International Journal of Research (IJR)

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 10 Issue 01
January 2023

Regression Analysis of Sonographic Prediction of Cerebrovascular Accident in Nigeria

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Abstract

The high mortality rate of cerebrovascular accidents (CVA) in Nigeria is due to its sudden onset and absence of prior awareness of risk factors. There is therefore the need to develop a predictive equation for the occurrence of stroke among subject. This study made up of 420 subjects, comprising 107 apparently healthy subjects and 313 patients with cardiovascular diseases. A cross section of 420 adults between ages 18years to 60years randomly selected under these categories was investigated. Anthropometric data, carotid artery dimensions and Doppler parameters were obtained on all the subjects. Data were analyzed using statistical tools, Pearson correlation analysis used to evaluate relationships. Regression analysis was used to generate a predictive model for estimation of CVA risk. The result show that apparently healthy subjects had the highest mean of the common carotid artery intima media thickness (CCA IMT) of 0.64mm ± 0.06mm while subjects at risk of cerebrovascular had 0.62m 0.07mm as the mean CCA IMT. The mean end diastolic velocity (EDV) of the apparently healthy subject was 13.96 ± 2.3 while the subjects at risk had 13.7 ± 25 as their mean EDV. The mean peak systolic velocity (PSV) of the apparently healthy subjects was -4.10 while the subjects at risk of cerebrovascular accident had – 1.73 as the mean PSV. Base on the findings there was a significant relationship among the obese, hypertensive, diabetic and apparently healthy subjects.

Keywords: Cerebrovascular accident, Dementia, Sonographic , Stroke

1.0 Introduction

Cerebrovascular accident (CVA) is the medical term for stroke. It occurs when there is interruption of flow of blood to part of brain, which damages brain tissue as a result death of brain cells from lack of oxygen and nutrients. The interruption of flow of blood to the brain could be as a result of narrowing, total blockage, breakage or rupture of the blood vessels. There are two major types of stroke:

i. *Ischemic stroke*: which occurs when the artery that supply blood to the brain is blocked, thus cutting off blood supply to the part of brain, making the brain cells to die as a result of lack of oxygen and nutrients. Ischemic stroke occurs in different forms, such as, *thrombotic stroke* and *embolic stroke* (Nazzaro *et al*., 2012).
ii. *Hemorrhagic stroke*: It occurs when the vessel that supplies blood to the brain bursts completely or there is leakage of blood from the vessel (Naqvi *et al*., 2014).

Other problems that may occur as a result of cerebrovascular accident include; problems of speech and sometimes aphasia, visual impairments, including inability to see with the right visual field of each eye and impaired ability to organize, reason and analyze issues. Other effects include stiffness, difficulty in gripping objects and slowness in communication which affects the quality of life generally. Loss of function varies with location and extent of damage. When stroke occurs, the victim may have concurrent medical conditions like heart disease, diabetes, traumatic brain injury, which may combine to drive the hospitalization cost up and affects ongoing medical expenses as well. The economic effect of living with stroke related deficits can be steep (Mapulanga *et al*., 2012). University of Texas Southern Medical Centre estimates the lifetime cost of stroke at sixty thousand U.S dollars while Center for Disease Control (CDC) estimate stroke cost at 34 billion dollars per year in U.S. This grand total includes medical procedures, healthcare services, prescriptions, medications, and loss of man hours for all adults affected annually (Gonzalez *et al*., 2019). In the words of Kim *et al* (2015), severe stroke can cause personality changes, intellectual deficits and disorders like dementia. Also, risk factors of stroke include non-modifiable factors like age, sex and race. Hereditary and modifiable risks like asymptomatic carotid arterystenosis, diabetes, heart disease, a trial fibrillation, heavy alcohol consumption,

Received: *20 Dec. 2022*
Revised: *2 Jan 2022*
Final Accepted for publication: *7 Jan 2023*

hypercoagulability, hyperlipidemia, hypertension, obesity, oral contraceptive use, physical inactivity, smoking, sickle cell disease (Greenland *et al*., 2019). Globally, stroke is a menace because of its high mortality rate and its consequent adverse economic effects on the individual, family and society at large (Pirson *et al*., 2019). Drug therapy, life style modifications and other measures to prevent stroke has not done much in reducing the incidence (Pengfi *et al*., 2020).

1.1 Statement of Problem

Cerebrovascular accident is one of the most common cause of death and major cause of acquired disabilities in adult; particularly in low income countries like Nigeria (Atinuke *et al.*, 2013). Despite advances in research in the last decade, early detection, prevention and treatment strategies still suffer significant limitations (Orazi *et al*., 2012). However, Chukwuma (2016) and Chioma (2017) identified stroke and heart attack as the major causes of 98.7% cases of sudden and unexpected deaths (SUD) in Nigeria population. Cardiovascular risk factors such as obesity, age and sex are strongly related to carotid arterial dimension. Hence, there is need to independently associate carotid artery rheology with the risk factors for stroke especially in young asymptomatic adults; where compensatory processes have not occurred (Rochmah *et al.*, 2021).

1.2 Objectives of the Study

The specific objectives of the study include:

1) To measure the intima media thickness and of the common carotid arteries on apparently healthy adults, hypertensive, obese and diabetic subjects.
2) To measure the peak systolic velocity (PSV) and end diastolic velocity (EDV), obtain the pulsaltility index (PI) and the resistive index (RI) of the apparently healthy adults, hypertensive, obese and diabetic subjects.
3) To measure the blood pressure, fasting blood sugar, body weight, height and obtain the body mass index (BMI) on the apparently healthy subjects, diabetics, obese and hypertensive subjects.
4) To establish the upper and lower limits of normality of the apparently healthy subjects and cross-validate it with values obtained from the subjects with cardiovascular risk factors such as hypertension, diabetes, and obesity using percentile curves.
5) To develop a cerebrovascular accident (CVA) predictive model using carotid artery dimensions and Doppler parameters obtained from this study.

2.0 Conceptual Review

Cerebrovascular accident (CVA) is defined as the sudden death of brain cells due to lack of oxygen and nutrient caused by either blockage of flow of blood or rupture of an artery that supply blood to the brain. When this occurs, it results to local neurological deficit as a result of cell death because brain cells need constant supply of oxygen and nutrients to survive and function well. When brain cell death occurs, the part of the body controlled by that part of brain will lose its functions and the presentation will be an obvious deficit. When the damage occurs in the right side of the brain, left side of the body will be affected but when the damage occurs on the left side of the brain the right side the right side of the body will be affected (Polak,2013)

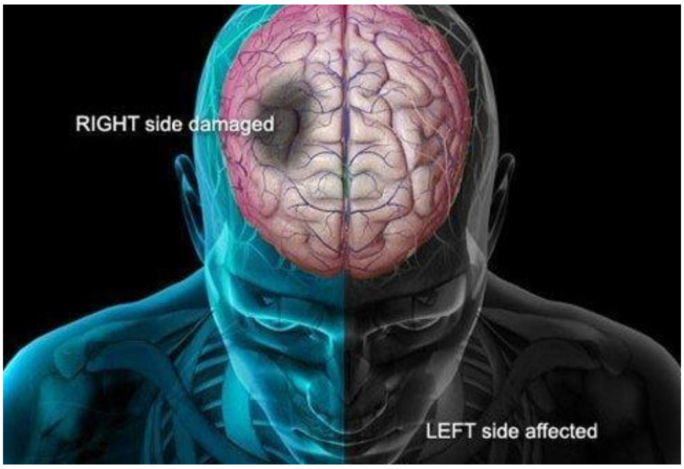

Fig 1.0: Right - sided brain lesion (Mayfield Clinics)

Received: *20 Dec. 2022*
Revised: *2 Jan 2022*
Final Accepted for publication: *7 Jan 2023*

The presentations are variable, ranging from subtle to severe, depending on the area of brain involved and the nature of the attack. Stroke is broadly classified into two: Ischemic stroke and hemorrhagic stroke (Wang *et al*., 2014). Ischemic stroke is the most common type of stroke. It occurs as a result of decreased flow of blood to an area of the brain due to complete occlusion of an artery either by blood clot (Thrombus or embolus) or by buildup of fatty deposits and cholesterol on the lumen of the cerebral vessels (kim *et al*., 2015). This build up of deposits is called plaque and the process of the formation of the plaques is known as atherosclerosis. Ischemic stroke may also occur as a result of systemic failure leading to reduction in the volume of blood flowing in the cerebral vessels. Hemorrhagic stroke occurs as a result of rupture, bursting or breakage of cerebral vessels, causing spillage and flooding of blood into nearby brain tissue. When hemorrhagic stroke occurs, pressure builds in the nearby tissue causing even more damage and irritation; this is because as blood vessels ruptures and blood accumulates in the tissues around the rupture, putting pressure on the brain cells causing loss of blood supply to the surrounding areas. Symptoms vary depending on the site of hemorrhage in the brain. It could occur in the subarachnoid space, or in the brain ventricles or in the cerebrospinal space between the arachnoid and pia matter. The major cause is the rupture of a cerebral aneurysm. The clinical manifestation includes loss of body functions like mobility, respiratory function, speech functions and swallowing (Polak *et al.*, 2013).

2.1 Risk Factors for Stroke

Stroke can occur at any age but chances of having stroke increases with age if there are some risk factors. Some of these risk factors can be modified (controlled) while some cannot be modified. So these risk factors are not modifiable include: age, race, gender, history of previous strokes, sickle cell anaemia, location, climate, family history, social economic factors. The following stroke predisposing factors can be controlled or managed for example blood pressure, blood sugar level, obesity, smoking, cardiovascular diseases, birth control, pills, history of TIA, high red cell count, high blood cholesterol and otherlipids (Polak, 2011).

