International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/

(RESEARCH ARTICLE)

Check for updates

Sonographic evaluation of carotid intima-media thickness among hypertensive adults in Port Harcourt metropolis, Rivers State Nigeria

Emmanuel Ifeanyi Omeje [1], Daniel Chimuanya Ugwuanyi [1], Maurice Amaechi Nnabuchi [1], Oliver Chikwado Nweze [1], Nmesoma Rosemary Nzotta [1], Stephen Mbonuejike Ugwu [1] and Akintayo Daniel Omojola [2, *]

[1] *Department of Radiology and Radiological Sciences, Faculty of Health Sciences and Technology, College of Health Sciences, Nnamdi Azikiwe University, Akwa, Anambra State.*
[2] *Department of Medical Physics, Royal Infirmary of Edinburgh, Little France Crescent Edinburgh, Scotland, United Kingdom, EH16 4SA.*

International Journal of Science and Research Archive, 2025, 17(03), 990-999

Publication history: Received on 20 November 2025; revised on 26 December 2025; accepted on 29 December 2025

Article DOI: https://doi.org/10.30574/ijsra.2025.17.3.3352

Abstract

Carotid Intima-Media Thickness (CIMT) is a reliable surrogate marker for atherosclerosis and can predict future cardiovascular events. The study assessed CIMT in hypertensive adults living in Port Harcourt to understand vascular wall changes linked to hypertension. CIMT was measured in 111 hypertensive and 111 non-hypertensive adults using B-mode ultrasound high-frequency linear probe (7–12 MHz), following Mannheim CIMT Consensus Guidelines. Measurements were taken bilaterally from the common carotid artery (10 mm before bifurcation), focusing on the far wall, and mean CIMT values were calculated. Hypertensive patients showed significantly higher CIMT values (right, left, and mean) compared to non-hypertensive individuals ($p < 0.05$) Hypertension was more common in older individuals and those with a higher BMI. Age and duration of hypertension had positive correlations with CIMT. BMI showed a weak negative correlation, and only age was statistically significant. Hypertensive adults have increased CIMT, indicating higher risk of subclinical atherosclerosis. The study supports incorporating sonographic CIMT assessment into cardiovascular risk evaluation and preventive healthcare strategies in Nigeria.

Keywords: Carotid Intima-Media Thickness (CIMT); Common Carotid Artery (CCA); Ultrasound; Sonography; Hypertension; Cardiovascular Disease (CVD)

1. Introduction

Cardiovascular diseases (CVDs) are a leading cause of death globally, and hypertension remains one of the most significant modifiable risk factors contributing to this burden [1]. The cardiovascular system consists of the heart, blood vessels, and blood, functioning together to deliver oxygen and nutrients while removing metabolic waste [2]. The heart's chambers, valves, coronary arteries, and conduction system maintain effective circulation and electrical activity essential for life. Cardiovascular diseases (CVDs) arise when structural or functional abnormalities—such as atherosclerosis, hypertension, valvular defects, or myocardial damage—impair this system [3].

Pathologically, CVDs commonly involve endothelial dysfunction, plaque formation, vascular inflammation, myocardial ischemia, and cardiac remodeling [4]. The pathophysiology includes progressive narrowing of vessels, impaired myocardial perfusion, increased afterload, and neurohormonal activation, ultimately leading to complications like heart failure, arrhythmia, and infarction [5]. These interconnected processes explain the chronic and progressive nature of most cardiovascular diseases.

* Corresponding author: Akintayo Daniel Omojola

In Nigeria, the prevalence of hypertension has been on the rise, particularly in urban centers such as Port Harcourt. This increase is attributed to urbanization, dietary transitions, sedentary lifestyles, and other socio-economic factors. Hypertension is a silent killer, often asymptomatic until severe complications such as stroke or myocardial infarction occur, underscoring the need for early detection and risk assessment strategies [6].

One such strategy involves the evaluation of carotid intima-media thickness (CIMT), which measures the thickness of the innermost layers of the carotid artery. Carotid intima-media thickness is typically measured using B-mode ultrasonography, which provides high-resolution images of the carotid artery walls. This method is non-invasive and allows for repeated use without exposing patients to ionizing radiation [7]. Measurements are generally taken 1 cm proximal to the carotid bifurcation on both the left and right sides of the neck. Equipment used for CIMT assessment includes ultrasound machines equipped with high-frequency linear transducers (usually 7.5–10 MHz). In Nigerian settings, devices such as the GE Logic 5 and Ultrasonic Sonia SP have been utilized effectively for this purpose [8]. This assessment provides critical insights into the structural changes in the arterial walls, particularly among individuals with cardiovascular risk factors such as hypertension [9].

