INTERNATIONAL JOURNAL OF LATEST TECHNOLOGY IN ENGINEERING, MANAGEMENT & APPLIED SCIENCE (IJLTEMAS)

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VI, June 2026

Carotid Artery Diameter and Blood Pressure: A Weak and Sex-Dependent Association in a Normotensive Nigerian Population

Selekeowei Peter Kespi Kpuduwei, ***MD, PhD, FWACS***

Department of Surgery, Federal Medical Centre Yenagoa, Bayelsa State, Nigeria

DOI: https://doi.org/10.51583/IJLTEMAS.2026.150600051

Received: 17 June 2026; Accepted: 22 June 2026; Published: 04 July 2026

ABSTRACT

Background: The relationship between systemic arterial blood pressure (BP) and carotid artery diameter is often derived from hypertensive cohorts. This study explores this relationship in a normotensive Nigerian population to understand vascular physiology in the absence of pathology.

Methods: We analyzed data from 104 healthy adults. Carotid artery diameters were measured via ultrasonography. Pearson's correlation and ANOVA were used to assess relationships with systolic blood pressure, diastolic blood pressure and their mean arterial pressures (MAP).

Results: Mean age of the cohort was 28 years. In the overall cohort, correlations between BP and carotid diameter were largely absent or weak. A sex-stratified analysis revealed a distinct pattern: in females, there were significant positive correlations between MAP and the right ECA (r=0.453, p=0.003) and left ECA (r=0.335, p=0.030). No significant correlations were observed in males at all. No correlations existed between the larger common and internal carotid arteries with blood pressure parameters

Conclusion: The relationship between arterial blood pressure and carotid artery diameter in healthy, normotensive individuals is weak and exhibits sexual dimorphism, being evident only in females. This suggests that the strong correlations reported in literature are likely a feature of pathological hypertensive remodeling rather than normal physiology. The female-specific association warrants further investigation.

Keywords: Blood pressure, Carotid artery diameter, Normotensive, Correlation, Healthy Nigerian population.

INTRODUCTION

Systemic blood pressure is a fundamental determining factor of arterial wall stress and a key driver of vascular remodeling. The US Center of Disease Control (CDC) defines hypertension "as systolic blood pressure (SBP) of ≥130 mm Hg or diastolic pressure (DBP) of ≥80 mm Hg" and also noted an increasing number of the condition among its young adult population.[1] However, the definition of hypertension in Nigeria remains the same as that of the World Health organisation (WHO), which is "persistent elevated systolic blood pressure of ≥140 mm Hg or diastolic pressure of ≥90 mm Hg measured twice" or in the condition of taking antihypertensives or has been previously diagnosed by a physician.[2,3] Lawal reports a prevalence of 9.2 to 70.3% of hypertension in Nigeria and awareness rate between 12 to 93.2%,[4] which makes it a public health emergency with all of its attributes becoming a science to study. It is estimated that 1 in 3 adult Nigerians are pre-hypertensive with (SBP ≥130 mm Hg or DBP of ≥80 mm Hg).[5] Hypertension is implicated in cardiovascular, renovascular and cerebrovascular diseases as a significant risk factor for morbidity and mortality. Chronic elevations of system blood pressure evoke series of mechanobiological responses from arteries as a result of phenotypic changes often by the primary cells of the wall. These are said to be differential gene expression driving remodeling in the arteries.[1] This vascular remodeling that occurs in hypertension result from structural changes in the so called vascular smooth muscle cells (VSMCs) supported by other primary cells like the endothelial cells, fibroblasts and resident macrophages.[1,6] In hypertension, increased distending pressure leads to structural adaptations, including an increase in arterial diameter to normalize wall stress[7,8]. By Poiseuille's law, lumen diameter is more significant in vessel resistance to blood flow than vessel length and viscosity because vessel resistance is inversely