2.2 Diagnosis of Stroke

Carotid ultrasound also known as vascular ultrasound is examination that combines two types of ultrasound techniques, to assess the carotid artery check for blockage which is the major risk for stroke and to assess the flow of blood in the carotid artery. The two types of ultrasound techniques used in carotid ultrasound are: Conventional or B-mode ultrasound and Doppler ultrasound also known as carotid Duplex ultrasound. The B-mode ultrasound is a safe, painless procedure that uses high frequency sound waves to create images of the internal structures of the carotid artery to assess the diameter of the carotid artery lumen, if there is obstruction; it assesses the degree of obstruction. It also helps to diagnose aneurysm, thromboses, dissections, and other vascular diseases caused by plaques or congenital abnormalities. Doppler ultrasound uses high frequency sound waves to track the flow of blood (movement) along the carotid artery thus assessing the velocity (speed) of flow of blood in the carotid artery. Carotid ultrasound gives linear and volumetric blood flow information in the carotid, vertebral and other arteries.

2.3 Stroke Prevention Strategies

Surgery like carotid endarectomy can be done to remove plaque and clots from the carotid artery in cases of carotid stenosis. A minimally invasive procedure like stent placement and carotid angioplasty may be done in cases of carotidstenosis of the carotid artery to improve blood flow. It is a minimal invasive procedure that opens clogged arteries to restore blood flow to the brain. A stent is a tiny, short wire –mesh tube that is inserted to keep the blocked passage open. The procedure involves inserting and inflating a tiny balloon into the clogged artery to widen the area so that blood can flow easily. Carotid angioplasty is often combined with stinting. (Pomella *et al.*, 2017).

2.4 Path physiology of Stroke

Energy demands of nervous tissue are very high, so sufficient blood supply to the brain must be maintained consistently. The brain oxygen consumption is entirely for the oxidative metabolism of glucose which is normal physiological condition needed for brain to function well. Stroke occurs when the blood flow to an area of brain is interrupted either by blockage (atherosclerosis) or by bursting or leakage of blood vessels in the brain, severe stress and untimely cell death usually occurs (necrosis) due to lack of oxygen and nutrients, resulting in some degree of permanent neurological damage (O'Leary *et al.*, 2010).

2.5 Anatomy of the Carotid Artery

The cerebrospinal vasculature originates at the aortic arch. The right brachiocephalic divides into right common carotid artery. The left common carotid and left subclavian artery arises directly from the aortic arch. The two

Received: *20 Dec. 2022*
Revised: *2 Jan 2022*
Final Accepted for publication: *7 Jan 2023*

common carotid arteries bifurcate into the internal and external carotid arteries including the anterior and middle cerebral arteries. The vertebral arteries arise off the subclavians and join at the pontomedullary junction to form the basilar artery. The vertebrobasilar system and distal braches are commonly known as the posterior circulation of the brain (kozakova *et al*., 2016).

2.6 Empirical Review

2.6.1 Carotid Artery Intima Media Thickness as it Relates to Cerebrovascular Accident Prediction

Mayowa *et al.* (2019) in intima media thickness of femoral arteries and carotid among an adult hypertensive Nigerian population; uses a case control study to assess their use a surrogate markers of atherosclerosis stated that recent advance in ultrasonography have solidified the place of ultrasonography and positioned intima media thickness (IMT) and plaque assessment as an important tool in cerebrovascular disease evaluation, and has been documented that femoral IMT is to be used as a more representative indicator for generalized atherosclerosis because it shows early and advanced stage atherosclerosis. The result of their study showed the mean right femoral artery IMT to be 0.80mm ± 15mm compared to control group which had 0.64mm ± 006mm, p < 0.001 and the mean of the left femoral artery IMT to be 0.81± 0.16mm compared to the control group which has their mean left femoral artery IMT as 0.61 ± 0.22mm.However, they found that majority of their subjects had dyslipidemia and hypertension. The femoral carotid artery intima media thickness increases when dyslipidemia, hypertension or diabetes is present. They stated that those subjects have 6.5 times higher risk of hypertension. Blood pressure has direct effect on CIMT because it causes hypertrophy of tunica media of blood vessels thereby increasing the CIMT. The study was done using high resolution B-mode ultrasound which was not able to detect differences in CIMT due low sensitivity of B-mode ultrasound in doing that. Shao-Yuan Chuang *et al.* (2014) in blood pressure, carotid flow pulsatility and risk of stroke aim to investigate the combined influence of central blood pressure and pulsatility index (PI) in the incidence of stroke and stated that flow velocity obtained by Doppler sonography has demonstrated to have prognostic value. They recommended a further investigation of the effects of combined carotid flow pulsatility index and central systolic blood pressure (CSBP) for stroke risk in prospective study with the general population. Calos de Cruz-Cosme *et al.* (2018) in Doppler resistivity and cerebral small vessel disease stated that hemodynamic structural correlation and usefulness of etiological classification in acute ischemic stroke prospectively recorded internal carotid artery resistivity and Fazeka score for all the participants in the study who has acute ischemic stroke. Using 74 patients, a correlation observed between Fazekas score and resistivity index. They concluded Doppler ultrasound is a useful technique for determining the Lacuna origin of acute stroke. The research was actually performed to confirm that resistive index (RI) and pulsatility index (PI) correlate with cerebral small vessel lesion burden to determine whether these parameters are useful in supporting a lacuna origin (LO) in acute stroke. Manisha *et al.* (2017) in a case control study conducted in general population selected hypertensive, diabetic and stroke patients randomly after obtaining consent from the subjects. The research was carried out with the aim to assess the common carotid artery resistive index with future risk for development of cerebrovascular accident. Various risk factors for stroke were evaluated which included age, hypertension, diabetes, dyslipidemia, smoking. The subjects were grouped into two for the purpose of the study. Group A were the patients with cerebrovascular risk factors. Group B were patients with stroke.

3.1 Research Design

This study prospectively, studied a cross-section of 420 adults, randomly selected from two groups of a longitudinal cohort. Apparently healthy adults and adults that are already being managed for cardiovascular risk factors, which include subjects that are either hypertensive, diabetic or obese.

3.2 Study Location

All the participants in the study were volunteers. The apparently healthy subjects were students of the department of medical Radiography and radiological sciences, university of Nigeria, Enugu Campus who volunteered to participate in the study. The Subjects with cardiovascular risk factors were also volunteers from medical outpatient's department of ESUT Teaching Hospital, Parklane and medical outpatient's department of UNTH, Ituku-ozalla who agreed and consented to be part of the study. All the volunteers were taken to lifechart Diagnostic center for the carotid ultrasound scanning. The study was carried out in Lifechart Diagnostic Center, Trans-Ekulu, Enugu, Nigeria. Lifechart Diagnostic Center was chosen as a location for this study because of the availability of facility for the research in the diagnostic center.

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3.3 Study Population

The target populations were both male and female adults ages from 18 years and not older than 60 years, residing in Enugu Metropolis were recruited for the study.

Received: 20 Dec. 2022
Revised: 2 Jan 2022
Final Accepted for publication: 7 Jan 2023

3.4 Sampling Technique

Convenient sampling method was used to recruit the needed participants for this study. All subjects that fit into the required criteria for selection and gave their consent were all selected for the study.

3.5 Determination of Sample Size

The sample size was determined using the formula for determination of sample size in a cross sectional study.

$$Z^{2\ P(1-P)} / d^2$$

where,

n = the sample size
z = level of confidence (z score= 1.96) which is the standard normal variate at 5% type 1 error (P<0.05)
p = Expected proportion in population based on previous studies (at 95%confidence interval)
d = absolute error or precision.

For this study, 5% precision and 95% confidence. 10% of the sample size (38.4) was added to correct for extraneous variables to improve accuracy, making the total sample size for this study to be 422. Participants were selected for this study which is greater than the minimum sample size of 395, thereby reducing the sampling error.

3.6 Method of Data Collection

All the participants for this study were given consent form to fill. On obtaining their consents, demographic data forms were given to obtain the demographic information of the subjects which includes age, sex, date of birth, and subjects that cannot read and write were interview by the researcher. Other data collected from the participants include: weight using weighing scale, height using meter rule, Blood Pressure using sphygmomanometer, fasting blood sugar (FBS) using glucometer.

Data Analysis

The mean, standard deviation and range of values for various hemodynamic factors which includes the peak systolic velocities, the diastolic velocities, and the intima-media thickness of the carotid artery were analyzed using statistical software package, SPSS 20.0 window version. Regression analysis was used develop predictive model for CVA.

4.1 Result

Four hundred and twenty-two (422) subjects were used for the study, four hundred and twenty (420) subjects were found valid for data analysis. The rejected subjects were due to incomplete record of the required parameters. The subjects comprise of 107 (25.5%) apparently healthy adults, 100 (23.8%) hypertensive, 112 (26.7%) diabetic and 101 (24.0%) obese as shown in table 4.1 below.