Risk factors contributing to increased CIMT include aging, male gender, smoking, hyperlipidemia, diabetes mellitus, obesity, and lack of physical activity [10]. In urban Nigerian populations, these risk factors are becoming increasingly prevalent due to lifestyle changes and limited access to preventive healthcare services. As such, the burden of atherosclerosis and related cardiovascular complications is expected to rise unless proactive measures are taken.

Previous studies conducted in other parts of Nigeria have demonstrated a significant increase in CIMT among hypertensive individuals, highlighting the impact of chronic conditions on arterial wall thickness [9, 11].

Although there is no single gold standard for the assessment of subclinical atherosclerosis, B-mode ultrasonography of CIMT is widely accepted due to its practicality, accuracy, and cost-effectiveness. It is endorsed by various professional bodies and continues to be an essential tool in both clinical evaluation and research settings [10].

The sonographic evaluation of carotid intima-media thickness among hypertensive adults in Port Harcourt is both timely and essential. This study has the potential to provide crucial data on the burden of subclinical atherosclerosis within this population. By establishing region-specific normative CIMT values and correlating them with hypertension, the research will contribute to better cardiovascular risk assessment and ultimately improve health outcomes in the region.

Despite its clinical relevance, there is limited data on CIMT values among hypertensive adults in Port Harcourt. This presents a research gap, as the absence of localized normative data limits the ability of clinicians to interpret CIMT values accurately within the context of the local population. Additionally, variability in CIMT measurements based on ethnicity, age, and other demographic factors emphasizes the importance of conducting region-specific studies. Understanding the typical CIMT values in hypertensive patients in Port Harcourt will help improve diagnostic precision and enhance cardiovascular risk stratification.

2. Material and Methods

2.1. Research Design

This study adopted a cross-sectional, analytical research design to assess the carotid intima-media thickness among hypertensive and non-hypertensive adults in Port Harcourt Metropolis using ultrasonography. A cross-sectional analytical research design is a type of study where data is collected from a sub-set of an entire population at a single point in time to determine the characteristics of the entire population. This design is appropriate because it allows for the comparison of CIMT between hypertensive and non-hypertensive individuals at a specific point in time. It also enables the analysis of associations between CIMT and cardiovascular risk factors such as age, body mass index (BMI), and lipid profile.

2.2. Study Area

The study was conducted in 4 medical diagnostic facilities: Real Time Medical Diagnostics, Orange Medical Diagnostics, Olive Tree Diagnostics and Twin Medical Diagnostics; all located in Port Harcourt Metropolis, Rivers State, Nigeria. Port Harcourt is a major urban center with a high prevalence of hypertension and cardiovascular diseases due to urbanization, lifestyle factors, and limited access to preventive healthcare services. The diagnostic centers selected for the study have functional ultrasound facilities.

3. Study Population

The study population comprised of hypertensive adults who attended one of the 4 medical diagnostic facilities. A control group of non-hypertensive adults was also included for comparative analysis from the diagnostic centres.

3.1. Inclusion Criteria

- The test group included adults aged 18 years and above diagnosed with hypertension (SBP ≥140 mmHg and/or DBP ≥90 mmHg). Early onset of hypertension often begins at 30 years [12].
- The Control group included people of 18 years and above with medically confirmed evidence of no hypertension.
- Patients who agreed and signed provided informed consent to participate in the study.
- Patients with no prior history of stroke, myocardial infarction.

3.2. Exclusion Criteria

- Non-hypertensive adults are excluded from the test group
- Hypertensive patients are excluded from the control group.
- Subjects for investigation other than cardiovascular system are excluded.
- Patients with incomplete clinical data or unwillingness to undergo ultrasound assessment.

3.3. Sample Size and parameters required for measurements

The study included 111 hypertensive patients (60 female and 51 male) and 111 non-hypertensive patients (58 female and 53 male), from the 4 privately owned medical diagnostic facilities in Port Harcourt, Nigeria.