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VI, June 2026

proportional to radius of its lumen to the fourth power (r^4). Hence, forces that act to either reduce or increase the radius of a vessel (that is to say its lumen diameter) say by 50% cause significant impact on vessel resistance by 16-fold.[6] Since it has been recognized that vessel resistance is a key driver and biomarker of established hypertension,[9] the relation that exists in its absence or pre-hypertensive states needs to be studied among healthy people. Interestingly, the vascular remodeling is not a one-way traffic: it can be hypotrophic, hypertrophic or eutrophic. Moreso, it can also be inward remodeling (reduction of lumen diameter) or outward remodeling (increase in lumen diameter). Wherefore, "inward remodeling" is reported as the commonest in hypertensive states that leads (under passive conditions) to reduction of lumen diameter while "outward remodeling" is commoner among those on antihypertensives and conditions of increased flow.[6] Consequently, positive correlations between carotid diameter and blood pressure are consistently reported in studies involving hypertensive patients, which remains the basis for the presumptions.[10,11] From the above, one would presume a differential increase in luminal diameter of all critical arteries like the carotid, coronary and renal arteries in normotensive individuals in the same population where hypertensive individuals have luminal diameter reduction as highlighted in previous studies.

However, the nature of this relationship in healthy, normotensive individuals, where such compensatory remodeling is presumed absent, is less clear. Establishing this baseline is crucial for interpreting vascular changes in early disease. Unfortunately, there is paucity of studies on association between carotid artery luminal diameter and blood pressure among normotensive individuals in Nigeria despite establishing reference values and sexual dimorphism in previous studies.[12,13] This study aims to characterize the relationship between arterial blood pressure and carotid artery diameter in a cohort of normotensive adults in Nigeria.

METHODS

Study Design and Participants: This cross-sectional study involved 104 healthy Nigerian adult volunteers between 18 and 65 years with no history of hypertension in 2020. With no ethnic or occupation restriction they were randomly selected following Helsinki guidelines. Study received ethical approval of the University of Port Harcourt with number UPH/CEREMAD/REC/MM71/003 and all participants were enrolled after an informed consent form was signed. Resting brachial blood pressure was measured using an electronic sphygmomanometer ("KD-595"), confirmed manually. Both systolic and diastolic blood pressures were measured from which Mean Arterial Pressure (MAP) was calculated.

Carotid Ultrasound: Using an EcoMed version VERTU-3-portable machine with linear transducer and frequency of 7.0 MHz, standardized B-mode ultrasound was performed to measure the end-diastolic lumen diameters of the common carotid artery (CCA), internal carotid artery (ICA), and external carotid artery (ECA) with participants in supine position and head slightly tilted to assess the carotid groove. ALARA safety principle was followed. Each scan was performed by a certified consultant radiologist with 10 years' experience.

Statistical Analysis: Data analysis was done using IBM SPSS version 23. The relationship between carotid diameters and BP parameters was assessed with Pearson's correlation coefficient. Analysis of Variance (ANOVA) was used to compare diameters across MAP categories (Optimal, Normal, High-Normal). Analyses were conducted for the total sample and stratified by sex.

RESULTS

The mean age was 28 years and there were 62 males and 42 females. Luminal diameters were CCA 4.5-7.6 mm, ICA 4.4-7.5 mm and ECA 3.0-6.7 mm. For the total cohort, no significant correlations were found between any BP parameter and the diameters of the CCA or ICA. In sex-stratified analysis, a divergent pattern emerged. Table 1a shows that in males, no significant correlations were observed.

In females (table 1b), however, significant positive correlations were found between MAP and the diameter of the right ECA ($r=0.453$, $p=0.003$) and left ECA ($r=0.335$, $p=0.030$). While male values remain unchanged (table 2a), ANOVA and post hoc in females (tables 2b & 2c) confirmed that right ECA diameter differed significantly across MAP categories ($F=3.72$, $p=0.03$). No significant differences were found for the CCA or ICA in either sex when categorized by MAP.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VI, June 2026

Table 1a: Relationship between carotid artery size and blood pressure parameters in male participants

Parameters	Correlation	Right diameter			Left diameter		
		CCA	ICA	ECA	CCA	ICA	ECA
Systolic BP	r	0.098	**0.384****	**0.340****	0.021	0.168	0.039
	p-value	0.451	0.002	0.007	0.870	0.193	0.762
Diastolic BP	r	0.112	0.199	**0.278***	-0.083	0.019	-0.010
	p-value	0.388	0.121	0.029	0.523	0.884	0.939
MAP	r	0.116	**0.297***	**0.330****	-0.046	0.084	0.010
	p-value	0.370	0.019	0.009	0.725	0.514	0.937

** = Correlation is significant at the 0.01 level (2-tailed), * = Correlation is significant at the 0.05 level (2-tailed), **r** = Pearson correlation.

