THE EFFECT OF BODY AND ARM POSITIONS ON BLOOD PRESSURE READINGS

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A DISSERTATION SUBMITTED TO THE DEPARTMENT OF CLINICAL PHARMACY AND PHARMACY PRACTICE, FACULTY OF PHARMACY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DOCTOR OF PHARMACY (PHARM.D) DEGREE OF THE UNIVERSITY OF BENIN, BENIN CITY, EDO STATE, NIGERIA.

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CERTIFICATION

This is to certify that this project work was carried out by **AGBONKHESE EGHONGHON GEORGIANA** with the matriculation number **PHA1908445**, in the Department of Clinical Pharmacy and Pharmacy Practice, Faculty of Pharmacy, University of Benin, Benin City, under the supervision of Prof. Anthony Waka Udezi, in partial fulfilment of the PharmD degree of the University.

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ABSTRACT

Background: Blood pressure (BP) is the force exerted by circulating blood against the walls of the arteries as it is pumped by the heart. It is measured in millimetres of mercury (mmHg) and expressed as two numbers: Systolic BP (the pressure during heart contraction) over diastolic BP (the pressure during relaxation). Hypertension and hypotension are two common conditions associated with blood pressure dysregulation. Accurate measurement of BP is crucial in diagnosing and managing hypertension, which is a major risk factor for cardiovascular diseases, stroke, and kidney failure. Body and arm positioning significantly affect the accuracy of blood pressure readings.

Purpose: This study is to investigate the effect of body and arm positions on blood pressure readings.

Methods: The study checks the blood pressure of 60 student participants using a digital and a mercury sphygmomanometer to compare the difference in readings obtained before the digital sphygmomanometer was then used to measure the blood pressure of 60 staff of the University of Benin.

Results: The difference between the digital sphygmomanometer readings against mercury sphygmomanometer was determined to not be statistically significant ($P>0.05$). The findings show that the difference between the blood pressure values derived from the standard blood pressure measurement posture compared to the other 9 different arm and body positions used in this study was determined to be statistically significant (P-value <0.0001).

Conclusion: Body and arm positioning have significant effects on blood pressure readings, regardless of sex, age, or body mass index. Improper positioning such as unsupported back, crossed legs, or arm below heart level results in elevated readings that may lead to overestimation of blood pressure and potential misdiagnosis of hypertension. Digital sphygmomanometers can provide reliable results if proper blood pressure measurement techniques are followed.

CHAPTER ONE

1.0 INTRODUCTION

Blood pressure (BP) is the force exerted by circulating blood against the walls of the arteries as it is pumped by the heart. It is measured in millimetres of mercury (mmHg) and expressed as two numbers: Systolic BP (the pressure during heart contraction) over diastolic BP (the pressure during relaxation).

Hypertension and hypotension are two common conditions associated with blood pressure dysregulation. Hypertension is essentially high blood pressure, while hypotension is low blood pressure.

Hypertension happens when the blood is consistently exerting too much force on the walls of the artery, which could lead to serious health problems like a heart attack or stroke. Hypotension means there isn't enough pressure to adequately circulate blood, which can cause dizziness, fainting, or a sign of an underlying condition. Both conditions can be very fatal if not managed properly.

Accurate measurement of BP is crucial in diagnosing and managing hypertension, which is a major risk factor for cardiovascular diseases, stroke, and kidney failure. Hypertension is often termed a "silent killer" because it may remain asymptomatic while causing progressive damage to vital organs. Reliable BP measurement techniques are therefore critical for effective clinical practice and research (Frese et al., 2011).

Body and arm positioning significantly affect the accuracy of blood pressure readings. Clinical guidelines recommend that patients be seated with their back supported, feet flat on the floor, and arm supported at heart level during measurement (Pickering et al., 2005). When the arm is unsupported or positioned below heart level, readings are often falsely elevated. On the other hand, when the arm is above heart level, readings may be underestimated

(Familoni et al., 2005). A recent study by Liu et al. (2024) found that incorrect arm positioning, such as resting the arm on the lap or allowing it to hang unsupported can increase systolic and diastolic BP readings by 4–7 mmHg compared to the recommended position. Such deviations may lead to misdiagnosis or over-treatment of hypertension. Adhering to the standard posture is therefore essential to ensure reliable and clinically meaningful BP measurements.

Measuring blood pressure (BP) correctly is a key part of healthcare. It is the main way doctors can diagnose and manage high blood pressure, also known as hypertension, which is a major cause of heart disease, stroke, and early death. Because BP naturally changes throughout the day, it is very important to use a consistent and correct posture every time a reading is taken.