Demographic and clinical information was obtained from patients request forms, which included patient's age, gender, duration of hypertension, body mass index (BMI), blood pressure levels

3.4. Sonographic Measurement of CIMT

CIMT was measured using Mindray DP-10 2022-10-22, a B-mode ultrasound scanner with a high-frequency linear probe (7–12 MHz). The procedure followed the Mannheim CIMT Consensus Guidelines [9], which include:

- Measurements were taken from the common carotid artery (CCA), 10mm proximal to the carotid bifurcation.
- The intima-media thickness of the far wall of the artery was recorded.
- Measurements were taken bilaterally (both left and right carotid arteries), and the mean CIMT value was calculated.
- All ultrasound assessments were conducted by certified sonographers to ensure accuracy and consistency.
- An illustration of the measurements is shown in Figure 1 [13]

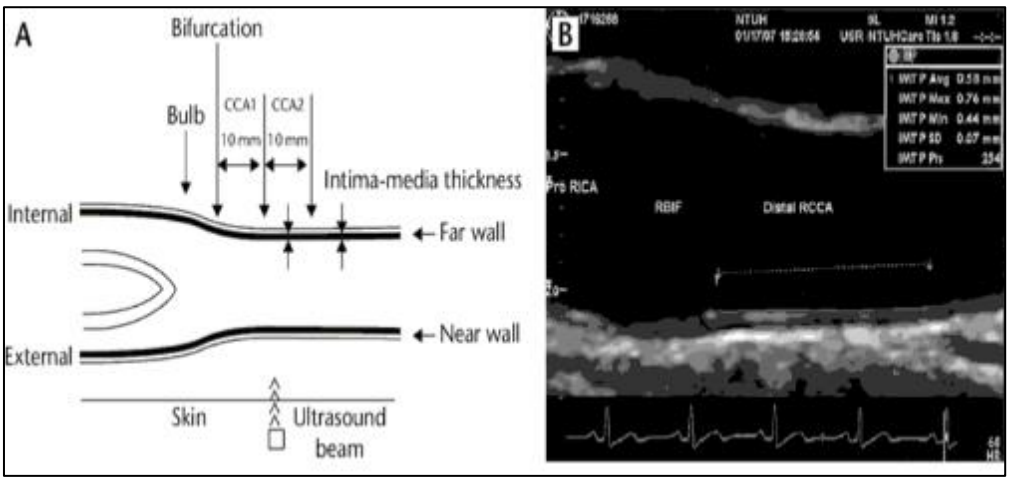

Figure 1 Diagrammatic representation of how CIMT is measured [13]

4. Data Analysis

Collected data were analyzed using Statistical Package for the Social Sciences (SPSS) version 26.0. The analysis included: Descriptive Statistics (Mean, standard deviation, and frequency distribution of participant characteristics (age, BMI, CIMT values)); Comparative Analysis:

(Independent t-test was used to compare mean CIMT values between hypertensive and non-hypertensive groups); Correlation Analysis: (Pearson's correlation was used to assess the relationship between CIMT and biophysical parameters).

to identify independent predictors of increased CIMT among hypertensive patients. Statistical significance was set at $p < 0.05$.

4.1. Ethical Consideration

This study adhered to ethical guidelines for research involving human participants.

Hence, ethical clearance was obtained from Health Research Ethics Committee, Rivers State Hospitals Management Board. No: RSHMB/RSHREC/2025/137. Permission was also gotten from the Head of Departments of the selected centers, to use their facilities for the research.

Participants were provided with detailed information about the study. Written informed consent was obtained before participation. All personal data were kept confidential and stored securely.

Data were anonymized to protect participant identity. The study poses minimal risk to participants as CIMT measurement is non-invasive. Participants found to have significantly increased CIMT were referred for further medical evaluation.