Table 1b: Relationship between carotid artery size and other measured parameters in female subjects

Parameters	Correlation	Right diameter			Left diameter		
		CCA	ICA	ECA	CCA	ICA	ECA
Systolic BP	r	0.233	0.255	**0.436****	-0.185	0.187	.353*
	p-value	0.138	0.103	0.004	0.240	0.236	0.022
Diastolic BP	r	0.083	0.263	**0.360***	-0.130	0.149	0.242
	p-value	0.601	0.092	0.019	0.411	0.345	0.122
MAP	r	0.172	0.298	**0.453****	-0.178	0.191	**0.335***
	p-value	0.275	0.055	0.003	0.260	0.226	0.030

** = Correlation is significant at the 0.01 level (2-tailed), * = Correlation is significant at the 0.05 level (2-tailed), **r** = Pearson correlation.

Table 2a: ANOVA comparing carotid artery diameter according to MAP in male subjects

Carotid artery diameter (cm)	MAP	N	Descriptive statistics				ANOVA		
			Min	Max	Mean	SD	df	F-value	p-value
Right									
CCA	Optimal	49	0.46	0.81	0.61	0.09	3	1.89	0.14
	Normal	6	0.56	0.83	0.68	0.10			

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VI, June 2026

	High Normal	4	0.55	0.69	0.63	0.06			
ICA	Optimal	49	0.35	0.81	0.59	0.09	3	0.78	0.51
	Normal	6	0.52	0.77	0.64	0.11			
	High Normal	4	0.59	0.67	0.64	0.04			
ECA	Optimal	49	0.31	0.61	0.48	0.07	3	2.43	0.07
	Normal	6	0.40	0.71	0.55	0.10			
	High Normal	4	0.52	0.56	0.55	0.02			
Left									
CCA	Optimal	49	0.43	0.77	0.60	0.08	3	0.53	0.67
	Normal	6	0.42	0.74	0.58	0.13			
	High Normal	4	0.52	0.64	0.58	0.06			
lCA	Optimal	49	0.39	0.73	0.60	0.08	3	0.35	0.79
	Normal	6	0.55	0.71	0.62	0.06			
	High Normal	4	0.55	0.63	0.60	0.04			
ECA	Optimal	49	-0.43	0.71	0.46	0.16	3	0.43	0.73
	Normal	6	0.43	0.65	0.53	0.08			
	High Normal	4	0.47	0.51	0.49	0.02			

* = significant, **CCA** = Common Carotid Artery, **ICA** = Internal Carotid Artery, **ECA** = External Carotid Artery, **MAP** = Mean Arterial Pressure

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VI, June 2026

Table 2b: ANOVA comparing carotid artery diameter according to MAP in female subjects

Carotid artery diameter (cm)	MAP	N	Descriptive statistics				ANOVA		
			Min	Max	Mean	SD	df	F-value	p-value
Right									
CCA	Optimal	28	0.43	0.76	0.60	0.07	2	2.10	0.14
	Normal	10	0.46	0.70	0.60	0.07			
	High Normal	4	0.55	0.77	0.68	0.10			
ICA	Optimal	28	0.27	0.79	0.59	0.10	2	1.70	0.20
	Normal	10	0.51	0.79	0.65	0.08			
	High Normal	4	0.47	0.79	0.63	0.14			
ECA	Optimal	28	0.33	0.58	0.49	0.07	2	3.72	**0.03***
	Normal	10	0.43	0.79	0.55	0.10			
	High Normal	4	0.42	0.69	0.58	0.12			
Left									
CCA	Optimal	28	0.47	0.70	0.59	0.06	2	0.61	0.55
	Normal	10	0.50	0.68	0.57	0.06			
	High Normal	4	0.54	0.68	0.59	0.06			
ICA	Optimal	28	0.43	0.75	0.59	0.07	2	1.79	0.18
	Normal	10	0.50	0.81	0.64	0.09			
	High Normal	4	0.57	0.75	0.63	0.08			
ECA	Optimal	28	0.26	0.59	0.47	0.06	2	5.31	**0.01***
	Normal	10	0.41	0.64	0.52	0.08			
	High Normal	4	0.53	0.66	0.58	0.06			