However, many people, including healthcare workers, do not always follow the official guidelines for taking blood pressure (British Heart Foundation, 2022). In fact, a study suggests that one in six American adults might have the wrong blood pressure information due to poor measurement techniques (Everyday Health, 2024). Small errors, like not positioning the arm correctly, can significantly change a reading and lead to wrong diagnosis or unnecessary treatment (American Heart Association, 2018).

Correct blood pressure measurement is a crucial skill that is often overlooked. Study shows clearly that an improper arm position can significantly and consistently inflate readings, especially in people who already have high blood pressure (American College of Cardiology, 2024). This is not a minor issue as it can lead to misdiagnoses, unnecessary treatments, and an overall lack of confidence in blood pressure data (American Heart Association, 2018).

However, there remains a lack of comprehensive understanding regarding the specific effects of body and arm positioning on the blood pressure readings and the subsequent impact on patient health.

Addressing this gap in knowledge is crucial for improving the design of blood pressure measurements and developing better guidelines for their use. This study aims to investigate the impact of body and arm positioning on blood pressure readings by measuring; Sitting with flat feet on the floor, left arm at heart level and back support. Sitting with feet flat on the floor, right arm at heart level and back support. Sitting with feet flat on the floor, left arm above heart level. Sitting with legs crossed, sitting with no back support and lastly left arm at heart standing level. This study also aims to explore the effects of Body Mass Index (BMI), sex and age on blood pressure readings, expanding the field of view on the various factors that influence blood pressure.

By providing detailed insights into these interactions, the research seeks to enhance the overall blood pressure measurement experience and promote general health. The findings will be instrumental in guiding the development of a more standard and accurate setup of BP measurement with consistent values.

Through a systematic approach, this study will contribute valuable data to the fields of healthcare and cardiovascular health ultimately benefiting both practitioners and patients.

Improved understanding of how body and arm positions affect BP readings across all age groups can lead to a more personalized, effective BP measurement solutions.

Different ways to measure Blood pressure

Blood pressure (BP) measurement is an essential clinical procedure for assessing cardiovascular health. There are several methods, each with specific applications;

Auscultatory Method makes use of a sphygmomanometer and stethoscope, the cuff is inflated to occlude blood flow, then deflated while listening to Korotkoff sounds to determine systolic and diastolic pressures. It is considered the traditional "gold standard" in clinical practice. However, it is prone to observer error and digit preference (rounding values). It is noted that despite its accuracy when performed correctly, variability between observers reduces reliability (Ogedegbe and Pickering, 2010).

Palpatory Method involves palpating the radial pulse while inflating and deflating the cuff, it provides an estimate of systolic pressure only and is often used as a quick screening or when auscultation is difficult. It is useful in noisy environments or when Korotkoff sounds are faint, but lacks precision. It was noted that it should only be used as a screening or backup method, not for clinical diagnosis (Pickering *et al.*, 2005).

Oscillometric Method is common in automated electronic BP monitors, it detects oscillations in cuff pressure during deflation and provides both systolic and diastolic readings, it is often used in clinics and home monitoring. It is convenient and reduces observer bias. However, studies show that results may be less accurate in arrhythmic patients or those with vascular stiffness. The importance of validating devices against reference standards before use was highlighted (Muntner *et al.*, 2019).

Ambulatory Blood Pressure Monitoring (ABPM) is a portable device that measures BP at intervals (usually every 15–30 minutes) over 24 hours, it helps detect white coat hypertension and monitor circadian BP variations. ABPM predicts cardiovascular outcomes more accurately than office BP, making it superior for diagnosing hypertension and detecting white-coat or masked hypertension (Hansen *et al.*, 2007)

Home Blood Pressure Monitoring (HBPM) enable patients measure BP at home with validated electronic devices. Studies show HBPM improves hypertension management and adherence. It is noted that HBPM provides reliable readings if patients are trained and follow a structured protocol (Stergiou *et al* , 2018). HBPM allows for repeated measurements in a relaxed setting, improving reliability of readings.

Intra-arterial Method is the direct measurement using a catheter inserted into an artery. It is mainly used in critical care or surgical settings. Although it is considered the most accurate technique, it is invasive and risky. It is advised to be best reserved for critically ill patients where continuous monitoring is essential (Ilies *et al.*, 2012).

Common Measurement Errors.

- **Improper body position**: Not having the back supported, feet flat on the floor, or legs uncrossed (American College of Cardiology, 2022).
- **Wrong cuff size**: Using a cuff that is too small can raise a reading by up to 20 mmHg (Everyday Health, 2024).
- **Placing the cuff over clothing**: This can increase a reading by as much as 50 mmHg (GE Healthcare, 2022).
- **Not resting beforehand**: Not sitting quietly for at least 5 minutes before the measurement can lead to a higher reading (Times of India, 2022).
- **Talking during the measurement**: Even just talking can add up to 10 mmHg to the reading (Times of India, 2022).