5. Results

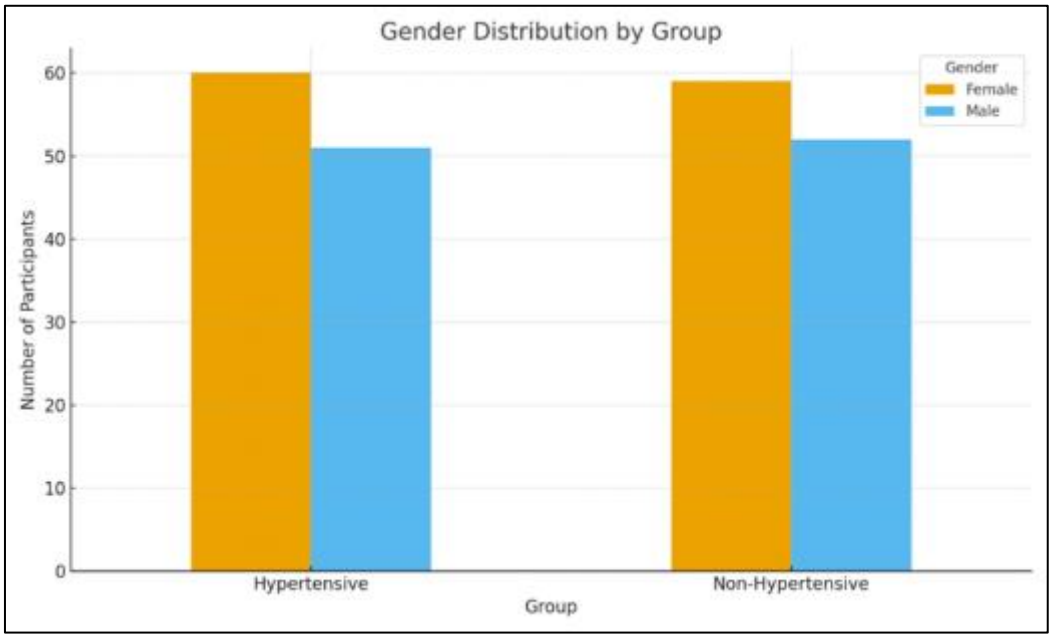

Figure 2 A Histogram Chart Showing Gender representation of the hypertensive patients and the Control

The bar chart above shows the gender distribution among hypertensive and non-hypertensive participants. There were 60 female hypertensive patients and 51 male hypertensive patients; there were also 58 female non-hypertensive patients and 53 male non-hypertensive patients. Both groups demonstrate a relatively balanced representation of males and females, although slight differences exist (Figure 2).

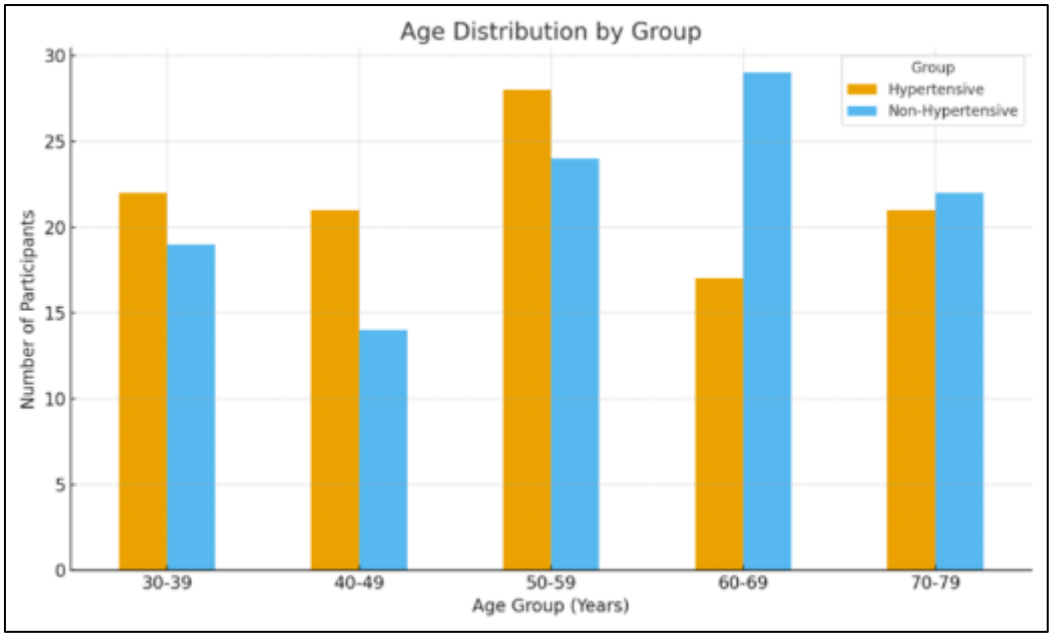

Figure 3 A histogram showing the Age ranges of the hypertensive patients and the control

The bar chart above illustrates the age distribution of hypertensive and non-hypertensive participants. Hypertensive individuals were more frequently observed in the age category 50-59 years, while majority of patients in the study that were non-hypertensive were within the age group of 60-69 years (Figure 3).