Table 4.1: Distribution of the subjects used for the study

Subjects	Frequency	Percentage
Apparently healthy	107	25.5
Hypertensive	100	23.8
Diabetic	112	26.7
Obese	101	24.0

Demographic characteristics of the subjects

The result in table 4.2 shows the demographic characteristics of the subjects, majority of the apparently healthy subjects were males 85 (79.4%), out of the 100 hypertensive subjects 61 (61.0%) were males, out of the 112

Received: *20 Dec. 2022*
Revised: *2 Jan 2022*
Final Accepted for publication: *7 Jan 2023*

subjects that were diabetic 73 (65.2%) were males, and out of the 101that were obese 65 (64.4%) were males. On their age group, majority of the apparently healthy participants 84 (78.5%) were between 21 – 30years while only 1 (0.9%) were more than 30 years. Majority of the hypertensive subjects 46 (46.0%) were between 31 – 40 years, while none of the hypertensive subjects were less than or equal to 20 years. Majority of the diabetic subjects 42 (37.5%) were between 21 – 30 years, while only 5 (4.5%) were between 51 – 60 years. The obese subjects 31(30.7%) each were between 21 – 30 years and 31 – 40 years, majority of the aged subjects 13 (12.9%) were between 51 – 60 years.

Table 4.2: Demographic characteristics of the subjects

Characteristics	App. Healthy (%)	Hypertensive (%)	Diabetic (%)	Obese (%)
Sex				
Male	85 (79.4)	61 (61.0)	73 (65.2)	65 (64.4)
Female	22 (20.6)	39 (39.0)	39 (34.8)	36 (35.6)
Age group				
=<20yrs	22 (20.6)	0 (0.0)	14 (12.5)	9 (8.9)
21 - 30yrs	84 (78.5)	11 (11.0)	42 (37.5)	31 (30.7)
31 - 40yrs	1 (0.9)	46 (46.0)	32 (28.6)	31 (30.7)
41 - 50yrs	0 (0.0)	24 (24.0)	19 (17.0)	17 (16.8)
51 - 60yrs	0 (0.0)	19 (19.0)	5 (4.5)	13 (12.9)

Specific objective 1: To measure the dimensions of the intima media thickness of the common carotid arteries on apparently normal adults, hypertensive, obese and diabetic subjects

There is a significant difference in the left common carotid artery (CCA) among the apparently healthy adults, hypertensive, obese and diabetic subjects ($F = 3.635$, $P = 0.013 < 0.05$)

This implies that the apparently healthy adults have the highest mean CCA IMT (0.64mm±0.06mm). The hypertensive group had the mean CCA IMT of 0.62mm±0.08mm, while the diabetic and obese had 0.61mm±0.06mm and 0.62mm±0.07mm as their mean IMT respectively.

Table 4.3a: Comparison of the left common carotid artery intima media thickness (Left CCA IMT) among the apparently healthy adults, hypertensive, obese and diabetic subjects

Subjects	No	Mean±SD (mm)	Mean sum of squares	F	P-value
Apparently healthy	107	0.64±0.06	0.016	3.635	0.013
Hypertensive	100	0.62±0.08	0.004		
Diabetic	112	0.61±0.07			
Obesse	101	0.61±0.06			
Total	420	0.62±0.07			

***Received**: 20 Dec. 2022*
***Revised**: 2 Jan 2022*
***Final Accepted for publication**: 7 Jan 2023*

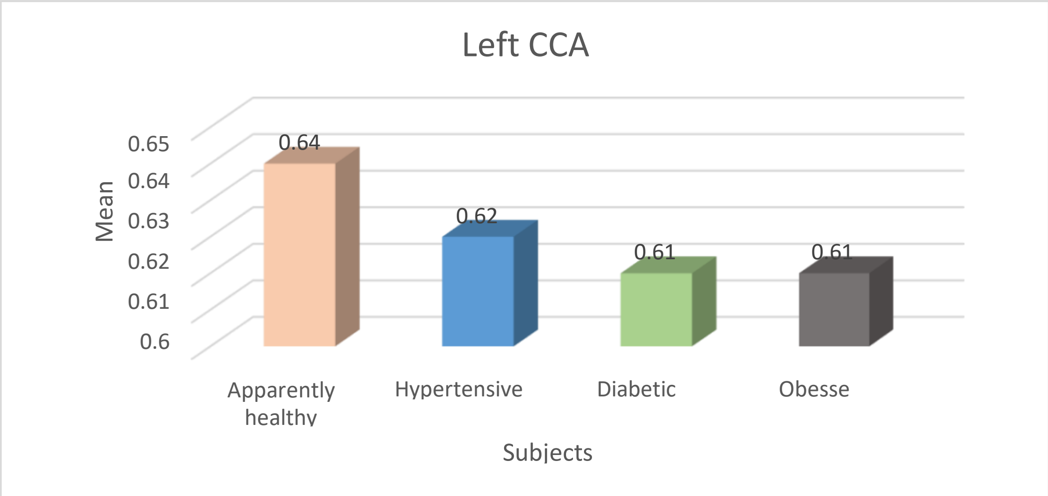

Fig. 4.1: The mean left CCA IMT among the subjects.

Table 4.3b: Post Hoc Tests (Multiple comparison) of the difference in left CCA IMT among the groups

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	P-value
Apparently healthy		0.0227	0.0092	0.014
	Hypertensive	0.002	0.0091	0.780
		0.0002	0.0091	0.987
		0.0024	0.0094	0.987

The Pair – wise comparism results as shown in table 4.3b were that there is significant difference in the mean CCA IMT among the apparently healthy adults, the hypertensive subjects ($P = 0.014 < 0.005$), diabetic subjects ($P= 0.005 < 0.05$). The diabetic and obese subjects also had a significant difference ($P = 0.987 > 0.05$).There is a significant difference in the right common carotid artery intima media thickness (CCA IMT) among the apparently healthy adults, hypertensive, obese and diabetic subjects ($F = 2.551$, $P = 0.055 < 0.05$). This implies that the apparently healthy adults have the highest mean CCA (0.64mm±0.06mm). The hypertensive and the diabetic subjects had their mean CCA IMT as 0.63mm±0.06mm, and the obese subjects had the lowest CCA IMT of 0.62mm±0.06mm.

Received: *20 Dec. 2022*
Revised: *2 Jan 2022*
Final Accepted for publication: *7 Jan 2023*

Table 4.4: **comparison of the right common carotid artery intima media thickness among the apparently healthy adults, hypertensive, obese and diabetic subjects**

Subjects	No	Mean±SD (mm)	Mean sum of squares	F	P-value
Apparently healthy	107	0.64±0.06	0.009	2.551	0.055
Hypertensive	100	0.63±0.06	0.004		
Diabetic	112	0.63±0.06			
Obese	101	0.62±0.06			
Total	420	0.63±0.06			

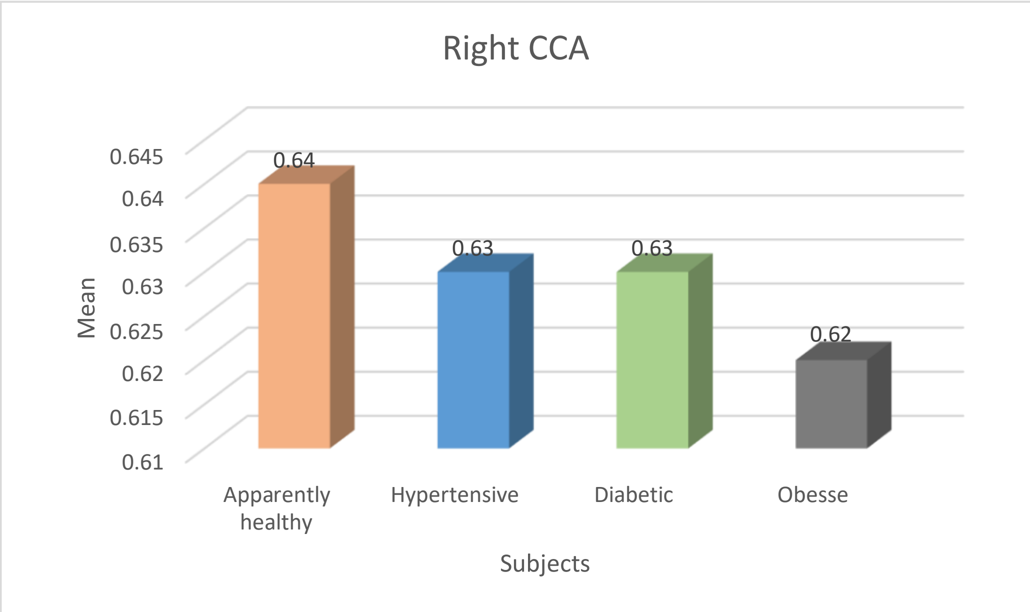

Fig. 4.2: The mean right CCA IMT Among the subjects

There is no significant difference between the CCA IMT of hypertensive and diabetic subjects (P = 0.954 > 0.05), but the hypertensive and obese subjects (P = 0.698 > 0.05), had a significant difference. The diabetic and obese subjects had (P = 0.684 > 0.05) as a significant difference

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Received: *20 Dec. 2022*
Revised: *2 Jan 2022*
Final Accepted for publication: *7 Jan 2023*

Table 4.4b: Post Hoc Tests (Multiple comparison) of the differences in right and left CCA IMT among the groups

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	P-value
Apparently healthy	Hypertensive	0.0176	0.0085	0.038
	Diabetic	0.0172	0.0082	0.038
Right	Obese	0.0210	0.0084	0.013
left	Hypertensive	-0.0005	0.0084	0.954
	Diabetic	0.0033	0.0086	0.698
	Obese	0.0038	0.0083	0.684

Pair-wise comparison result as shown in table 4.4b that there is significant difference in the mean CCA IMT amongst the apparently healthy adults, the hypertensive subjects ($P = 0.038 < 0.05$) the diabetic subjects ($P = 0.038 < 0.05$) and obese subjects ($P = 0.013 < 0.05$).