1.1 BACKGROUND OF THE STUDY

Blood pressure (BP) measurement is one of the most common and important clinical procedures used to diagnose and monitor cardiovascular health. Accurate BP assessment is essential because misclassification of hypertension can lead to either unnecessary treatment or missed diagnosis of high-risk individuals (Pickering et al., 2005). The reliability of these measurements, however, is highly dependent on strict adherence to standardized techniques.

Among the various factors influencing BP readings, patient positioning, specifically of the body and the arm is a critical and often overlooked variable that can significantly impact measurement accuracy and subsequent clinical decisions.

Despite its importance, numerous factors influence the accuracy of BP readings, including cuff size, observer technique, device type, and importantly, the body and arm position during measurement (Parati et al., 2014).

Body and arm position significantly affect the hydrostatic pressure exerted on arteries, thereby influencing the accuracy of recorded values. When the arm is not at heart level, for example, readings can be systematically biased: for every 10 cm the arm is positioned above or below the right atrium, a difference of about 7–8 mmHg in systolic pressure may be observed (Beevers, Lip, & O'Brien, 2001). Similarly, crossing the legs, sitting without back support, or failing to rest the arm properly can all lead to elevated or inconsistent readings (Ogedegbe & Pickering, 2010).

Research has shown that seated measurements with the patient's arm supported at heart level provide the most reproducible and clinically useful readings (Pickering et al., 2005). Conversely, lying supine or measuring BP with the arm dangling at the side may yield artificially high or low values, depending on the angle relative to the heart (Shirasaki et al., 2012). These variations have major implications for diagnosis, as even small differences (5–10 mmHg) can alter hypertension classification (Stergiou et al., 2018).

The American Heart Association and European Society of Cardiology both recommend standardised positioning for BP measurement: the patient should be seated with their back supported, feet flat on the floor, legs uncrossed, and the arm supported at heart level (Muntner et al., 2019).

The rationale for back support is physiological; sitting without support can cause an isometric contraction of the back muscles, which elevates cardiac output and systemic vascular resistance, thereby increasing diastolic blood pressure (DBP) (Netea et al., 2003). Similarly, crossing the legs at the knee has been consistently shown to raise systolic blood pressure (SBP) and DBP. This effect is attributed to the translocation of venous blood from the dependent legs to the thorax, increasing preload and cardiac output, as well as a possible increase in systemic vascular resistance due to compression of vasculature (Pinar et al., 2010).

Despite these guidelines, non-standardised practices are common in clinical and community settings, leading to concerns about the reliability of routine BP recordings (Parati et al., 2014).

Thus, exploring the effect of body and arm positions on BP readings is critical. Understanding these influences not only ensures proper clinical decision-making but also improves patient safety, reduces misdiagnosis, and aligns practice with international guidelines.

This study aims to explore the effects of body and arm position on BP readings, providing valuable insights that could lead to advancements on a standardized method of taking a more reliable blood pressure readings and better clinical management of hypertensive and hypotensive patients. By focusing on the role of body and arm positions in an accurate BP reading, the research seeks to contribute to the development of more reliable methods of BP measurements that prioritize cardiovascular health.

1.2 STATEMENT OF PROBLEM

Blood pressure measurement is one of the most routine procedures in healthcare, yet it is also one of the most error-prone (Pickering et al., 2005). Despite the existence of international guidelines recommending standardised procedures, clinical practice often varies widely, particularly in terms of patient body posture and arm positioning during measurement

(Muntner et al., 2019). Such inconsistencies can produce systematic errors that may lead to misclassification of hypertension, inappropriate treatment, or missed opportunities for early intervention (Stergiou et al., 2018).

Research has shown that small deviations in position, such as crossing the legs, failing to support the back, or placing the arm below or above heart level, can shift blood pressure readings by 5–15 mmHg (Shirasaki et al., 2012). These differences are clinically significant, as they may alter diagnostic thresholds or affect monitoring of treatment outcomes. For example, a patient incorrectly labelled hypertensive because of poor positioning may be placed on unnecessary medication, while a true hypertensive patient measured in a misleading position could remain untreated.

Additionally, if a patient's blood pressure is measured differently before and after treatment, a clinician might mistakenly think a treatment is working better than it is. This could delay important changes to a treatment plan (American Journal of Hypertension, 2011).

Although studies have highlighted these positional effects, improper measurement techniques remain common in both hospital and community settings (Parati et al., 2014). This persistent gap between guideline recommendations and clinical practice creates uncertainty in blood pressure assessment and ultimately undermines cardiovascular risk evaluation.

Therefore, it is essential to investigate systematically the effect of body and arm positions on blood pressure readings. The research not only reinforces the importance of measurement standardisation but also provides evidence that could guide healthcare workers and patients towards more reliable and reproducible practices.