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VI, June 2026

Table 2c: Post hoc multiple comparison test of carotid artery diameter in female subjects

Carotid artery diameter (cm)	MAP (I)	MAP (J)	95% C.I		M.D (I-J)	S.E of M.D	p-value
			Lower	Upper			
Left							
ECA	Optimal	Normal	-0.11	0.01	-0.05	0.02	0.15
		High Normal	-0.19	-0.02	-0.11	0.04	**0.01***
	Normal	High Normal	-0.15	0.04	-0.06	0.04	0.32

* = significant, **C.I** = Confidence Interval, **M.D** = Mean Difference, **S.E** = Standard Error of Mean Difference.

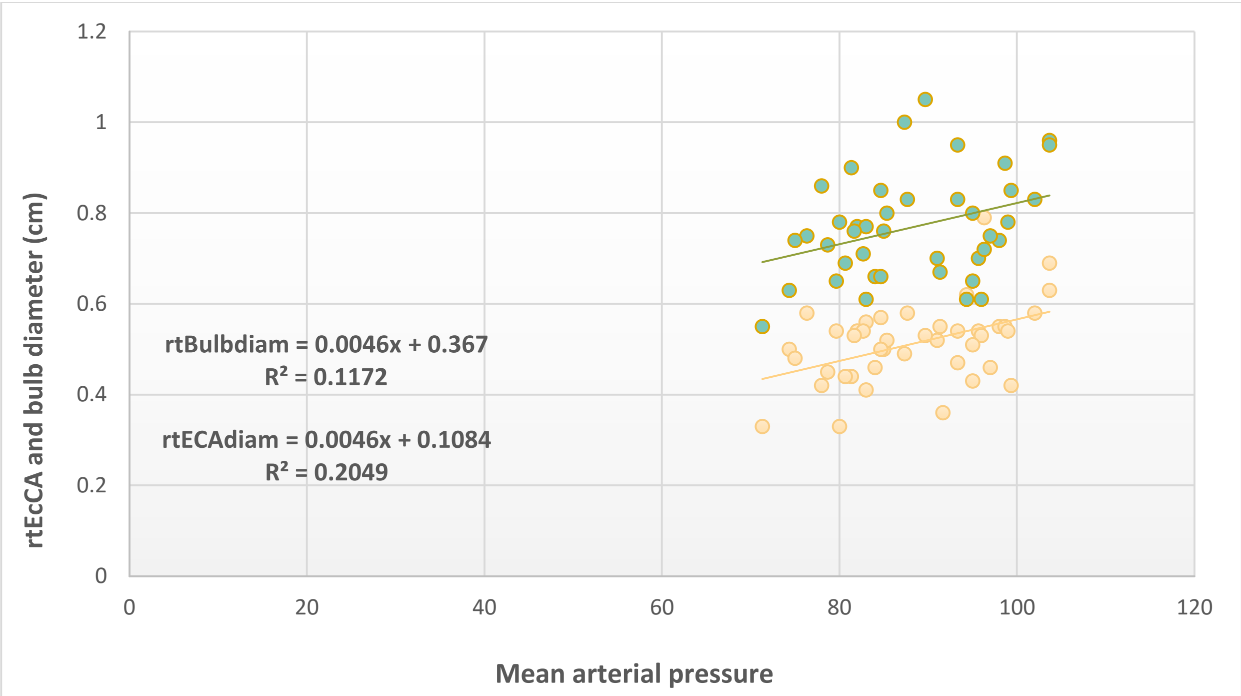

Figure 1: A scatterplot of right diameter of the external carotid artery and bulb against mean arterial pressure in female subjects.