Specific objective 2: To ascertain effect of the peak systolic velocity, end diastolic velocity(EDV) and pulsaltility index (PI) on apparently healthy adults, hypertensive, obese and diabetic subjects

There is no significant difference in the mean left peak systolic velocity (PSV) among the apparently healthy adults, hypertensive, obese and diabetic subjects ($F = 2.401$, $P = 0.067 > 0.05$). However, there is a significant difference in the mean right peak systolic velocity (PSV) among the apparently healthy adults, hypertensive, obese and diabetic subjects ($F = 4.456$, $P = 0.004 < 0.05$).

Table 4.5a: Comparison of the left and right peak systolic velocity among the apparently healthy adults, hypertensive, obese and diabetic subjects

Side	Subjects	No	Mean±SD (mm)	Mean sum of squares	F	P-value
Left	Apparently healthy	107	75.96±11.46	321.161	2.401	0.067
	Hypertensive	100	80.06±11.51	133.756		
	Diabetic	112	77.27±12.87			
	Obese	101	78.59±10.11			
	Total	420	77.92±11.62			
Right	Apparently healthy	107	74.51±11.93	584.264	4.456	0.004
	Hypertensive	100	80.03±11.06	131.114		
	Diabetic	112	76.82±12.31			

Received: *20 Dec. 2022*
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Obese	101	78.55±10.25
Total	420	77.41±11.59

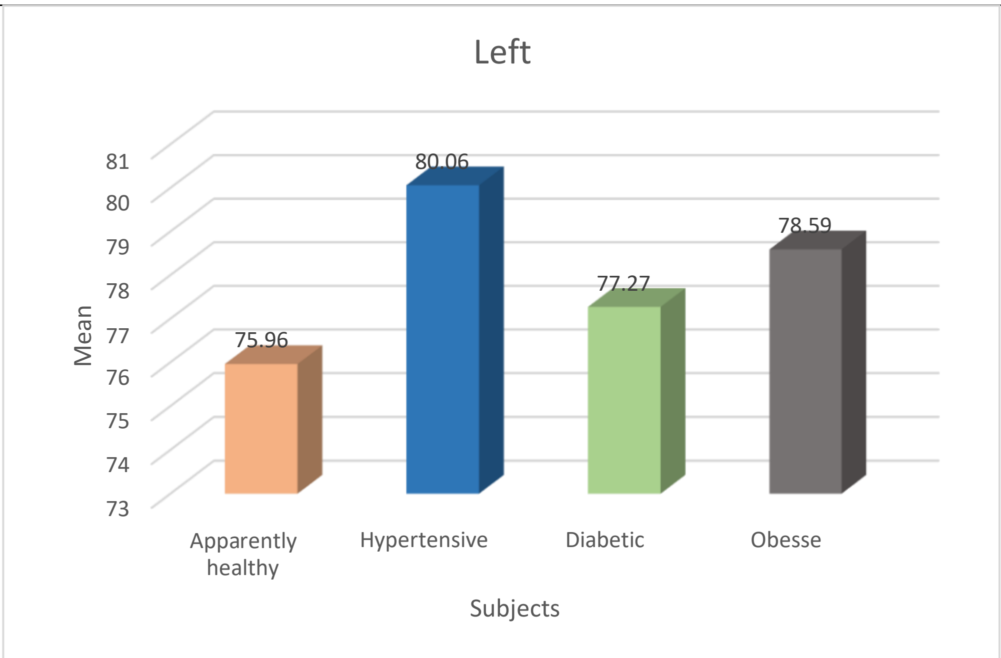

Fig. 4.3a: The mean Left PSVamong the subjects

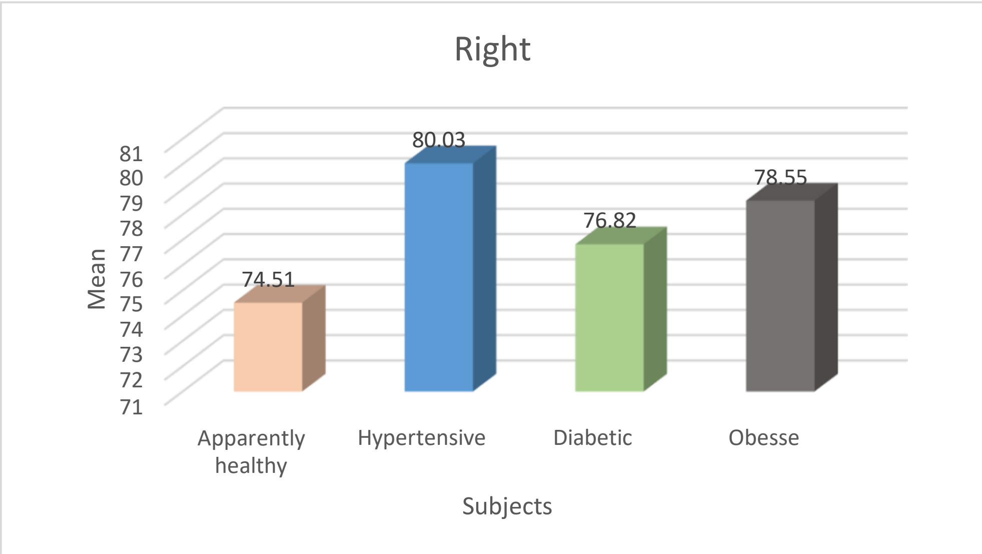

Fig. 4.3b: The mean right PSV Among the subjects

Table 4.3a shows that there is only a significant difference between the right PSV of the apparently healthy adults and hypertensive adults (P = 0.011 < 0.05).

Received: *20 Dec. 2022*
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Final Accepted for publication: *7 Jan 2023*

On the right PSV, there is a significant difference between the apparently healthy and hypertensive subject (P = 0.011 < 0.05), and there is a significant difference between the PSV of apparently healthy adults and obese subjects (P = 0.011 < 0.05).

Table 4.5b: Post Hoc Tests (Multiple comparison) of the difference in PSV among the groups

Side	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	P-value
Left	Apparently healthy		-4.1033	1.6086	0.011
		Diabetic	-1.3108	1.5634	0.402
		Obese	-2.6337	1.6045	0.101
		Hypertensive	2.7926	1.5912	0.080
Right	Apparently healthy		-5.5136	1.5926	0.001
		Diabetic	-2.3037	1.5479	0.137
		Obese	-4.0345	1.5886	0.011
		Hypertensive	3.2099	1.5754	0.042

There is a significant difference in the mean end diastolic systolic velocity (EDV) among the apparently healthy adults, hypertensive, obese and diabetic subjects (F = 3.625, P = 0.013 < 0.05). More so there is a significant difference in the mean right end diastolic velocity (EDV) among the apparently normal adults, hypertensive, obese and diabetic subjects (F = 2.934, P = 0.033 < 0.05).

Table 4.6a: Comparison of the left and right end diastolic velocity among the apparently Healthy adults, Hypertensive, Obese and Diabetic Subjects.

Side	Subjects	No	Mean±SD (mm)	Mean sum of squares	F	P-value
Left	Apparently healthy	107	13.96±2.32	23.107	3.625	0.013
	Hypertensive	100	14.81±2.65	6.374		
	Diabetic	112	13.81±2.60			

Received: *20 Dec. 2022*
Revised: *2 Jan 2022*
Final Accepted for publication: *7 Jan 2023*

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 10 Issue 01
January 2023

	Obese	101	13.83±2.52			
	Total	420	14.09±2.55			
Right	Apparently healthy	107	13.94±2.60	19.850	2.934	0.033
	Hypertensive	100	14.64±2.67	6.764		
	Diabetic	112	13.67±2.60			
	Obese	101	13.75±2.53			
		420	13.99±2.62			
	Total					

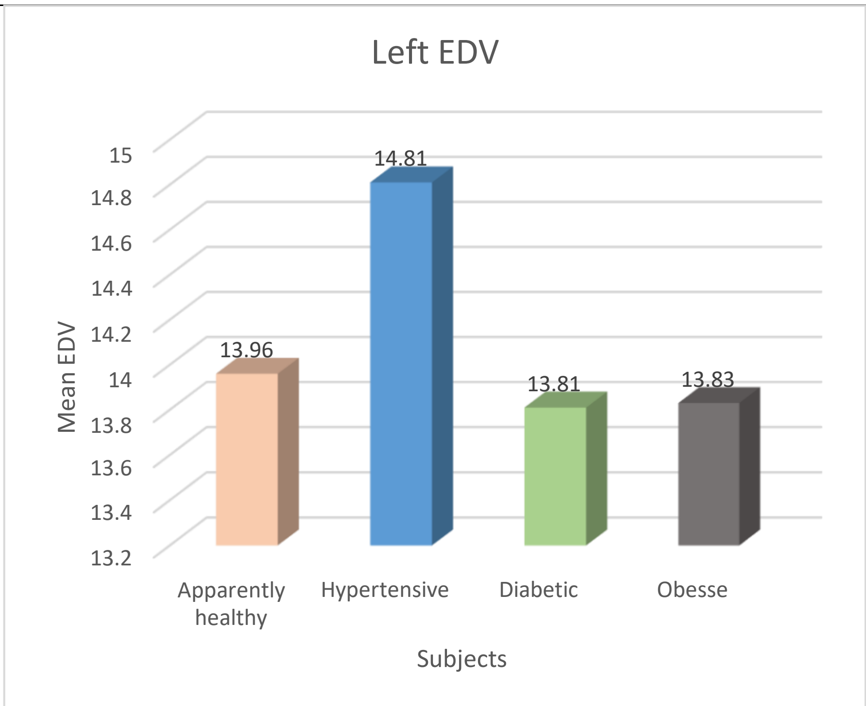

Fig. 4.4a: The mean left EDV among the subjects

Received: *20 Dec. 2022*
Revised: *2 Jan 2022*
Final Accepted for publication: *7 Jan 2023*