1.3 JUSTIFICATION OF THE STUDY

Blood pressure measurement serves as a fundamental clinical procedure used to detect hypertension and assess cardiovascular risk. However, the accuracy of this measurement is largely dependent on proper technique, including correct body and arm positioning. Despite clear international guidelines, posture-related errors in BP measurement continue to be highly prevalent in daily practice. This increases the likelihood of obtaining falsely elevated or underestimated readings, which can negatively affect clinical decision-making and patient outcomes.

Given the high global burden of hypertension and the importance of early and correct diagnosis, there is a strong need to further evaluate how different body and arm positions influence BP readings. This study is justified because it provides evidence that can help strengthen measurement protocols, particularly in environments such as outpatient clinics, hospitals, and home settings where variability in technique is more common.

Furthermore, by identifying positions that produce significant deviations in BP values, this study will help reduce misclassification of hypertensive status, minimise the risk of inappropriate treatment, and promote better long-term cardiovascular care. The results will be especially meaningful for training healthcare workers and educating patients, ensuring that both groups adopt standardised practices that yield more reliable and reproducible measurements.

1.4 AIM AND OBJECTIVES

1.4.1 AIMS

The primary aim of this research is to assess the effect of body and arm positions on blood pressure readings.

1.4.2 OBJECTIVES

i. To determine the effect of body posture and arm positions on blood pressure (BP readings)

ii. ii. To determine the effect of sex on BP readings.

iii. To determine the effect of age on BP readings.

iv. To determine the effect of Body Mass Index (BMI) on BP readings.

v. To compare the accuracy of the digital with the mercury sphygmomanometer.

1.5 SIGNIFICANCE OF STUDY

This study on the effect of body and arm positions on Blood pressure readings is significant for several reasons:

The study is significant because it highlights how non-standardised body and arm positions (common errors in both clinical and community settings) can lead to inaccurate BP recordings. Understanding the extent of these variations will reinforce the importance of proper technique, particularly in primary healthcare settings where most BP assessments occur.

It will also contribute to improving the training of medical and paramedical personnel, including students, interns, and community health workers.

The study supports patient education by showing individuals how to correctly measure their BP at home. Since home monitoring is increasingly used for hypertension management, ensuring proper technique can improve treatment adherence and self-management.

Overall, the study has the potential to improve BP measurement accuracy, enhance clinical outcomes, reduce healthcare costs linked to erroneous diagnoses, and strengthen guidelines.

CHAPTER TWO

LITERATURE REVIEW

2.0 EFFECTS OF BODY AND ARM POSITION ON BLOOD PRESSURE READINGS

Several studies have documented how deviations from recommended positions lead to systematic bias in BP readings.

Eser et al. Conducted a study of 157 healthy young students in which BP was measured in four positions: sitting, standing, supine, and supine with crossed legs. They found that systolic BP was significantly highest in the supine position compared with standing, sitting, and supine with crossed legs ($p < 0.001$), although diastolic differences were not always significant. The authors concluded that body position must be taken into account when measuring BP.

Several studies have demonstrated that arm position significantly affects systolic blood pressure (SBP) and diastolic blood pressure (DBP). When the arm is placed below heart level, gravitational force causes blood to pool downward, resulting in an increased BP reading. Adiyaman et al. found that unsupported arms can raise SBP by approximately 4–10 mmHg, which may lead to false hypertension classification. Similarly, Netea reported that placing the arm on the patient’s lap resulted in an average increase of about 4 mmHg for both SBP and DBP compared to the recommended position. Research by Middel et al. (1998) found that placing the patient’s arm on the armrest of a chair (i.e., not at the level of the right atrium) resulted in systolic BP elevations of ~9.7 ± 9.4 mmHg and diastolic ~10.8 ± 5.8 mmHg compared to when the arm was at heart level.

Additionally, a more recent crossover randomised clinical trial involving 133 adults compared three arm positions (supported on a desk at heart level, resting in the lap, unsupported hanging by the side). Results showed that lap position overestimated systolic BP by ~3.9 mmHg and diastolic by 4.0 mmHg; hanging by the side overestimated systolic by ~6.5 mmHg and diastolic by ~4.4 mmHg compared to the correct position. Additional analyses suggest that when the arm is positioned below heart level, gravity increases hydrostatic pressure at the measurement site, thereby elevating the reading. When the arm is too high, readings may be falsely lowered. The implications are substantial.

Arm support is equally important. Unsupported arm muscles contract isometrically, increasing vascular resistance and causing measurement errors. Overall, literature strongly supports that standardizing both body posture and arm support at heart level reduces BP variability, improves diagnosis accuracy, and aligns with international measurement standards.

2.1 EFFECTS OF AGE AND BODY MASS INDEX ON BLOOD PRESSURE READINGS

The relationship between body composition (often indexed by BMI) and age with blood pressure has been extensively studied, given the rising global prevalence of overweight/obesity and ageing populations.