Table 1A Descriptive Analysis of Age, BMI, and Duration of non-hypertensive patients

Variable	Mean ±SD	Median	Mode	25th Percentile	75th Percentile
Age	55.59 ± 14.56	57.0	68	42.5	68.0
BMI	27.71 ± 4.04	28.0	25.3	25.6	30.65

Table 1B Descriptive Analysis of Age, BMI, and Duration of hypertensive patients

Variable	Mean ±SD	Median	Mode	25th Percentile	75th Percentile
Age	53.53 ± 14.42	53.0	53	42.0	66.5
BMI	27.59 ± 4.01	27.3	24.5	24.9	30.6
Duration of Hypertension (Years)	11.06 ± 5.64	11.0	15.0	6.0	15.5

The table above shows that for the non-hypertensive patients; the mean age was 55.59 ± 14.56 and a mean BMI of 27.71 ± 4.04 (Table 1a). For Hypertensive patients, the mean age was 53.53 ± 14.42, the mean BMI was 27.59 ± 4.01 and the mean years for duration of hypertension was 11.06 ± 5.64 (Table 1b).

Table 2 Mean presentation of the CIMT between hypertensive patients and the control (non-hypertensive)

Factor	N	Minimum CIMT	Maximum CIMT	Mean ± SD
Hypertensive	111	0.98	1.1	1.05 ± 0.1
Non-hypertensive	111	0.75	0.85	0.81 ± 0.08

The table above shows that the CIMT of hypertensive patients is higher than that of non-hypertensive patients. The t-value is 3.07289. The p-value is 0.0916. The result is not significant at $p < 0.05$ (Table 2)

Table 3 Distribution showing mean CIMT between the right and left artery

Factor	N	Minimum CIMT	Maximum CIMT	Mean ± SD
Right CIMT of hypertensive patients	111	0.93	1.16	1.04 ± 0.16
Left CIMT of hypertensive patients	111	0.98	1.12	1.05 ± 0.13
Right CIMT of Control	111	0.74	0.89	0.82 ± 0.12
Left CIMT of Control	111	0.71	0.87	0.8 ± 0.12

The table above shows that the right CIMT was higher than the left CIMT both in hypertensive patients and the control group. The two-tailed P value equals 0.0406 (Table 3).

Table 4 Comparative Analysis of CIMT Between hypertensive and non-hypertensive Patients

Variable	t-value	p-value	Interpretation
CIMT Right (mm)	13.35	0.0000	Significant difference
CIMT Left (mm)	14.38	0.0000	Significant difference
CIMT Mean (mm)	19.92	0.0000	Significant difference

Independent t-test results show statistically significant differences in right, left, and mean CIMT values between hypertensive and non-hypertensive patients ($p < 0.05$). Hypertensive patients consistently demonstrated higher CIMT values, indicating more pronounced arterial wall thickening compared to non-hypertensive participants (Table 4).

Table 5 Correlation Analysis of CIMT with Duration of hypertension

Variable Pair	Correlation (r)	p-value	Interpretation
Duration of hypertension Versus CIMT right (mm)	0.06	0.5609	Not significant
Duration of hypertension Versus CIMT left (mm)	-0.13	0.1856	Not significant
Duration of hypertension Versus CIMT mean (mm)	-0.05	0.5700	Not significant

These correlations were statistically insignificant ($p < 0.05$), suggesting that longer duration of hypertension is not directly associated with greater carotid wall thickening. The correlation analysis showed no association for the right, left, and mean CIMT measurements (Table 5).

Table 6 Correlation Analysis of Mean CIMT with Age and BMI

Variable Pair	Correlation (r)	p-value	Interpretation
Age versus CIMT mean (mm)	0.22	0.0185	Significant positive correlation
BMI versus CIMT mean (mm)	-0.07	0.4710	Not significant

The correlation analysis indicates that there is a significantly positive correlation between age and mean CIMT. There was also poor but insignificantly negative correlation between CIMT and BMI ($p < 0.05$) (Table 6).

6. Discussion

6.1. Gender distribution

The analysis of gender distribution revealed that both hypertensive and non-hypertensive groups included males and females, with slight variations in proportions having more females than males in both groups. This finding has important implications in cardiovascular research, as gender has been identified as a significant determinant of cardiovascular

risk and vascular remodeling. Several studies have demonstrated that males are generally at a higher risk of developing increased carotid intima-media thickness (CIMT) compared to females, particularly in hypertensive populations. For instance, Lorenz et al [14] reported that male gender was associated with higher CIMT progression rates, likely due to hormonal and lifestyle differences. Similarly, Okeahialam et al [15] in Nigeria found that hypertensive males showed greater CIMT values compared to their female counterparts. The findings of the present analysis, which show that both genders are well represented in the sample, agree with studies that emphasize the necessity of including both males and females when evaluating cardiovascular risk factors. However, while some literature highlights a pronounced male predominance in hypertensive complications, the slight dominance of females observed here may reflect increasing exposure of women to cardiovascular risk factors due to urbanization and lifestyle changes, consistent with observations from Giardina et al [16].