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 10 Issue 01
January 2023

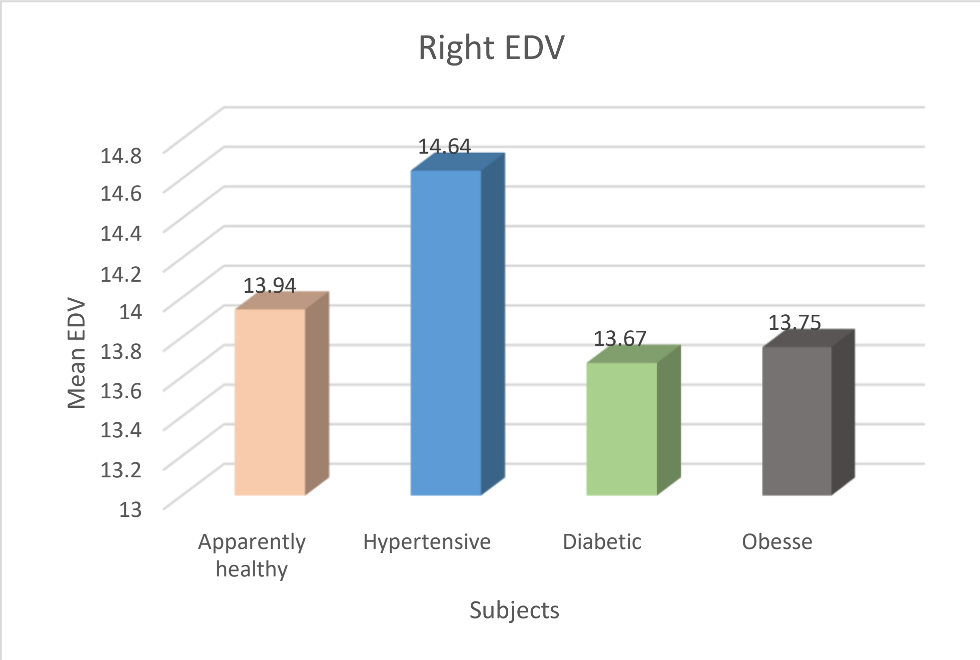

Fig. 4.4b: The mean Right EDV among the subjects

Table 4.5b shows that there is a significant difference between the left EDV of an apparently healthy adults and hypertensive adults (P = 0.016 < 0.05). There is also a significant difference between the hypertensive and diabetic subjects (P = 0.004 < 0.05). On the right EDV, there is a significant difference between the hypertensive and diabetic subjects (P = 0.007 < 0.05), and there is a significant difference between the EDV of hypertensive and obese subjects (P = 0.016 < 0.05).

Table 4.6b: Post Hoc Tests (Multiple comparison) of the difference in EDV among the groups

Side	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	P-value
Left	Apparently healthy		-0.8486	0.3512	0.016
		Diabetic	0.1513	0.3413	0.658
		Obese Hypertensive	0.1335	0.3503	0.703
			0.999	0.3474	0.004
Right	Apparently healthy		-0.6909	0.3618	0.057
		Diabetic	0.2766	0.3516	0.432
		Obese	0.1994	0.3608	0.581
		Hypertensive	0.9675	0.3578	0.581

***Received**: 20 Dec. 2022*
***Revised**: 2 Jan 2022*
***Final Accepted for publication**: 7 Jan 2023*

There was no significant difference in the pulsatility index (PI) among the apparently healthy adults, hypertensive, obese and diabetic subjects (F = 1.231, P = 0.298 > 0.05).

Table 4: Comparison of the pulsatility index (PI) among the apparently Healthy adults, hypertensive, obese and diabetic subjects

Subjects	No	Mean±SD (mm)	Mean sum of squares	F	P-value
Apparently healthy	107	0.66±0.06	0.006	1.231	0.298
Hypertensive	100	0.67±0.07	0.005		
Diabetic	112	0.66±0.07			
Obesse	101	0.65±0.07			
Total	420	0.66±0.07			

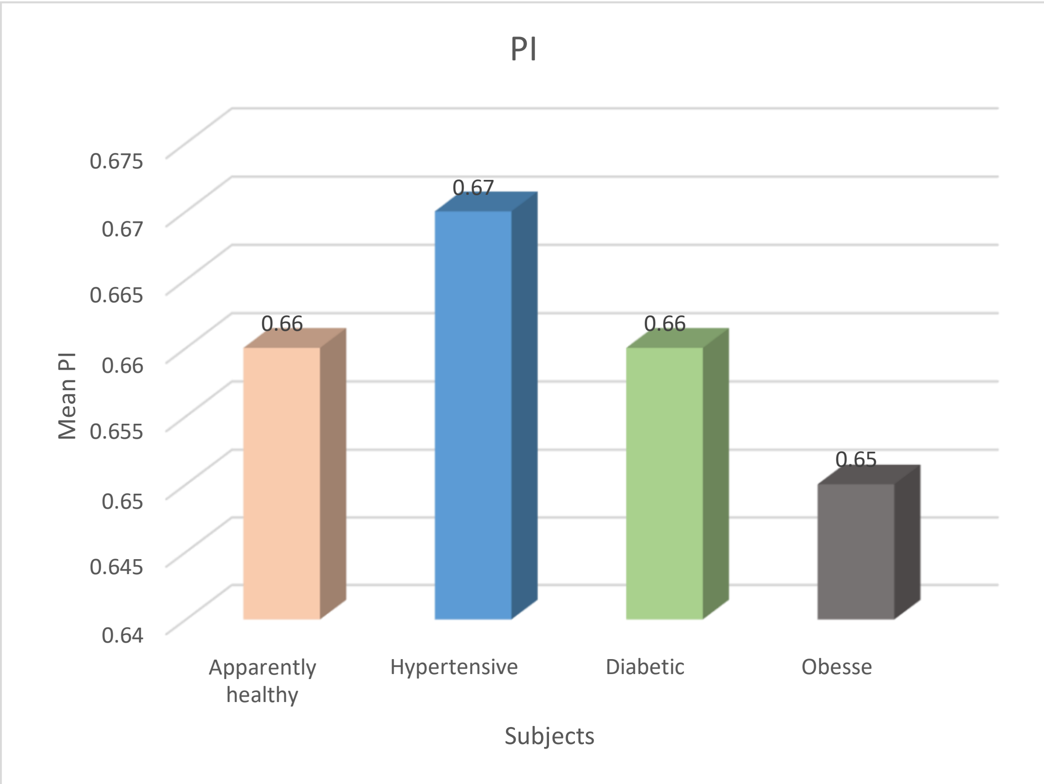

Fig. 4.5b: The mean pulsatility index (PI) among the subjects

Specific objective 3: To assess the effect of blood pressure and the body mass index (BMI), on apparently healthy subjects, diabetics, obese and hypertensive subjects

There is a significant difference in the mean systolic blood pressure among the apparently normal adults, hypertensive, obese and diabetic subjects (F = 66.474, P = 0.001 < 0.05). This implies that the hypertensive subjects have the highest systolic blood pressure 167.26mmHg±21.12mmHg. The obese subjects have a comparative high systolic BP after the hypertensive subjects with mean and standard deviation of 139.96mmHg±30.04mmHg.

Received: *20 Dec. 2022*
Revised: *2 Jan 2022*
Final Accepted for publication: *7 Jan 2023*

International Journal of Research (IJR)
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 10 Issue 01
January 2023

Table 4.8a: Comparison of the systolic blood pressure among the apparently normal adults, hypertensive, obese and diabetic subjects

	Subjects	No	Mean±SD (mmHg)	Mean sum of squares	F	P-value
Systolic	Apparently healthy	107	128.77±19.18	36329.269	66.474	0.001
	Hypertensive	100	167.26±21.12	546.517		
	Diabetic	112	126.25±22.05			
	Obese	101	139.96±30.04			
	Total	420	139.95±28.33			

