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# Evaluation of inter-arm blood pressure difference in diabetic subjects and diabetic subjects with co-existing hypertension in Nnewi, Anambra state

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**Abstract**
Differences in blood pressure between arms above 10mmHg has been reported in several studies to be associated with increased cardiovascular events such as cerebrovascular accident and mortality. It is not yet a common practice among clinicians in Nigeria to measure blood pressure in both arms especially in patients with morbidities such as hypertension and diabetes. The aim of the study was to evaluate the inter-arm blood pressure difference in diabetic subjects including those with co-existing hypertension. The study population was obtained using convenience sampling method and comprised of male and female diabetic subjects including those patients with co-existing hypertension ≥20 years, from the cardiology and endocrinology units of Nnamdi Azikiwe University Teaching Hospital Nnewi. Normotensive subjects of the same age range and gender were used as control. Blood pressure was measured thrice, simultaneously on both arms using the digital sphygmomanometer and the average of three readings was used in all the subjects. The result of the finding showed no significant Inter-arm blood pressure difference in all the subjects. There was no significant difference in the systolic and diastolic inter-arm blood pressure difference of individuals with co-existing hypertension and diabetes in relation to those with only diabetes suggesting that the coexistence of hypertension and diabetes may have no adverse effect on inter-arm blood pressure difference.

**Keywords:** Inter-arm, blood pressure, difference, co-existing, diabetes.

## Introduction
Diabetes mellitus (DM) is defined as a metabolic disorder characterized by the presence of chronic hyperglycemia resulting from defects in insulin secretion, insulin action, or both and accompanied by greater or lesser impairment in the metabolism of carbohydrates, lipids and proteins [1] [2]. Generally, diabetes is a huge public health problem and puts a serious burden on health-care systems [3]. It is presently among the fastest growing global health emergencies [4]. The vast majority of cases of diabetes mellitus fall into two broad etiopathogenetic categories which are type 1 and type 2 diabetes mellitus. Type 1 diabetes is caused by an absolute deficiency of insulin secretion while type 2 diabetes is caused by a combination of resistance to insulin action and an inadequate compensatory insulin secretory response [2]. Type 2 diabetes accounts for more than 90% of patients with diabetes mellitus and most often leads to microvascular and macrovascular complications that cause profound psychological and physical stress to both patients and their relatives [3]. According to Wild *et al.* (2004), the incidence and prevalence of type 2 diabetes are increasing globally and it is estimated that the total number will rise from 171 million in the year 2000 to 366 million by the year 2030[5]. Diabetes and hypertension co-predict each other, also elevated blood pressure values are usually a common finding in patients with type 2 diabetes [6]. An accurate measurement of blood pressure is essential for the early diagnosis of hypertension and proper treatment [7]. International guidelines recommend that blood pressure should be measured in both arms during the first clinical visit, after which subsequent monitoring of the blood pressure should be done with the arm with a higher reading [8] [9] [10]. This is crucial in order to avoid misdiagnosing hypertension because there are typical variations in blood pressure between the two arms [11]. The measurement of blood pressure in both arms have received growing attention in the last decade because inter-arm blood pressure difference has been discovered to be associated with peripheral vascular disease, diabetic microvascular

complications and increased cardiovascular morbidity and mortality [12] [13]. An inter-arm blood pressure difference of a few millimeters of mercury is considered normal, but any difference more than 10mmHg could reflect underlying pathologies such as subclavian stenosis, peripheral arterial disease or asymmetrical arterial stenosis[14] [15]. Studies that have examined the inter-arm BP difference in people with type 2 diabetes, reported a prevalence of a systolic difference ≥10 mmHg between arms of 9-10% of patients [16] [17] [18]. If an inter-arm blood pressure difference is not specifically looked for, there could be a delay in the diagnosis or in the treatment of hypertension which is also a key component of effective diabetes care, hence exposing individuals to avoidable risk through sub-optimal blood pressure control [12] [17].

**Aim**

The aim of this study was to evaluate the inter-arm blood pressure difference in diabetic subjects and in subjects with co-existing hypertension in Nnewi, Anambra state.

**Study area**

This study was conducted at Nnamdi Azikiwe University Teaching Hospital Nnewi in Nnewi North Local Government Area of Anambra State, Nigeria. Nnewi comprises of four autonomous villages: Otolo, Umudim, Nnewichi and Uruagu. Nnewi is the second largest city in Anambra State after Onitsha and is popularly known for its high commercial activity. It has an estimated population of 391,227 people according to the Nigerian census of 2006. The city spans over 1,076.9 square meters (2,789km2) in Anambra state, which is in the Southeastern part of Nigeria and is located between latitudes 6˚017′N and 6˚1′N and longitudes 6˚55′E and 6˚917′E.