Multiple epidemiologic studies demonstrate that higher BMI is associated with higher systolic and diastolic BP, and increased odds of hypertension. For example, Li et al. found in a Chinese adult population that elevated BMI significantly increased the risk of hypertension, with family history interacting synergistically.

Similarly, Pikilidou et al. Reported that the burden of obesity on BP is greater in younger age groups, and the effect of BMI on hypertension attenuates with advancing age, suggesting an age-modification of the BMI–BP relationship. A more recent longitudinal analysis of BMI trajectories found that even within the “normal” BMI range, modest increases in BMI during childhood/adolescence were associated with higher BP and future risk of hypertension, emphasising early life BMI changes as critical.

Systematically, age also independently influences BP via arterial stiffening, endothelial dysfunction and reduced baroreceptor sensitivity. Pettersen et al. Argued arterial stiffening alone could account for primary hypertension's emergence with age.

The interaction of BMI and age further complicates interpretation: increased fat mass contributes to elevated cardiac output, sympathetic activation and vascular resistance; whereas advanced age may modify these pathways and reduce the relative impact of BMI on BP.

2.2 EFFECT OF SEX ON BLOOD PRESSURE READINGS

The relationship between sex on blood pressure readings have to do with a complex interplay of the differences in general body composition, hormones and cardiovascular physiology between males and females. Overall, younger adult men tend to have higher blood pressure and higher prevalence of hypertension compared to younger women. For example, in one study of 16–23 year olds: 9% of males vs 1% of females had hypertension. However, the difference changes with age as women's blood pressure rises more steeply in middle age and older age, such that post-menopausal women may equal or exceed men in BP levels (Stergiou et al. (2018),

Estrogen in women appears protective as it increases nitric oxide bioavailability, reduces vascular tone, and decreases sodium reabsorption. Testosterone in men may have pro-hypertensive effects (e.g., via increased sympathetic activity, sodium retention)

Generally, the literature indicates that while both BMI and age significantly relate to BP readings and hypertension risk, the strength and nature of those associations may vary by age group, sex, ethnicity, and temporal trends. It underscores the need for age-specific and BMI-sensitive BP assessment and management approaches.

CHAPTER THREE

METHODOLOGY

3.0 SETTING

The study was conducted a within the university of Benin. The clinic used was equipped with a desk and a chair with a back and arm rest to ensure proper blood pressure measurement.

3.1 INSTRUMENT

A digital sphygmomanometer (OMRON M-2) was used in the blood pressure measurement of the University of Benin staff. The blood pressure values of the students were taken with both the digital sphygmomanometer and a mercury sphygmomanometer. A weight scale and a tape measure were also used to measure each participant's weight and height respectively.

3.2 SAMPLE

The sample size for this study was 120 participants

3.3 PROCEDURE

The study commenced with the random selection of 60 students (30 males and 30females) from the 600-level class of the faculty of pharmacy, University of Benin. Each student was allowed to rest for at least 5 minutes before his/her blood pressure was taken seated with their back supported, feet flat on the floor, and arm supported at heart level. The procedure was repeated three times per arm using both the digital and the mercury sphygmomanometer with a time interval of one minute between each measurement. The results from the digital sphygmomanometer were compared to that of the mercury and no significant difference was found.

The digital sphygmomanometer was then used to check the blood pressure of 60 University of Benin staff, 30 males and females each, in the ten different body postures and arm positions listed below;

1. Sitting with feet flat on the floor, left arm at heart level and back support.
2. Sitting with feet flat on the floor, right arm at heart level and back support.
3. Sitting with feet flat on the floor, left arm above heart level and back support.
4. Sitting with feet flat on the floor, left arm below heart level and back support.
5. Sitting with no back support, left arm at heart level and feet flat on the floor.
6. Sitting with no back support, right arm at heart level and feet flat on the floor.
7. Sitting with legs crossed, left arm at heart level and back support.
8. Sitting with legs crossed, right arm at heart level and back support.
9. Left arm at heart level, standing.
10. Right arm at heart level, standing.

The weight and height of each participant was measured with a weight scale and tape measure respectively.

3.4 DATA COLLECTION

Blood pressure readings were measured in each of the participants 3 times each per body/arm position and the average values were recorded into a copy of document 1 which is inserted at the end of this paper. The sociodemographic data, height, weight and, Body Mass Index, of each participant was also recorded.

3.5 DATA ANALYSIS

The blood pressure values and sociodemographic data of each subject was coded and entered into Microsoft excel spreadsheet. Descriptive statistics including mean, standard deviation, and percentages were utilized to analyze the data. Additionally, inferential statistics was also conducted via Graphpad instat software where student t-test and one way analysis of variance (ANOVA) was used to test for difference between categories to test the hypotheses. Statistical significance difference is determined if P-Value is <0.05 for this study. To give a visual depiction of the data, the findings were presented using tables.