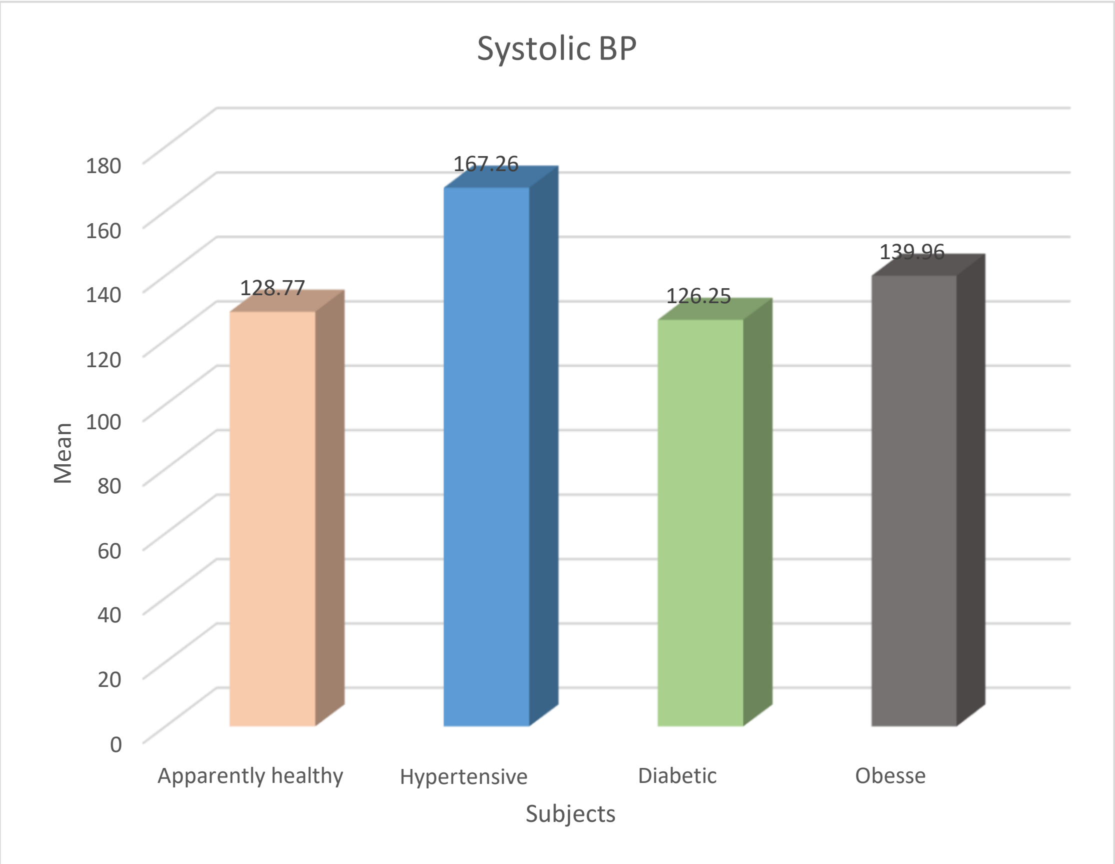

Fig. 4.6: The mean systolic Blood Pressure Among the subjects.

***Received**: 20 Dec. 2022*
***Revised**: 2 Jan 2022*
***Final Accepted for publication**: 7 Jan 2023*

Result in table 4.6b shows that there is a significant difference between the mean systolic BP of all the groups except between apparently healthy and diabetic subjects P = 0.426 > 0.05).

Table 4.8b: Post Hoc Tests (Multiple comparison) of the difference in systolic BP among the groups

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	P-value
Apparently healthy		-38.494	3.252	0.001
	Diabetic	2.516	3.160	0.426
	Obese	-11.194	3.243	0.001
	Hypertensive	41.010	3.126	0.001

Table 4.9a: Comparison of the Diastolic blood pressure among the apparently healthy adults, hypertensive, obese and diabetic subjects

	Subjects	No	Mean±SD (mmHg)	Mean sum of squares	F	P-value
Diastolic	Apparently healthy	107	75.47±8.61	12426.668	101.699	<0.001
	Hypertensive	100	98.57±10.63	122.190		
	Diabetic	112	75.09±12.02			
	Obese	101	83.01±12.55			
	Total	420	82.68±14.50			

There is a significant difference in the mean diastolic blood pressure among the apparently healthy adults, hypertensive, obese and diabetic subjects (F = 101.699, P < 0.05). This implies that the hypertensive subjects have the highest diastolic blood pressure 98.57mmHg±10.63mmHg. The obese subjects have a comparative high diastolic BP after the hypertensive subjects with mean and standard deviation of 83.01mmHg±12.55mmHg.

Received: *20 Dec. 2022*
Revised: *2 Jan 2022*
Final Accepted for publication: *7 Jan 2023*

Fig. 4.7

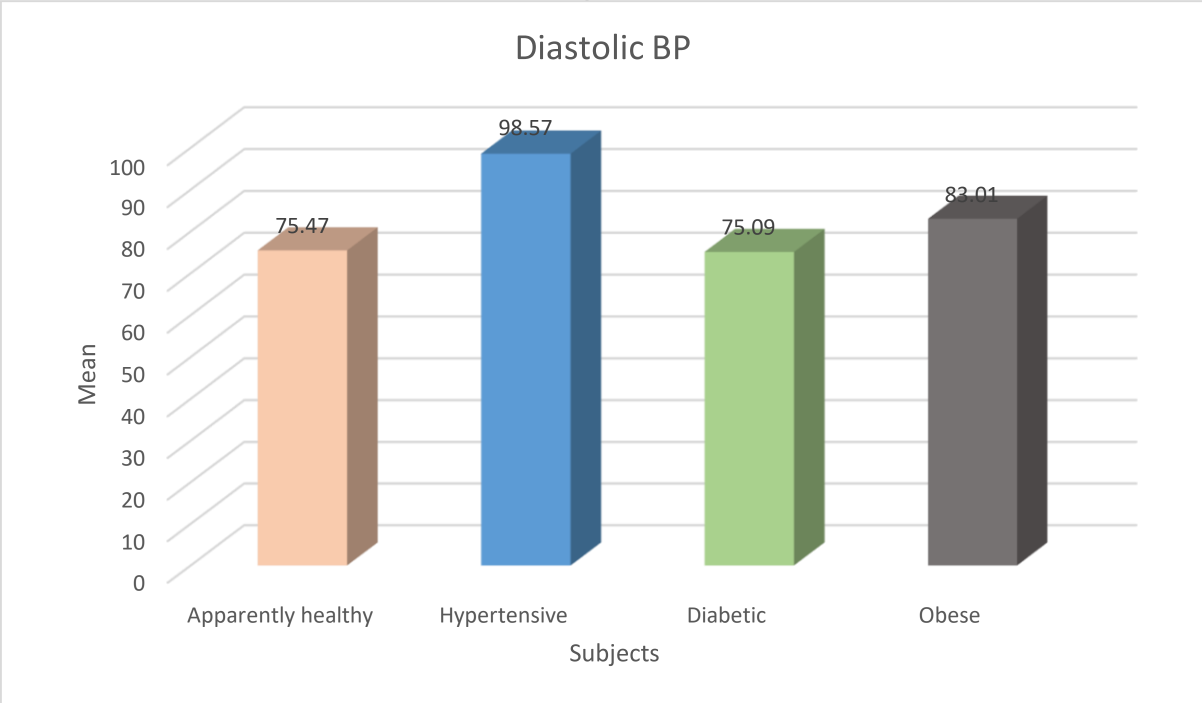

Fig 4.6b: The mean systolic BP Among the subjects.

Result in table 4.6b shows that there is a significant difference between the mean systolic BP of all the groups except between apparently healthy and diabetic subjects P = 0.800 >0.05)

Table 4.10a: Comparison of the BMI among the apparently normal adults, hypertensive, obese and diabetic subjects

	Subjects	**No**	**Mean±SD (mmHg)**	**Mean Values**		**P-value**
BMI	**Apparently healthy**	107	40.05±17.02	63957.222	26.729	<0.001
	Hypertensive	100	43.31±36.36	2392.762		
	Diabetic	112	29.96±13.77			
	Obese	101	85.57±90.15			
	Total	**420**	**48.81±53.23**			

Received: *20 Dec. 2022*
Revised: *2 Jan 2022*
Final Accepted for publication: *7 Jan 2023*

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Vol. 10 Issue 01
January 2023