6.2. Age distribution

The distribution of participants across age groups reveals that hypertension is more prevalent among older adults, consistent with global and Nigerian epidemiological data. Hypertensive participants were concentrated in the 50–79 years age range, indicating the strong association between aging and vascular remodeling, but does not mean that for this study CIMT values in the age group. This finding aligns with the reports of Polak et al [17], who demonstrated that age is a strong determinant of carotid intima-media thickness (CIMT) progression. Similarly, Mancia et al [18] emphasized that cumulative exposure to elevated blood pressure accelerates vascular aging, leading to arterial wall thickening. Comparatively, non-hypertensive individuals in this study were more evenly distributed across younger age groups, suggesting that the onset of hypertension tends to manifest later in adulthood. This agrees with the findings of Higashi et al [19], who reported that the prevalence of hypertension increases significantly with age due to endothelial dysfunction and arterial stiffness. In Nigeria, Akinyemi et al [20] reported that the burden of stroke and cardiovascular complications is highest among older hypertensive adults, underscoring the need for early detection and control of blood pressure. The current study's findings agree with these observations, supporting the hypothesis that age is a critical factor influencing hypertension and its vascular consequences in Port Harcourt metropolis.

6.3. Age and BMI in both groups

The inclusion of standard deviations alongside means provides a deeper understanding of the variability within the studied groups. Hypertensive participants had higher mean ages and BMI values with notable standard deviations, reflecting both the central tendency and spread of these variables. This highlights that while the average hypertensive patient is older and heavier, there is still a wide range of variation within the group. According to Whelton et al [21], such variability is expected due to differences in lifestyle, genetics, and healthcare access. The duration of hypertension also displayed high variability, with a wide interquartile range, consistent with findings by Mancia et al [18], who noted that chronic hypertension progression differs significantly between patients. This emphasizes the importance of individualized management approaches. Furthermore, Higashi et al [19] confirmed that prolonged hypertension duration correlates with greater vascular changes, reinforcing the implications of variability observed in this study. Non-hypertensive participants displayed lower means and narrower standard deviations in both age and BMI, aligning with epidemiological data that younger, leaner adults are less likely to develop hypertension (Polak et al [17]). This comparative stability underscores the protective effect of youth and normal body weight. Overall, these findings agree with prior studies, emphasizing the significant roles of age, BMI, and duration of hypertension in cardiovascular risk, while also acknowledging the variability captured by standard deviations as critical for accurate interpretation of patient populations.

6.4. CIMT in hypertensive and non-hypertensive individuals

The findings confirm that hypertensive individuals exhibit greater carotid intima-media thickness (CIMT) compared to their non-hypertensive counterparts. Both right and left CIMT values were elevated in hypertensive patients, consistent with previous studies such as Umeh et al [11] and Okeahialam et al [15], who demonstrated that hypertension is strongly associated with arterial wall thickening in Nigerian populations. The variability captured by the standard deviations highlights the heterogeneity of CIMT progression, which may be influenced by age, BMI, and duration of hypertension. This aligns with Lorenz et al [14], who reported that each 0.1 mm increase in CIMT corresponds to a significant increase in cardiovascular event risk. Comparatively, non-hypertensive participants showed lower CIMT values, generally within normal reference ranges, confirming observations by Stein et al [22] that CIMT serves as a reliable marker for subclinical atherosclerosis primarily in individuals with established risk factors.

The results of the independent t-tests demonstrate significant differences in CIMT values between hypertensive and non-hypertensive individuals, supporting the hypothesis that hypertension is associated with vascular remodeling and arterial wall thickening. This finding aligns with Okeahialam et al [15], who reported that hypertensive Nigerians had

significantly greater CIMT compared to normotensive controls. These results also corroborate findings from Umeh et al [11], who demonstrated elevated CIMT values in hypertensive patients in Ibadan, Nigeria. Furthermore, Lorenz et al [14] in their meta-analysis emphasized that CIMT serves as a strong predictor of future cardiovascular events, and hypertensive populations typically exhibit higher values compared to normotensive populations. The present study's findings are also consistent with Stein et al [22], who noted that CIMT measurement is a reliable, non-invasive tool for detecting subclinical atherosclerosis, particularly in populations with known risk factors such as hypertension. Overall, these results reinforce the clinical value of CIMT in risk.