**Sampling technique**

The study population was obtained using convenience sampling method and comprised of male and female diabetic patients including those with co-existing hypertension aged 22 to 81 years, from endocrinology and cardiology units NAUTH Nnewi. Normotensive and non-diabetic subjects of the same age range and gender were used as control.

**Sample size**

The sample size was determined using the formula:

n= (z2pq)/d2

Where d= level of precision required 5% (0.05)
z is the standard normal deviate at 95% confidence level= 1.96
p is the proportion of persons in the population with factors under study that is, the proportion of respondents in previous Nigerian studies with IAD ≥ 10 mmHg which is 0.043[13]
And

q is 1- p = 1- 0.043 = 0.957

n= (z2pq)/d2

n= ((1.96)2 x 0.043 x 0.957)/ (0.05)2

= (3.8416 x 0.0412)/ 0.0025

= 0.1583/0.0025

n= 63.24

However, 10% attrition rate of sample size is 10/100 x 63.24 = 6.32

Therefore,

total sample size= 63.24 + 6.32 = 69.56 = 70 subjects.

70 subjects were recruited over a period of four months, using convenience sampling technique. A total 54 subjects with complete data were used for the study, while 32 both normotensive and non-diabetic subjects were used as control.

**Ethical clearance/ Informed consent**

Ethical clearance was sought and obtained from NAUTH ethical committee according to the ethical principles for medical research involving human subjects. (Ref: NAUTH/CS/66/VOL.16/VER.3/87/2024/028). The research procedure was thoroughly explained to the participants and each voluntarily signed an informed consent form in line with the human research ethics guidelines.

**Inclusion and Exclusion Criteria**

Apparently healthy adults aged ≥18 years who have been previously diagnosed of diabetes mellitus alone or with co-existing hypertension for about one to twenty years were included in the study, while apparently healthy adults of the same age range without a prior history of hypertension or diabetes were selected as controls.
Pregnant women, people with one arm, or with an upper limb deformity and children were not included in the study population. People with other acute or chronic diseases aside from diabetes mellitus and hypertension, such as malignancies, congestive cardiac failure or cardiomyopathies and endocrine diseases were also excluded from the study population.

**Data Collection**

Data was obtained from eligible subjects. Biodata and medical history were obtained from each of the subjects.

**Body Weight and Height Measurements**

The eligible subjects were asked to stand on a stadiometer on bare feet with minimal clothing. Weight was measured in kilograms, and height, measured in meters avoiding error due to parallax. Body Mass Index of the subjects was calculated using the formula; BMI=Weight (Kg)/Height (m2) and was stratified based on the World Health Organization (WHO) classification of BMI: underweight (BMI <18.5kg/m2), Normal 18.5-24.99kg/m2, Overweight 25.0-29.99kg/m2, and obese ≥ 30.0kg/m2.

**Blood Pressure (BP) Measurement**

Blood pressure measurement was taken after each subject had relaxed for five minutes. The subjects were instructed to sit comfortably on a chair with back support and both feet flat on the ground. Appropriately sized blood pressure cuff was placed 2.5 centimeter above the ante-cubital fossa.

Using two Omron M1 Basic digital sphygmomanometers, BP was measured simultaneously on both arms three times. The average of the three readings was taken, after which the difference between the average systolic BP and diastolic BP in the left and right arms was computed.

**Statistical Analysis**

Data was collated and managed in Microsoft Excel sheet and was analyzed using the Statistical Package for Social Sciences (SPSS) software version 25. The results were expressed as mean and standard error of mean. Independent samples t-test was used for comparison of the results, while one-way analysis of variance (ANOVA) was used to compare the means across groups. p-values ≤0.05 were considered statistically significant.

**Results**

A total of 54 diabetic subjects were included in the study, 21 subjects (7 males, 14 females) had only diabetes, while 33 subjects (13 males, 20 females) had co-existing hypertension.

The diabetic males and females in this study including those with co-existing hypertension were significantly shorter than the control group. The diabetic females as well as females with both hypertension and diabetes had a higher mean weight and BMI than the group of females without hypertension or diabetes.

There was no significant difference between the mean right and left systolic blood pressure and mean right and left diastolic blood pressure in the males and females diabetic subjects. There was no significant difference in the inter-arm systolic and diastolic blood pressure differences between the control and diabetic male and female subjects.