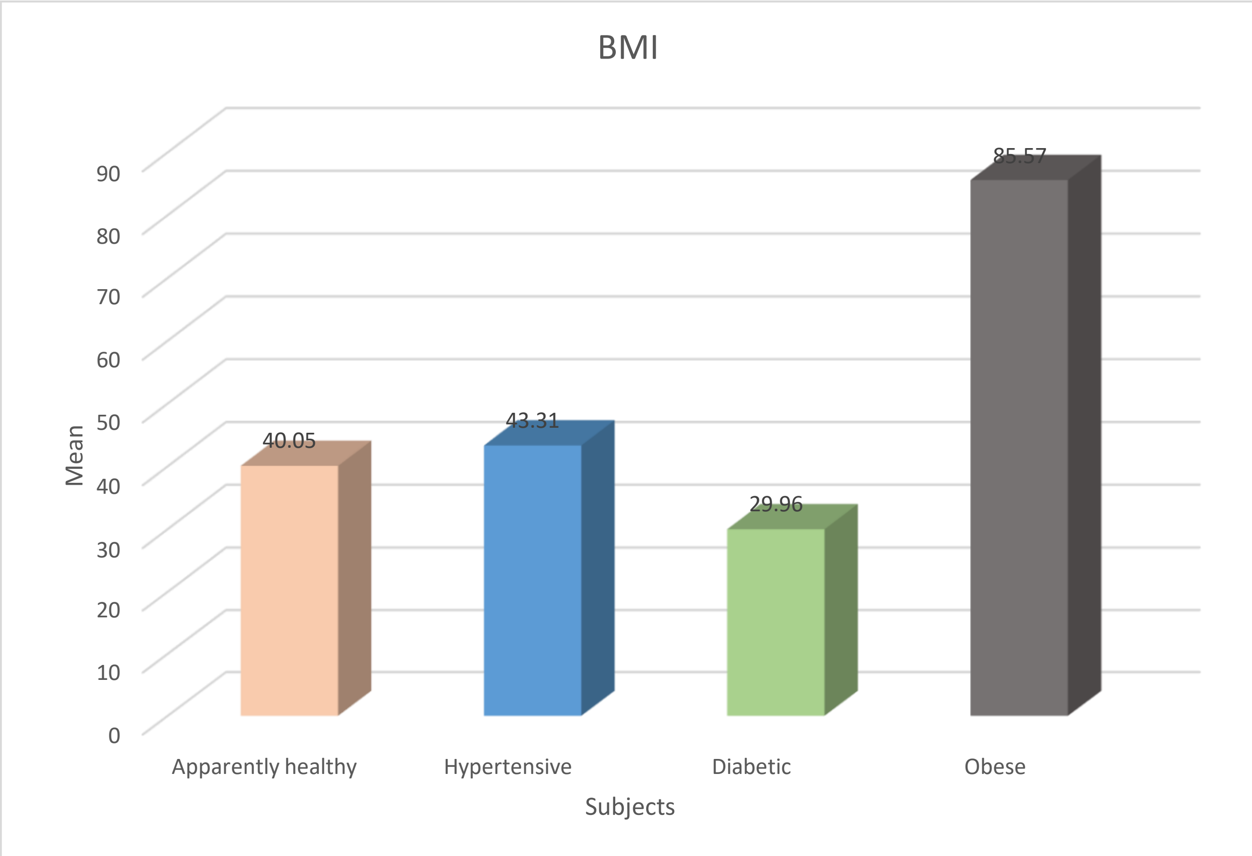

Fig. 4.8: The mean BMI of the subjects

There is a significant difference in the mean BMI among the apparently normal adults, hypertensive, obese and diabetic subjects (F = 26.729, P < 0.05). This implies that the obese subjects have the highest BMI 85.57kg/m^2±90.15kg/m^2. The diabetic subjects have a comparative low BMI with mean and standard deviation of 29.96kg/m^2±13.77kg/m^2Z.

Specific objective 4: To establish the upper and lower limits of normality ofcarotid artery intima media thickness and cross- validate with cerbrovascular risk factors using normal curves

The upper and lower limits of normality of common carotid artery intima media thickness (CCAIMT) using normality curve.

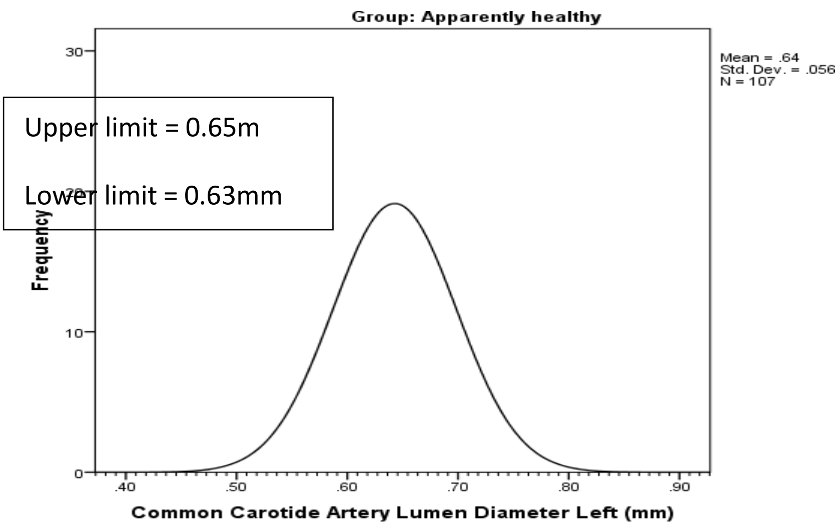

Fig. 4.9: The left CCA IMT of the apparently healthy subjects

Received: *20 Dec. 2022*
Revised: *2 Jan 2022*
Final Accepted for publication: *7 Jan 2023*

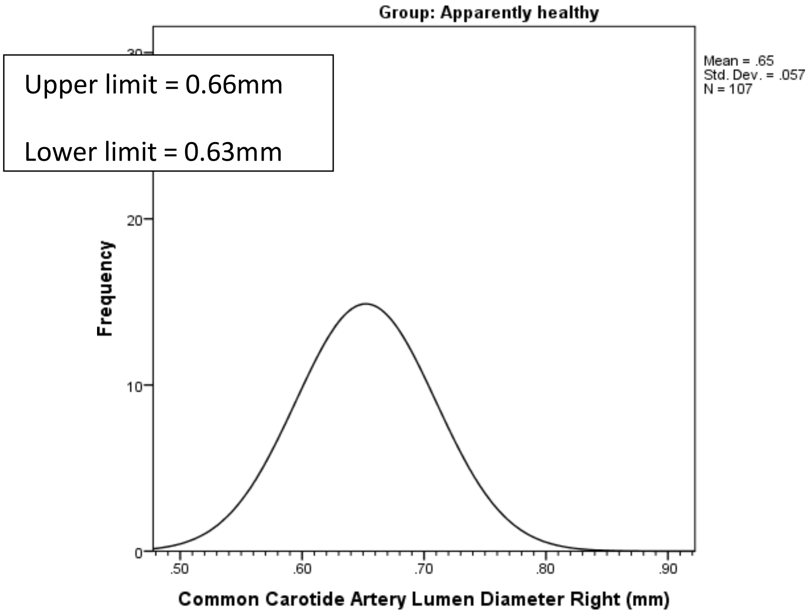

Fig. 4.10: The Right CCA IMT of the apparently healthy subjects.

The lower and upper limit of left carotid artery of the apparently healthy subjects was 0.65mm and 0.63mm respectively, while that of right carotid artery was 0.63mm and 0.66mm and 0.63mm respectively. These were shown in figure 4.9 and 4.10 above.

5.2 RESULTS

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Demographic characteristics of the subjects

The result in table 4.2 shows the demographic characteristics of the subjects. Majority of the apparently healthy subjects were males 85 (79.4%), out of the 100 hypertensive subjects 61 (61.0%) were males, out of the 112 subjects that were diabetic 73 (65.2%) were males, and out of the 101that were obese 65 (64.4%) were males. The apparently healthy participants 84 (78.5%) were between 21 – 30years while only 1 (0.9%) was more than 30 years. Majority of the hypertensive subjects 46 (46.0%) were between 31 – 40 years, while none of the hypertensive subjects were less than or equal to 20 years. Majority of the diabetic subjects 42 (37.5%) were between 21 –30 years, while only 5 (4.5%) were between 51 – 60 years. The obese subjects 31(30.7%) were between 21 – 40 years, majority of the subjects 13 (12.9%) were between 51 – 60 years. The result of this study showed a significant difference in the left and right common carotid artery Intima Media Thickness (CCAIMT) among the apparently healthy adults, hypertensive, obese and diabetic subjects that participated in this study. The apparently healthy subjects had the highest mean IMT of 0.64mm±0.06mm,the Subjects with cardiovascular risk factors like hypertensive subjects had the mean IMT of 0.62mm ± 0.08mm, diabetic subjects (0.61m±0.06mm) and obese had the mean IMT of 0.62mm±0.06mm.

The Relationship between Intima Media Thickness of the Common Carotid Arteries on Apparently Healthy Adults, Hypertensive, Obeseand Diabetic Adult Subject.

The development of sonography technology has allowed the noninvasive evaluation of atherosclerosis in the carotid arteries. The initial manifestation of carotid atherosclerosis is characterized by a subtle increase in

Received: *20 Dec. 2022*
Revised: *2 Jan 2022*
Final Accepted for publication: *7 Jan 2023*

vascular IMT, the progression of which leads to plaque formation and vascular narrowing. Increased CCA IMT is associated with higher risk for stroke (Badassarre *et al.*, 2012). According to Lee *et al.*(2007) increased CCA IMT has been reported under various conditions including hypertension, obesity, diabetes, smoking and ischemic stroke. Increase in CCA IMT is generally considered as an early marker of atherosclerosis. The result of this study showed that CCA IMT associated with modifiable CVA risk factors like hypertension, diabetes and obesity and with non-modifiable risk factors like age and gender. Which means that to control and prevent future occurrence of stroke, it means that a strict control of hypertension, diabetes and obesity together with monitoring of CCA IMT will be very helpful and very important? Polak et al., 2011, Sharma *et al.* (2009) found atthat the rate of change in CCA IMT is associated with incident stroke. This study showed a significant difference between the left and right CCA IMT among all the groups studied. This was in support of the work done by Polak *et al*. (2011) who concluded that age, systolic blood pressure; diabetes and obesity are associated with increase in risk of stroke occurrence. Also, in another Study by Sharma et al, a significant difference existed in bilateral CCA IMT amongst the smokers and non-smoker hypertensive patients (p> 0.02), they found out that IMT increase with increase in age and concluded that measurement of CCA IMT was helpful in identifying the individual at risk of cardiovascular and cerebrovascular accident and itscomplications amongst the populace which is in line with this present study. Carotid artery is one of the vital vessels needed for early detection of any wall thickness change due to pathology.IMT is important parameter in diagnosing and early detection of disorders like atherosclerosis knowing the value of IMT in serving as a pointerto cardiovascular disease processes. Mayowa (2019) showed in their result that the mean of right IMT was 0.80mm ± 15mm compared to control group 0.64mm ± 006mm, p < 0.001and the mean left (IMT(MM) to be in 0.81± 0.16mm compared to the control group 0.61 ± 0.22mm that had dyslipidemia and hypertension, Showing that CIMT increases when dyslipidemia, hypertension and diabetes are present But however, stated that those subjects have 6.5 times higher risk of hypertension and stated that hypertension has direct effect on CIMT because it causes hypertrophy of the turnica media of blood vessels, therefore increasing CIMT.