6.5. Correlation of CIMT with duration of hypertension

The results show that the longer an individual has hypertension, the greater their carotid intima-media thickness (CIMT), however, this was statistically insignificant so can be due to chance. This reflects the cumulative effect of prolonged high blood pressure on vascular remodeling and arterial wall changes. Mancia et al [18] emphasized that chronic hypertension leads to progressive endothelial dysfunction, vascular stiffening, and intimal thickening. Similarly, Higashi et al [19] found that prolonged exposure to hypertension significantly increases the risk of subclinical atherosclerosis. These findings are also supported by Okeahialam et al [15], who demonstrated that hypertensive patients with longer disease history showed higher CIMT values compared to those with shorter durations. The present study's results are therefore consistent with regional and international evidence, highlighting the importance of early detection and management of hypertension to prevent vascular complications.

6.6. Correlation of CIMT with age and BMI

This analysis confirms that while age is significant predictor of carotid intima-media thickness (CIMT), BMI was not. Older participants had higher CIMT values, consistent with Polak et al [17], who reported that vascular aging contributes to progressive arterial wall thickening. Similarly, Lorenz et al [14] demonstrated that CIMT increases steadily with age and serves as a predictor of cardiovascular risk. BMI had a poor negative correlation with CIMT, suggesting that overweight and obesity contribute to vascular changes but not significantly. This finding supports Whelton et al [21], who noted obesity as a major risk factor for hypertension and cardiovascular disease, as well as Stein et al [22], who emphasized that increased adiposity accelerates vascular remodeling. These findings align with global and regional literature, reinforcing the role of age and BMI in the pathophysiology of hypertension and subclinical atherosclerosis. Together, they highlight the need for lifestyle interventions targeting weight reduction and cardiovascular screening in older adults.

7. Conclusion

This study demonstrated that hypertensive adults in Port Harcourt metropolis have significantly increased carotid intima-media thickness compared to non-hypertensive individuals. Age, BMI, and duration of hypertension were strongly associated with CIMT, indicating their roles as independent predictors of subclinical atherosclerosis. These findings are consistent with both regional and international literature and highlight the importance of incorporating sonographic CIMT evaluation into cardiovascular risk stratification and preventive healthcare strategies in Nigeria.

Limitations of the study

- The study design limited causal inference, as associations between hypertension, age, BMI, and CIMT cannot confirm directionality.
- Though adequate, a larger sample could provide more robust subgroup analyses (e.g., gender-specific correlations).
- The study was restricted to Port Harcourt metropolis, which may not reflect CIMT variations across other Nigerian populations.
- Potential confounding factors such as smoking, alcohol consumption, and lipid abnormalities were not extensively analyzed.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict-of-interest to be disclosed.

Statement of ethical approval

Ethical clearance was obtained from Health Research Ethics Committee, Rivers State Hospitals Management Board (No: RSHMB/RSHREC/2025/137). Approval was also obtained from the Heads of Departments of the chosen centers to utilize their facilities for the research.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

References

[1] Lu W, Li W, Zou Z, Yang Q, Tian J. The association between blood pressure, renal function, and subclinical atherosclerosis in young and middle-aged non-hypertensive individuals: a mediation analysis. Front Cardiovasc Med. 2025;12: 1613785.

[2] Robinson WF, Robinson NA. Cardiovascular System. Jubb, Kennedy & Palmer's Pathology of Domestic Animals. 2016; 3: 1–101.e1.

[3] Saheera S, Krishnamurthy P. Cardiovascular Changes Associated with Hypertensive Heart Disease and Aging. Cell Transplant. 2020; 29: 963689720920830.

[4] Libby P, Ridker PM, Hansson GK. Leducq Transatlantic Network on Atherothrombosis. Inflammation in atherosclerosis: from pathophysiology to practice. J Am Coll Cardiol. 2009; 54(23): 2129-38.

[5] Manolis AA, Manolis TA, Manolis AS. Neurohumoral Activation in Heart Failure. Int J Mol Sci. 2023; 24(20): 15472.