**Discussion**

The diabetic males and females in this study including those with co-existing hypertension were significantly shorter than the control group. This is congruent with the finding of a retrospective cohort study done by Loosen *et al*. (2023) in Germany among 783,029 male and female adults in which the incidence of type 2 DM was found to decrease with increasing body height. The mechanism behind the association between body height and type 2 DM is not yet known. It is assumed to be due to multiple, complex and overlapping biological pathways involving adipose tissue metabolism and function, and is probably influenced by hormonal factors associated with growth, intrauterine nutrition, childhood nutrition and vitamin D deficiency [19].

The diabetic females as well as females with both hypertension and diabetes had a higher mean weight and BMI than the group of females without hypertension or diabetes. This finding agrees with that of the study done by Bays *et al.* in which increased BMI was associated with increased prevalence of DM, hypertension and dyslipidemia [20]. Generally, body fat, most importantly, visceral fat increases the risk of developing metabolic disorders such as type 2 DM and hypertension [9] [20] [21]. Hence, overweight and obese individuals are more at risk of developing metabolic disorders such as type 2 DM and hypertension.

There was no significant difference between the right and left mean arterial systolic blood pressure and mean right and left diastolic blood pressure in male and female diabetic subjects. This may be as a result of the small sample size used for this study because in other studies with larger sample size, there was significant interarm systolic and diastolic blood pressure difference among type 2 diabetics [7] [17] [22]. It may also be as a result of the use of simultaneous blood pressure measurement as against sequential measurement used in most previous studies [17]. This suggestion is supported by the findings in the study done by Kim *et al*. (2013), in which simultaneous interarm blood pressure measurement was used to assess patients without cardiovascular diseases who had other morbidities such as DM, hypertension, obesity and metabolic syndrome and no significant IABPD was observed [23].

People with both hypertension and DM are at higher risk of cardio-cerebrovascular disease due to Vascular damage and endothelial dysfunction [25] [26]. Wang *et al*. (2021) in their study, observed that diabetes and hypertension had a significant synergistic additive interaction on coronary heart disease (ischaemic heart disease), in which increased interarm blood pressure difference has been observed [26]. However, in this study, there was no significant difference between the right and left mean arterial systolic blood pressure and mean diastolic blood pressure difference in the male and female subjects with both hypertension and DM. There was also no significant difference between the interarm systolic and diastolic blood pressure differences of diabetic males and females and that of the males and females with both hypertension and DM. Hence, the coexistence of hypertension and DM has no effect on interarm blood pressure difference according to the findings of this study.

**Table 1:** Comparison of demographic characteristics of control and diabetic subjects among males

| Variables | Control | Diabetic | P-value | T-value |
|---|---|---|---|---|
| | MEAN±SEM | MEAN±SEM | | |
| Age (Years) | 45.42±4.23 | 55.14±9.18 | 0.28[a] | -1.11 |
| Weight (Kg) | 81.07±6.19 | 71.42±4.87 | 0.32[a] | 1.02 |
| Height (meter) | 1.72±0.02 | 1.50±0.11 | 0.02* | 2.43 |
| Body mass index (kg/m2) | 27.24±1.61 | 37.84±9.44 | 0.14[a] | -1.54 |

Data was analysed using independent T-test and values were considered significant at $p<0.05$, SEM: standard error of mean, *: significance, a: not significant

Table 1 result showed that the diabetic males were significantly shorter in height than the control group.

**Table 2:** Comparison of demographic characteristics of control and diabetic subjects among females

| Variables | Control | Diabetic | P-value | T-value |
|---|---|---|---|---|
| | MEAN±SEM | MEAN±SEM | | |
| Age (Years) | 44.88±3.48 | 45.21±3.91 | 0.95[a] | -0.06 |
| Weight (Kg) | 66.05±2.97 | 77.90±5.33 | 0.04* | -2.05 |
| Height (meter) | 1.63±0.01 | 1.58±0.01 | 0.02* | 2.46 |
| Body mass index (kg/m2) | 24.69±1.10 | 30.54±1.68 | 0.01* | -3.01 |

Data was analysed using independent T-test and values were considered significant at $p<0.05$, SEM: standard error of mean, *: significance, a: not significant

Table 2 result showed a significant higher weight and BMI in diabetic compared to control, and a significant decrease in mean height in diabetic females when compared to the control group.