CHAPTER FOUR

4.0 RESULTS

This study involved a total of 120 subjects with an even distribution of 60 University of Benin staff and 60 students from the 600-level pharmacy class.

4.1 Sociodemographic Factors of Student Participants

In table 4.1, the blood pressure of 30 male students and 30 female students was measured.

The students who were aged 25-34 years were only 4 in number (6.67%), the remaining students were all at or below 25 years (93.33%).

Out of the 60 students measured, from the Body Mass Index ratio calculated from their respective body height and weight, 10 of the students were found to be overweight (16.67%), 38 of them were of normal weight (63.33%) and a considerable number; 12 of them were underweight (20.00%).

Variable	Number Reporting	Percentage (%)
SEX		
Male	30	50.00
Female	30	50.00
AGE(Yrs)		
<25	56	93.33
25-34	4	6.67
35-44	-	
BMI(Kg/M2)		
Overweight (25-29.9)	10	16.67
Normal weight (18.5-24.9)	38	63.33
Underweight (<18.5)	12	20.00

Table 1: Sociodemographic Factors of Student Participants

4.2 Sociodemographic Factors of Staff Respondents

In table 2, of all the University of Benin staff sampled, 20 subjects each fell into the age grades of 35-44 and 45-55 years (33.33% each) and 19 of them were aged 55 and above (31.67%).

The BMI values calculated showed that more of the sampled staff were overweight (31, 51.67%) compared to the number of normal weighted (28, 46.67%) and underweight staff (1, 1.67%).

Table 2: Sociodemographic Factors of Staff Respondents

Variable	Number Reporting	Percentage (%)
SEX		
Male	30	50.00
Female	30	50.00
AGE (Yrs)		
<25	-	-
25-34	1	1.67
35-44	20	33.33
45-54	20	33.33
55+	19	31.67
BMI(Kg/M2)		
Overweight (25-29.9)	31	51.67
Normal weight (18.5-24.9)	28	46.67
Under weight (<18.5)	1	1.67

4.3 Blood Pressure Readings Based on Body Positioning

Table 3 displays the average blood pressure values of the University of Benin staff taken from 10 different body and arm positions.

The difference between the systolic blood pressure values derived from the 10 different arm and body positions used in this study was determined to be statistically significant (P-value <0.0001 each).

Table 3: Blood Pressure Readings Based on Body Positioning

POSITIONING	n	SYSTOLIC BP ± SD	DIASTOLIC BP ± SD
1. Sitting with feet flat on the floor, left arm at heart level and back support.	60	129.07 ± 15.24	83.35 ± 11.78
2. Sitting with feet flat on the floor, right arm at heart level and back support	60	130.66 ± 13.63	84.95 ± 10.65
3. Sitting with feet flat on the floor, left arm above heart level and back support	60	116.70 ± 14.61	70.71 ± 12.71
4. Sitting with feet flat on the floor, left arm below heart level and back support	60	129.75 ± 13.88	84.77 ± 11.84
5. Sitting with no back support, left arm at heart level and feet flat on the floor	60	127.10 ± 14.53	92.75 ± 11.79
6. Sitting with no back support, right arm at heart level and feet flat on the floor	60	128.82 ± 13.66	84.63 ± 11.60
7. Sitting with legs crossed, left arm at heart level and back support	60	130.89 ± 15.51	83.92 ± 11.25
8. Sitting with legs crossed, right arm at heart level and back support	60	131.94 ± 14.39	84.22 ± 11.53
9. Left arm at heart level, standing	60	127.36 ± 14.54	85.56 ± 11.34
10. Right arm at heart level, standing	60	133.42 ± 13.83	89.29 ± 11.09
P value		<0.0001	<0.0001

4.4 Validation of Digital Sphygmomanometer Readings Against Mercury Sphygmomanometer

Table 4 shows the comparison of the digital sphygmomanometer readings against that of the mercury sphygmomanometer. The difference between the digital sphygmomanometer readings against mercury sphygmomanometer was determined to not be statistically significant ($P>0.05$)

Table 4: Validation Of Digital Sphygmomanometer Readings Against Mercury Sphygmomanometer

	RIGHT ARM		LEFT ARM	
APPARATUS	**SYSTOLIC BP ± SD**	**DIASTOLIC BP ± SD**	**SYSTOLIC BP ± SD**	**DIASTOLIC BP ± SD**
MECURY	119.70 ± 12.10	77.38 ± 10.14	117.23 ± 11.78	77.30 ± 9.84
DIGITAL	117.41 ± 14.66	76.92 ± 9.82	112.69 ± 19.28	78.02 ± 17.12
P VALUE	0.3256	0.8012	0.1223	0.7781

4.5 Effect of Age and Body/Arm Position on Blood Pressure

Table 5 presents the Effect of age and body/arm positioning on blood pressure values. The p value of the mean systolic blood pressure taken in the 10 different positions of the staff aged 35-44 and 45-54 years was determined to not be significant (P >0.05).