DISCUSSION

The primary finding of this study is the weak and sexually dimorphic nature of the arterial blood pressure-carotid diameter relationship in health. The carotid artery pressure – carotid artery diameter relationship has been noted to be almost linear one in previous studies among patients.[14] However, among our participants the correlation is a not similar (figures 1). Even though among the females, there was significance, it was weak (tables 1b & 2b). We see mostly in literature, the correlation of increased carotid artery diameter or intima-media thickness with cardiovascular and neurovascular diseases (hypertension, atherosclerosis, aortic regurgitation, stoke, etc) in patients in comparison to control (normal) subjects without those risk factors.[15] However, little is said in the same publications about correlation of the parameters BP, pulse to the diameter and wall thickness in normal healthy subjects. This is one aspect this index study has helped to reveal. Lanne et al had written that the pressure and diameter relationship of arterial wall is curvilinear and appears to be biphasic, having an inflection at 90-

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VI, June 2026

110 mm Hg, above which the vessel is stiffer and less compliant. This is because during small arterial wall distensions (by normal pressure), elastin bears the load, while during large distensions (higher pressure) both elastin and collagen bear the load.[16] It was also highlighted that, the nonlinear curves drawn from the dependence of these indexes on blood pressure makes it difficult for general application, which was demonstrated by Bonyhay et al.[17] The general lack of a strong, consistent correlation in this normotensive cohort supports the hypothesis that the significant associations reported in other studies are a consequence of persistent, pathological hypertensive stimulus leading to structural remodeling.[7,8] The isolated correlation found in the ECA of females is intriguing and without a clear physiological explanation in the literature. It may reflect sex-specific differences in vascular reactivity, hormonal influences on the muscular ECA versus the elastic CCA/ICA,[18–20] or simply be an occurrence by chance in this exploratory analysis. The fact that our cohort was young population (mean age 28 years) and normotensive means that age-related stiffening and hypertensive remodeling were minimized, providing a clearer window into normal vascular physiology.[16]

LIMITATION

The study did not compare the relationship of blood pressure with carotid luminal diameters between normotensive and hypertensive individuals in the same population at the same time. In addition, there was no follow up to identify changes.

CONCLUSION

In a healthy Nigerian population, blood pressure is not a major determinant of carotid artery diameter, and any association appears to be weak and specific to the external carotid artery in females. This underscores that the carotid diameter-BP relationship observed in patient populations is an acquired phenomenon. Understanding this baseline is vital for distinguishing early pathological change from normal anatomical variation.

REFERENCES

1. Humphrey JD. Mechanisms of Vascular Remodeling in Hypertension. Am J Hypertens. 2020 May 1;34(5):432. doi:10.1093/ajh/hpaa195 PubMed PMID: 33245319.
2. WHO. World Health organization [Internet]. 2025 [cited 2026 Mar 10]. Hypertension. Available from: https://www.who.int/news-room/fact-sheets/detail/hypertension
3. Baldridge AS, Aluka-Omitiran K, Orji IA, Shedul GL, Ojo TM, Eze H, et al. Hypertension Treatment in Nigeria (HTN) Program: rationale and design for a type 2 hybrid, effectiveness, and implementation interrupted time series trial. Implement Sci Commun. 2022 Dec 1;3(1):84. doi:10.1186/s43058-022-00328-9 PubMed PMID: 35918703.
4. Lawal Y, Kantaris M. The awareness, control, and treatment of hypertension among adult population in Nigeria: a scoping review. The Nigerian Health Journal. 2024 Jun 10;24(2):1166–77. doi:10.60787/tnhj.v24i2.771
5. Adeloye D, Owolabi EO, Ojji DB, Auta A, Dewan MT, Olanrewaju TO, et al. Prevalence, awareness, treatment, and control of hypertension in Nigeria in 1995 and 2020: A systematic analysis of current evidence. The Journal of Clinical Hypertension. 2021 May 1;23(5):963. doi:10.1111/jch.14220 PubMed PMID: 33600078.
6. Martinez-Quinones P, McCarthy CG, Watts SW, Klee NS, Komic A, Calmasini FB, et al. Hypertension Induced Morphological and Physiological Changes in Cells of the Arterial Wall. Am J Hypertens. 2018 Sep 11;31(10):1067. doi:10.1093/ajh/hpy083 PubMed PMID: 29788246.
7. Arnett DK, Boland LL, Evans GW, Riley W, Barnes R, Tyroler HA. Hypertension and Arterial Stiffness: The Atherosclerosis Risk in Communities Study. Amer J Hypertension. 2018;7061(April):317–23.
8. Hayoz D, Rutschmann B, Perret F, Niederberger M, Tardy Y, Mooser V, et al. Conduit artery compliance and distensibility are not necessarily reduced in hypertension. Hypertension. 1992;20(1):1–6. doi:10.1161/01.hyp.20.1.1 PubMed PMID: 1618544.
9. Delong C, Sharma S. Physiology, Peripheral Vascular Resistance. StatPearls. 2023 May 1. PubMed PMID: 30855892.

