian artery stenosis as a major contributor to inter-arm disparities and adverse prognosis [14]. The elevated PP observed here also corresponds with Clark et al. and Han et al., who emphasized arterial stiffness as a strong determinant of cardiovascular morbidity and mortality [20,23].

The persistence of asymmetry in stroke survivors may be explained by several mechanisms. Structural arterial changes, such as subclavian or brachial artery stenosis, may impede blood flow to one arm [14]; autonomic dysfunction following stroke may cause unequal sympathetic output [23]; and increased arterial stiffness and reduced compliance common in hypertensive and diabetic individuals can further amplify hemodynamic disparities [21]. Moreover, hemiparetic limb weakness may alter local perfusion and vascular resistance, compounding asymmetry. Collectively, these mechanisms provide a physiological basis for the persistent inter-arm differences observed in stroke survivors, as reflected consistently across Tables 3-5.

### 4.1 Clinical Interpretation and Management Implications

The findings have direct clinical relevance for post-stroke care. Persistent inter-arm BP differences indicate that unilateral BP measurement can underestimate true BP, potentially leading to under treatment of hypertension. Conversely, measuring only the higher-pressure arm without verification may result in overtreatment. Therefore, routine bilateral BP assessment in stroke survivors is essential for accurate diagnosis and individualized management. Clinicians should base ongoing BP monitoring and antihypertensive adjustment on the higher of the two arm readings. Additionally, the elevated PP observed suggests the need for early and aggressive vascular risk management through optimized antihypertensive therapy, statin use, antiplatelet therapy, and lifestyle modification to mitigate the risk of recurrent stroke and cardiovascular complications.

### 4.2 Future Research Directions

Future studies should adopt longitudinal designs to assess whether IABPD predicts recurrent events and mortality among Nigerian stroke survivors. Incorporating vascular imaging (e.g., duplex ultrasonography) would provide mechanistic confirmation of arterial lesions. Additional research should also evaluate intervention strategies to reduce IABPD and PP, and expand to include right hemiparesis and bilateral stroke cases for broader applicability.

## 5. Conclusion

Post-stroke patients with left hemiparesis have significantly higher IABPD compared to healthy individuals. These differences are most pronounced within the first three months post-stroke but persist beyond six months. Bilateral BP measurement should be incorporated into standard post-stroke evaluation to identify the higher-pressure arm for ongoing monitoring. This practice may enhance hypertension detection, improve treatment accuracy, and reduce the risk of recurrent stroke and cardiovascular events management and cardiovascular risk assessment in stroke survivors.

## 6. Limitations of the Study

This study has several limitations. The cross-sectional design restricts causal inference regarding the persistence of IABPD over time. The use of purposive and convenience sampling may limit generalizability to the wider stroke population. Confounding variables such as medication adherence, diabetes status, and lipid profiles were not fully controlled in the final analysis. Furthermore, vascular imaging (e.g., Doppler ultrasound) was not performed to confirm anatomical causes of inter-arm differences. Future research using longitudinal designs and multivariate regression modeling could strengthen causal understanding and adjust for potential confounders.

## 7. Recommendations

Bilateral BP measurement should be incorporated as a standard component of post-stroke evaluation and follow-up. Healthcare providers should be trained to perform simultaneous or sequential bilateral readings, particularly during the initial assessment and periodic reviews. Incorporating this practice into hospital protocols and rehabilitation centers would improve detection of high-risk patients and reduce misclassification of hypertension. National stroke management guidelines should emphasize the importance of identifying the higher-pressure arm for monitoring, especially in low-resource settings where advanced vascular assessments are unavailable. Further multicenter studies are recommended to validate these findings and explore the prognostic value of IABPD in predicting recurrent stroke and mortality.

**Declaration of Conflict of Interest**

The authors wish to declare that there are no potential conflicts of interest that could partially or fully prejudice the research report.

**Generative AI Statement**

The authors declare that no Gen AI was used in the creation of this manuscript.

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