**Table 3:** Comparison of demographic characteristics of control and both diabetic and hypertensive subjects

| Variables | Control | DM + HTN | P-value | T-value |
|---|---|---|---|---|
| | MEAN±SEM | MEAN±SEM | | |
| Age (Years) | 45.43±4.23 | 55.54±3.93 | 0.09[a] | -1.74 |
| Weight (Kg) | 81.07±6.19 | 82.38±4.24 | 0.86[a] | -0.17 |
| Height (meter) | 1.72±0.02 | 1.65±0.01 | 0.08[a] | 1.81 |
| Body mass index (kg/m2) | 27.24±1.62 | 29.94±1.31 | 0.21[a] | -1.28 |

Data was analysed using independent T-test and values were considered significant at $p<0.05$, SEM: standard error of mean, *: significance, a: not significant, DM: diabetes mellitus, HTN: hypertension

Table 3 result showed a non-significant difference in the mean age, weight, height of the subjects.

**Table 4:** Comparison of demographic characteristics of control and both diabetic and hypertensive subjects among females

| Variables | Control | DM + HTN | P-value | T-value |
|---|---|---|---|---|
| | MEAN±SEM | MEAN±SEM | | |
| Age (Years) | 44.88±3.48 | 62.77±2.21 | 0.00* | -4.48 |
| Weight (Kg) | 66.05±2.97 | 78.59±3.37 | 0.01* | -2.72 |
| Height (meter) | 1.63±0.01 | 1.54±0.00 | 0.00* | 6.16 |
| Body mass index (kg/m2) | 24.69±1.10 | 32.74±1.30 | 0.00* | -4.56 |

Data was analysed using independent T-test and values were considered significant at $p<0.05$, SEM: standard error of mean, *: significance, a: not significant, DM: diabetes mellitus, HTN: hypertension.

Table 4 result showed a significant higher mean age, weight, and BMI in both DM + HTN females compared to control, while a significant higher height in control compared to both DM + HTN females.

**Table 5:** Comparison between Right and Left Systolic and Diastolic Blood Pressure among Male Subjects

| | Right arm | Left arm | P-value | T-value |
|---|---|---|---|---|
| | MEAN ± SEM | MEAN ± SEM | | |
| **Control n=14** | | | | |
| MASBP (mmHg) | 125.33±2.14 | 123.17±2.31 | 0.498 | 0.687 |
| MDBP (mmHg) | 77.15±2.39 | 77.59±2.05 | 0.890 | -0.140 |
| **Diabetes mellitus n=7** | | | | |
| MASBP (mmHg) | 138.28±5.30 | 135.47±5.04 | 0.708 | 0.384 |
| MDBP (mmHg) | 79.04±4.08 | 80.04±3.58 | 0.857 | -0.184 |
| **Both DM + HTN n=13** | | | | |
| MASBP (mmHg) | 142.69±3.79 | 140.33±4.06 | 0.675 | 0.424 |
| MDBP (mmHg) | 86.25±2.54 | 86.07±2.02 | 0.956 | 0.055 |

Significant at $p\leq0.05$. MASBP: mean arterial systolic blood pressure, MDBP: mean diastolic blood pressure. HTN: Hypertension, DM: Diabetes mellitus

Table 5 result showed that there were no significant differences between the arterial blood pressure of the right and left arms of all the male subjects.

**Table 6:** Comparison between Right and Left Systolic and Diastolic Blood Pressure among Female Subjects

| | Right arm | Left arm | P-value | T-value |
|---|---|---|---|---|
| | MEAN ± SEM | MEAN ± SEM | | |
| **Control n=18** | | | | |
| MASBP (mmHg) | 118.20±2.78 | 117.07±2.64 | 0.772 | 0.292 |
| MDBP (mmHg) | 75.83±1.57 | 77.07±2.06 | 0.639 | -0.483 |
| **Diabetes mellitus n=14** | | | | |
| MASBP (mmHg) | 131.19±4.90 | 131.83±3.23 | 0.914 | -0.109 |
| MDBP (mmHg) | 81.17±2.63 | 82.11±1.33 | 0.750 | -0.322 |
| **Both DM + HTN n=20** | | | | |
| MASBP (mmHg) | 148.20±3.35 | 147.88±3.49 | 0.948 | 0.065 |
| MDBP (mmHg) | 89.20±1.68 | 88.30±1.57 | 0.699 | 0.390 |

Significant at $p\leq0.05$. MASBP: mean arterial systolic blood pressure, MDBP: mean diastolic blood pressure. HTN: Hypertension, DM: Diabetes mellitus

Table 6 showed no significant differences between the arterial blood pressure of the right and left arms of all the female subjects.