10. Päivänsalo MJ, Merikanto J, Jerkkola T, Savolainen MJ, Rantala AO, Kauma H, et al. Effect of hypertension and risk factors on diameters of abdominal aorta and common iliac and femoral arteries in middle-aged hypertensive and control subjects: A cross-sectional systematic study with duplex ultrasound. Atherosclerosis. 2000;153(1):99–106. doi:10.1016/S0021-9150(00)00374-9 PubMed PMID: 11058704.
11. Ali AM, Ugwu AC, Mohammed MY, Abubakar U, Abubakar MI, Kachallah UM. Comparison of common carotid artery luminal diameter between adults with diabetes mellitus and healthy controls in North-eastern Nigeria . World Journal of Advanced Research and Reviews [Internet]. 2023 [cited 2026 Mar 11];19(2):13–21. Available from: https://wjarr.com/sites/default/files/WJARR-2023-1504.pdf
12. Kpuduwei SPK, Fawehinmi HB, Oladipo GS. Establishing Sexual Dimorphism in Diameter of Carotid Arteries among Normotensive Adult Nigerians. Nigerian Journal of Medicine. 2021 Mar;30(2):176–81. doi:10.4103/njm.njm_6_21
13. Kpuduwei SPK, Kiridi EK, Fawehinmi HB, Oladipo GS. Reference luminal diameters of the carotid arteries among healthy Nigerian adults. Folia Morphol (Warsz). 2022;81(3):579–83. doi:10.5603/FM.a2021.0062 PubMed PMID: 34184750.
14. Sugawara M, Niki K, Furuhata H. Relationship between the pressure and diameter of the carotid artery in humans. Heart Vessels. 2000;15:49–51.
15. Kervancioglu S, Davutoglu V, A. Ozkur, Sezen Y, Kervancioglu R, Bayram MM. Carotid and Brachial Intima Media Thickness Arterial Diameter and Resistivity Indices in Aortic Regurgitation. Acta radiol. 2004;45(8):815–8.
16. Lanne T, Hansen F, Mangell P, Sonesson B. Differences in mechanical properties of the common carotid artery and abdominal aorta in healthy males. J Vascular Surgery. 1994;20(2):218–25.
17. Bonyhay I, Jokkel G, Karlocai K, Reneman R, Kollai M. Effect of vasoactive drugs on carotid diameter in humans. https://doi.org/101152/ajpheart19972734H1629. 1997;273(4 42-4). doi:10.1152/ajpheart.1997.273.4.h1629 PubMed PMID: 9362224.
18. Jaroslaw K, Zenon M, Magdalena H, Slawomir W, Janusz L. Effect of endogenous estrogen on blood flow through carotid arteries. Stroke. 2001;32(1):30–6. doi:10.1161/01.STR.32.1.30 PubMed PMID: 11136910.
19. Krause DN, Duckles SP, Gonzales RJ. Local estrogenic/androgenic balance in the cerebral vasculature. Acta Physiol (Oxf). 2011 Sep;203(1):181. doi:10.1111/J.1748-1716.2011.02323.X PubMed PMID: 21535417.
20. Vaidya D, Golden SH, Haq N, Heckbert SR, Liu K, Ouyang P. The Association of Sex Hormones with Carotid Artery Distensibility in Men and Postmenopausal Women: Multi- Ethnic Study of Atherosclerosis. Hypertension. 2015 May 21;65(5):1020. doi:10.1161/HYPERTENSIONAHA.114.04826 PubMed PMID: 25753974.