[6] Cooper LL, Palmisano JN, Benjamin EJ, Larson MG, Vasan RS, Mitchell GF, Hamburg NM. Microvascular Function Contributes to the Relation Between Aortic Stiffness and Cardiovascular Events: The Framingham Heart Study. Circ Cardiovasc Imaging. 2016; 9(12): e004979.

[7] Jenkins S, Shiha MG, Yones E, Wardley J, Ryding A, Sawh C, Flather M, Morris P, Swift AJ, Vassiliou VS, Garg P. Cardiovascular examination using hand-held cardiac ultrasound. J Echocardiogr. 2022; 20(1): 1-9.

[8] Owoeye S, Ani C, Kenis S, Ukaonu B, Odoh G, Angbalaga A. Sonographic normative values of carotid intima-media thickness in an adult Nigerian population. Nigerian Journal of Medicine. 2018; 26(4): 316–319.

[9] Touboul PJ, Hennerici MG, Meairs S, Adams H, Amarenco P, Desvarieux M, Ebrahim S, Fatar M, Hernandez Hernandez R, Kownator S, Prati P, Rundek T, Taylor A, Bornstein N, Csiba L, Vicaut E, Woo KS, Zannad F; Advisory Board of the 3rd Watching the Risk Symposium 2004, 13th European Stroke Conference. Mannheim intima-media thickness consensus. Cerebrovasc Dis. 2004; 18(4): 346-9.

[10] RadiologyInfo. Carotid intima-media thickness test. Retrieved from https://www.radiologyinfo.org/en/info/carotid-intima [Accessed 22 Dec 2025]. 2022

[11] Umeh EO, Agunloye AM, Adekanmi AJ, Adeyinka AO. Ultrasound Evaluation of Intima-Media Thickness of Carotid Arteries in Adults with Primary Hypertension at Ibadan, Nigeria. West African Journal of Medicine. 2013; 32(1): 62–67.

[12] World Health Organization (WHO). Hypertension fact sheet. Available at: https://www.who.int/news-room/fact-sheets/detail/hypertension [Accessed 22 Dec 2025]. 2021

[13] Ta-Chen S, Jiann-Shing J, BaoShow H, Chiau SL. Application of Intima-media Thickness and Early Atherosclerosis at Carotid Arteries as a Window for Cardiovascular Disease in Preventive Cardiology. Journal of Medical Ultrasound. 2007; 15(2): 112-125.

[14] Lorenz MW, Markus HS, Bots ML, Rosvall M, Sitzer M. Prediction of clinical cardiovascular events with carotid intima-media thickness: a systematic review and meta-analysis. Circulation. 2007; 115(4): 459-67.

[15] Okeahialam BN, Alonge BA, Pam SD, Puepet FH. Carotid intima media thickness as a measure of cardiovascular disease burden in nigerian africans with hypertension and diabetes mellitus. Int J Vasc Med. 2011;2011:327171.

[16] Giardina EV, Paul TK, Hayes D, Sciacca RR. Cardiovascular Disease Risk Among Young Urban Women. J Womens Health (Larchmt). 2016; 25(11): 1139-1146.

[17] Polak JF, Herrington D, O'Leary DH. Associations of edge-detected and manual-traced common carotid artery intima-media thickness with incident peripheral artery disease: The Multi-Ethnic Study of Atherosclerosis. Vasc Med. 2019; 24(4): 306-312.

[18] Mancia G, Fagard R, Narkiewicz, K. Guidelines for the management of arterial hypertension. European Heart Journal. 2019; 34(28): 2159-2219.

[19] Higashi Y, Kihara Y, Noma K. Endothelial dysfunction and hypertension in aging. Hypertens Res. 2012; 35: 1039–1047.

[20] Akinyemi RO, Ovbiagele B, Adeniji OA. Stroke burden in Nigeria: Epidemiology, risk factors, and clinical outcomes. Lancet Neurology. 2020; 19(5): 385-396.

[21] Whelton PK, Carey RM, Aronow WS, Casey DE Jr, Collins KJ, Dennison Himmelfarb C, DePalma SM, Gidding S, Jamerson KA, Jones DW, MacLaughlin EJ, Muntner P, Ovbiagele B, Smith SC Jr, Spencer CC, Stafford RS, Taler SJ, Thomas RJ, Williams KA Sr, Williamson JD, Wright JT Jr. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. Hypertension. 2018; 71(6): e13-e115.

[22] Stein JH, Tattersall MC. Carotid intima-media thickness and cardiovascular disease risk prediction. J Am Coll Cardiol. 2024; 63(21): 2301-2.