**Table 7:** Comparison of Blood Pressure Parameters of Control and Diabetic Male Subjects

| Variables | Control | Diabetic | P-value | T-value |
|---|---|---|---|---|
| | MEAN ± SEM n=14 | MEAN±SEM n=7 | | |
| Inter-arm Systolic blood pressure difference (mmHg) | -2.17±1.02 | -2.81±1.86 | 0.74 | 0.33 |
| Inter-arm Diastolic blood pressure difference (mmHg) | 0.44±1.21 | 1.00±1.24 | 0.77 | -0.29 |

*: significant at $p\leq0.05$, SEM: standard error of mean

Table 7 result revealed no significant difference in the inter-arm systolic and diastolic blood pressure differences between the control and diabetic male subjects.

**Table 8:** Comparison of Blood Pressure Parameters of Control and Diabetic Female Subjects

| Variables | Control | Diabetic | P-value | T-value |
|---|---|---|---|---|
| | MEAN±SEM n=18 | MEAN±SEM n=14 | | |
| Inter-arm Systolic blood pressure difference (mmHg) | -0.75±1.00 | 0.64±2.62 | 0.59 | -0.55 |
| Inter-arm Diastolic blood pressure difference (mmHg) | 1.09±0.84 | 0.95±2.42 | 0.95 | -0.06 |

*: significant at $p\leq0.05$, SEM: standard error of mean.

Table 8 result showed no significant difference in the inter-arm systolic and diastolic blood pressure differences between the control and diabetic female subjects.

**Table 9:** Comparison of Blood Pressure Parameters of Control and Both Diabetic and Hypertensive Male Subjects

| Variables | Control | DM + HTN | P-value | T-value |
|---|---|---|---|---|
| | MEAN±SEM n=14 | MEAN±SEM n=13 | | |
| Inter-arm Systolic blood pressure difference (mmHg) | -2.16±1.02 | -2.36±1.00 | 0.89 | 0.13 |
| Inter-arm Diastolic blood pressure difference (mmHg) | 0.44±1.21 | -0.17±0.86 | 0.68 | 0.41 |

*: significant at $p \leq 0.05$, SEM: standard error of mean, DM: diabetes mellitus, HTN: hypertension

Table 9 result showed no difference in the inter-arm systolic and diastolic BP difference of the subjects with both DM and HTN and the control group.

**Table 10:** Comparison of Blood Pressure Parameters of Control and Both Diabetic and Hypertensive Female Subjects

| Variables | Control | DM + HTN | P-value | T-value |
|---|---|---|---|---|
| | MEAN±SEM n=18 | MEAN±SEM n=20 | | |
| Inter-arm Systolic blood pressure difference (mmHg) | -0.75±1.00 | 0.22±1.34 | 0.57 | -0.56 |
| Inter-arm Diastolic blood pressure difference (mmHg) | 1.09±0.84 | -0.51±0.90 | 0.21 | 1.27 |

*: significant at $p \leq 0.05$, SEM: standard error of mean, DM: diabetes mellitus, HTN: hypertension

Table 10 result showed no significant difference in the inter-arm systolic and diastolic blood pressure difference between the control and DM + HTN.

**Table 11:** Comparison of Inter-arm Blood Pressure Differences of Subjects with Both Diabetes and Hypertension to that of Subjects with Only Diabetes

| Variables | DM + HTN | DM | F-ratio | P-value |
|---|---|---|---|---|
| | MEAN ± SEM | MEAN ± SEM | | |
| **Males** | **n=13** | **n=7** | | |
| Inter-arm Systolic blood pressure difference (mmHg) | -2.35±1.00 | -2.80±1.87 [a] | 0.04 | 0.85 |
| Inter-arm diastolic blood pressure difference (mmHg) | -0.18±0.86 | 1.00±1.24 [a] | 0.70 | 0.42 |
| **Females** | **n=20** | n=14 | | |
| Inter-arm systolic blood pressure difference (mmHg) | 0.22±1.34 | 0.64±2.62[a] | 0.03 | 0.87 |
| Inter-arm diastolic blood pressure difference (mmHg) | -0.51±0.90 | 0.95±2.42[a] | 0.95 | 0.34 |

Significant at $p \leq 0.05$, SEM: Standard error of mean, a: not significant. DM: diabetes mellitus, HTN: Hypertension

Table 11 result one-way ANOVA showed no significant difference in the mean inter-arm systolic blood pressure difference or mean inter-arm diastolic blood pressure difference between diabetic only and diabetic hypertensive males and females.

## Conclusion

In conclusion, this study has not shown any significant difference in the inter-arm systolic and diastolic blood pressure difference of individuals with both hypertension and diabetes mellitus in relation to those with diabetes suggesting that the coexistence of hypertension and diabetes mellitus may have no adverse effect on IABPD. This implies that inter-arm blood pressure difference may not be as pronounced as it has been in other studies, if it is assessed in both arms simultaneously.

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