Table 5: Effect of Age and Body/Arm Position on Blood Pressure

			BODY POSITIONING									
AGE(Years)		**n**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
35-44	Mean Systolic BP± SD	20	126.98 15.24	130.37 13.56	116.91 14.84	129.12 14.27	125.42 14.91	126.86 14.22	128.84 16.26	131.37 15.09	126.42 15.13	130.86 14.21
	Mean Diastolic BP ± SD		82.19 11.12	86.16 10.12	67.12 12.68	81.95 11.53	77.26 11.85	81.70 11.65	79.23 11.21	81.58 11.72	83.02 11.47	85.47 11.02
45-54	Mean Systolic BP ± SD	20	123.00 15.62	122.70 13.94	111.15 15.90	123.44 14.13	121.49 14.70	123.86 14.02	125.77 15.87	125.26 14.81	124.40 14.99	127.36 14.11
	Mean Diastolic BP ± SD		82.44 11.91	80.32 10.72	68.18 12.76	81.71 11.94	83.85 11.79	81.14 11.51	81.33 11.27	81.97 11.40	82.80 11.49	86.34 10.88
55+	Mean Systolic BP ± SD	19	131.69 15.13	134.67 13.66	117.46 14.13	131.16 14.00	129.44 14.33	131.37 13.30	133.25 15.46	134.47 14.49	130.47 15.12	137.00 13.64
	Mean Diastolic BP ± SD		87.33 11.76	86.84 10.75	73.56 11.28	87.02 11.66	84.68 11.30	87.32 10.92	87.40 10.89	85.86 10.69	87.72 10.93	92.32 10.47
P values	Systolic BP		0.2088	0.0257	0.3433	0.2104	0.2379	0.2203	0.2075	0.0264	0.2401	0.0968
	Diastolic BP		0.2948	0.1097	0.2135	0.2803	0.2704	0.2923	0.2707	0.2709	0.2004	0.1567

KEY**:** **1**; Sitting with feet flat on the floor, left arm at heart level and back support., **2**. Sitting with feet flat on the floor, right arm at heart level and back support., **3**. Sitting with feet flat on the floor, left arm above heart level and back support., **4**. Sitting with feet flat on the floor, left arm below heart level and back support, **5**. Sitting with no back support, left arm at heart level and feet flat on the floor, **6**. Sitting with no back support, right arm at heart level and feet flat on the floor, **7**. Sitting with legs crossed, left arm at heart level and back support, **8**.Sitting with legs crossed, right arm at heart level and back support, **9**. Left arm at heart level, standing, **10**. Right arm at heart level, standing

4.6 Effect of Age and Body/Arm Position on Blood Pressure

Table 6 displays the effect of sex and body/arm positioning on blood pressure values. The impact of gender/sex and each body position on the mean blood pressure values resulting therefore is statistically significant with P value < 0.05

Table 6: Effect of Sex and Body/Arm Position on Blood Pressure

			BODY/ARM POSITIONING									
SEX		**n**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Male	Mean Systolic BP± SD	30	135.01 12.92	134.91 11.99	121.49 13.50	135.28 11.47	130.96 12.56	132.54 12.93	135.93 14.08	136.62 13.70	131.82 10.63	137.77 11.13
	Mean Diastolic BP ± SD	30	89.30 10.09	87.95 10.02	72.75 13.27	88.15 11.06	84.24 11.63	87.18 11.72	86.61 10.86	87.07 12.14	88.36 10.40	91.70 11.14
Female	Mean Systolic BP ± SD	30	123.13 15.25	126.41 14.03	111.91 14.31	124.12 13.98	123.25 15.52	125.10 13.56	125.85 15.45	127.26 13.72	122.75 16.66	129.08 15.06
	Mean Diastolic BP ± SD	30	81.38 12.17	81.95 10.57	68.67 12.01	81.39 11.80	79.45 11.63	82.01 11.10	81.23 11.15	81.37 10.32	82.76 11.71	86.88 10.70
P-Value	Systolic BP		0.0019	0.0144	0.0099	0.0016	0.0140	0.0123	0.0021	0.0135	0.0026	0.0056
	Diastolic BP		0.0081	0.0278	0.2168	0.0076	0.1161	0.2100	0.2204	0.0267	0.0092	0.0307