Relating the Cardiovascular Risk factors with the Doppler Parameters.

End diastolic velocity (EDV) is an index measured in spectral waveform. The EDV correspond to the point marked at the end of cardiac cycle (just prior to the systolic peak).Peak systolic velocity (PSV) in Doppler wave form corresponds to each tall peak in the spectrum window. Pulsatility index (PI) is the measurement of the variability of blood in the vessel. Resistive index (RI) is the measure of pulsatile blood flow that reflects the resistance to blood flow caused by microvascular bed distal to the site of measurement. Mirza *et al. (*2007) measured hemodynamic parameters such PSV, EDV, RI and PI and concluded that CCA EDV and PSV were independently associated with future cerebrovascular accident (CVA) prediction and EDV improved the prediction of future CVA. According to Shao-Yuan *et al*, (2016), cardiac hemodynamic and carotid flow velocities are significantly based on vessel properties and pathological changes that might have occurred in the vessel. In this present study, there was no significant difference between the mean right peaks systolic velocity (PSV) of the common carotid artery (CCA) amongst the groups studied but a significant difference existed on the mean left CCA PSV amongst the groups studied. A significant difference also existed in the mean of the left end diastolic velocity (EDV)among the apparently normal subjects, hypertensive, obese and diabetic subjects (f = 3.625, P=0.13<0.05). There was also a significant difference in the EDV of the right CCA of the apparently normal, hypertensive diabetics and obese (f = 2.934, p = 0.033 < 0.05). This is in line with the study by Mirza *et al.* (2007) who stated that there was significant difference in bilateralIMT CCA among the smoker and non-smoker hypertensive patients (p<0.02) and found IMT to increase progressively with age and concluded that measurement of CCA IMT was helpful in identifying the individuals at risk of cardiovascular and cerebrovascular accidents and its complications among the populace. This present study showed no significant difference in the left and right CCA Pulsaltility Index (P1) and on the Resistive Index (RI) among all the groups studied. The upper limit of left carotid artery for the hypertensive subjects were 0.65mm and 0.63mm, respectively, while that of right carotid artery of the hypertensive subjects were 0.63mm and 0.66mm, respectively. These were shown in figure 4.11& 4.12 above. There is no significant difference in the pulsatility index (PI) among the apparently normal adults, hypertensive, obese and diabetic subjects (F = 1.231, P = 0.298 > 0.05) this supports earlier studies such as the done in Taiwan in 2011 by Chuang*et al.* (2011) who that established a link between hazard ratio for ischemic stroke using high IMT and low EDV

Received*: 20 Dec. 2022*
Revised*: 2 Jan 2022*
Final Accepted for publication*: 7 Jan 2023*

and concluded that individual with high IMT and low EDV had 2 folds ischemic stroke risk compared to those with low IMT and high EDV. Carotid artery intima media thickness (CIMT) and end diastolic velocity (EDV) jointly and independently predicted future ischemic stroke in the Taiwanese population. In another study by Calos *et al*. (2018) who correlated resistive index and pulsaltive index of the carotid artery with stroke and to ascertain how useful and stated that these parameters could be useful in prediction of stroke occurrence using Fazekas score.

Relationship between Cardiovascular Risk Factor and Stroke

There is a significant difference in the mean diastolic blood pressure among the apparently normal adults, hypertensive, obese and diabetic subjects (F = 101.699, P< 0.05). This implies that the hypertensive subjects have the highest diastolic blood pressure 98.57mmHg±10.63mmHg. The obese subjects have a comparative high diastolic BP after the hypertensive subjects with mean and standard deviation of 83.01mmHg±12.55mmHg. There is a significant difference in the mean BMI among the apparently normal adults, hypertensive, obese and diabetic subjects (F = 26.729, P < 0.05). The implication of this is that the Obese subjects have the highest BMI 85.57kg/m^2±90.15kg/m^2. The diabetic subjects have a comparative low BMI with mean and standard deviation of 29.96kg/m^2±13.77kg/m^2.Result in table 4.6b showed a significant difference between the mean systolic blood pressure of all the groups except among the apparently healthy and hypertensive subjects (p= 0.800 > 0.05), apparently healthy and diabetic subjects (p= 0.094 > 0.05). Result in table 10 a shows that there is a significant difference between the mean systolic blood pressure of all the groups except on apparently healthy and hypertensive subjects (p = 0.800 > 0.05), apparently healthy and diabetic subjects (p = 0.094 > 0.05). Result of the research carried out in America using American Indian population showed that age, smoking, status, alcohol consumption, waist circumference hypertension, status, antihypertensive therapy, fasting plasma glucose, diabetes meditation, BMI hypertension, Diabetes and obesity in stroke prediction. The normality curves cross validated the apparently healthy group with the subjects with cardiovascular risk factors using percentile curve.It showed 0.63mm as the upper limit of the curve and 0.60mm as the lower limit of the curve for apparently healthy subjects: hypertensive subjects (0.61mm and 0.63mm) diabetic group (0.61mm and 0.63mm) obese subjects (0.60mm and 0.63mm)The lower and upper limit of left carotid artery of the apparently healthy subjects were 0.63mm and 0.65mm, respectively, while that of right carotid artery were 0.63mm and 0.66mm, respectively as shown in figures 4.9 and 4.10. The lower and upper limit of left RI for the diabetic subjects were 0.80mm and 0.82mm, respectively, while that of right RI of the hypertensive subjects were 0.80mm and 0.82mm, respectively. The lower and upper limit of left carotid artery for the hypertensive subjects were 0.61mm and 0.63mm, respectively, while that of right carotid artery of the hypertensive subjects were 0.61mm and 0.63mm, respectively. The lower and upper limit of left carotid artery for the obese subjects was 0.60mm and 0.62mm, respectively, while that of right carotid artery of the obese subjects was 0.61mm and 0.63mm, respectively. The lower and upper limit of left PSV for the apparently healthy subjects were 73.68mm and 78.22mm, respectively, while that of right PSV of the apparently healthy subjects were 72.40mm and 77.14mm, respectively. The result in table 2 shows the relationship between the risk factors and health status of the hypertensive subjects. There is a significant relationship between the BP status and the health status of the subjects that are hypertensive. Majority of the subjects with high BP 89 (84.8%) were hypertensive, and 16 (15.2%) of the subjects with normal BP are hypertensive (p < 0.05). More 54 (51.4%) of the diabetic subjects are hypertensive and 73 (69.5%) of the normal subjects are hypertensive (p = < 0.05). There is a significant relationship between the BMI status and the health status of the hypertensive subjects were more 48 (45.7%) of the obese subjects were hypertensive (P < 0.05). Only the significant status will be subjected to logistic regression. There is no significant relationship between the hypertensive subjects, and the health status that are diabetic (p = > 0.05). There is a significant relationship between the glucose status and the health status that are diabetic subjects (p < 0.05). This implies that 84 (73.7%) of the subject with high glucose are diabetic. There is a significant relationship between the BMI status and the health status of the diabetic subjects (p = 0.001 < 0.05). This implies that 48 (42.1%) of the subjects with high BMI are diabetic and 66 (57.9%) of the subjects with normal BMI are diabetic. Only the significant ones were subjected to logistic regression. The logistic Regression shows that the subject that have high BP are 19 times more likely to be hypertensive than those with normal BP and it is significant = 22.165, 95% C.I = 10.354 – 47.446, p < 0.05). The predictive equation for Cardiovascular Accident is Y = -2.066 - 0.391(CONTANT) + 0.857(BMI) + 0.946(Glucose) + 2.939(BP). The logistic regression shows that the subjects with high glucose are 20 times more likely to be diabetic and is significant (OR = 20.216, 95% C.I of OR = 9.056 – 45.126, p < 0.05). The subjects with high BMI are 2 times more likely to be diabetic than those with normal or less BMI (OR = 2.304, 95% C.I of OR = 1.064 – 4.990, p < 0.05). The predictive equation for Cerebrovascular Accident among the diabetic subjects is Y = -0.602 – 1.878(Constant) + 0.835(BMI) + 0.3.006(Glucose). The predictive equation for CVA among the hypertensive subjects is: Y=2.066 – 0.391 (Constant) + 0.87 (BMI) + 2.937 (BP). The predictive equation for Cardiovascular Accident among the obese subjects is Y = -1.350 -2662 (Constant) + 2.662 (Constant) + (BMI) +0.423 (Glucose) + 0.955(BP). The model generated in this study is completely in line with the model generated by Poustch *et al*.(2019) for cardiovascular risk assessment in Iran.

Received: *20 Dec. 2022*
Revised: *2 Jan 2022*
Final Accepted for publication: *7 Jan 2023*

5.2 Conclusion

Cardiovascular disease (CVD) remains the world's top killer as reported by World Health Organization. Therefore, a considerable demand to improve cardiovascular health is greatly desired**.** Risk prediction modelsare used throughout medical practice for variety of purposes such as predicting patient at higher risk of developing a disease condition. The tool developed from this study will be specifically to identify those at higher risk of becoming a CVA victim in future. The predictive model for CVA developed from this study can help identify the patients at risk of having CVA in future which will be helpful in clinical decisions by the clinicians and also help patients have improved CVA prevention strategies.

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Received: *20 Dec. 2022*
Revised: *2 Jan 2022*
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Final Accepted for publication: *7 Jan 2023*