KEY**:** **1**; Sitting with feet flat on the floor, left arm at heart level and back support., **2**. Sitting with feet flat on the floor, right arm at heart level and back support., **3**. Sitting with feet flat on the floor, left arm above heart level and back support., **4**. Sitting with feet flat on the floor, left arm below heart level and back support, **5**. Sitting with no back support, left arm at heart level and feet flat on the floor, **6**. Sitting with no back support, right arm at heart level and feet flat on the floor, **7**. Sitting with legs crossed, left arm at heart level and back support, **8**.Sitting with legs crossed, right arm at heart level and back support, **9**. Left arm at heart level, standing, **10**. Right arm at heart level, standing

4.7 Effect of Body Mass Index (BMI) and Body/Arm Position on Blood Pressure

Table 7 presents the mean systolic and diastolic blood pressure (± standard deviation) of participants categorized according to their body mass index (BMI) and arm and body positioning during measurement. The values are grouped into two BMI classifications: Overweight (25–29.9 kg/m²) and Normal weight (18.5–24.9 kg/m²) as only one of the sampled staff is underweight (<18.5kg/m²) and an average and standard deviation cannot be calculated for this category.

The difference in mean systolic blood pressure values for the 10 different body/arm positioning measured in the overweight staff is not statistically significant ($P > 0.05$)

			BODY /ARM POSITIONING									
BMI(Kg/M2)		**n**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Overweight (25-29.9)	Mean Systolic BP ± SD	31	130.34	130.59	118.87	130.68	127.08	128.76	131.17	132.85	127.97	134.22
			15.39	13.76	14.71	14.08	14.66	13.75	15.77	14.58	14.70	13.90
	Mean Diastolic BP ± SD		87.50	85.69	73.31	87.07	87.85	85.91	85.50	86.00	85.69	90.03
			11.71	10.67	12.75	11.85	11.90	11.74	11.40	11.61	11.39	11.13
Normal weight (18.5-24.9)	Mean Systolic BP ± SD	28	128.17	130.81	114.72	129.09	127.05	129.14	130.90	130.88	127.39	132.63
			15.48	13.82	14.96	14.00	14.60	13.90	11.30	11.38	11.38	14.00
	Mean Diastolic BP ± SD		83.33	84.50	68.26	82.67	81.04	83.65	82.50	82.69	85.80	88.89
			11.82	10.64	12.74	11.95	11.56	11.45	14.69	14.86	11.38	10.82
P Value	Systolic BP		0.5918	0.9514	0.2876	0.6657	0.9938	0.9164	0.9406	0.5682	0.8671	0.6636
	Diastolic BP		0.1792	0.6700	0.1372	0.1615	0.0301	0.4581	0.3821	0.3420	0.9706	0.6921

Table 7: Effect of BMI and Body/Arm Position on Blood Pressure

KEY**: 1**; Sitting with feet flat on the floor, left arm at heart level and back support., **2**. Sitting with feet flat on the floor, right arm at heart level and back support., **3**. Sitting with feet flat on the floor, left arm above heart level and back support., **4**. Sitting with feet flat on the floor, left arm below heart level and back support, **5**. Sitting with no back support, left arm at heart level and feet flat on the floor, **6**. Sitting with no back support, right arm at heart level and feet flat on the floor, **7**. Sitting with legs crossed, left arm at heart level and back support, **8**.Sitting with legs crossed, right arm at heart level and back support, **9**. Left arm at heart level, standing, **10**. Right arm at heart level, standing.

CHAPTER FIVE

DISCUSSION AND CONCLUSION

5.0 DISCUSSION

This study investigated the effects of body and arm positioning on blood pressure (BP) readings among 120 participants, comprising 60 staff and 60 final-year pharmacy students of the University of Benin. The purpose was to determine how different body and arm positions influence blood pressure and also to compare variations in blood pressure readings by age, sex and body mass index (BMI). The study findings clearly demonstrate that both systolic and diastolic blood pressure values vary significantly depending on posture and arm placement.

The study discovered that for the UNIVERSITY OF BENIN staff, the mean systolic and diastolic BP values obtained from ten different body and arm positions showed statistically significant differences ($p < 0.0001$). This indicates that variations in body/arm positions significantly alter blood pressure readings. These findings are consistent with those of Netea et al. (2003), who reported that both body and arm positions significantly influence blood pressure, with readings overestimated when the arm is below heart level and underestimated when it is above. Also, Pickering et al. (2005) noted that for every 10 cm difference in arm height relative to the right atrium, there is a corresponding 7–8 mmHg change in systolic pressure. The results of this study correspond with these earlier findings and hence reemphasizes the importance of maintaining standardized positioning during blood pressure measurement.

Among the student participants, the comparison between mercury and digital sphygmomanometers indicated no statistically significant difference in blood pressure readings ($p > 0.05$). This suggests that both instruments can provide reliable results if proper blood pressure measurement techniques are followed. This finding is significant to people who check their blood pressure at home using a standard digital blood pressure monitor and follow the recommended guidelines for correct posture as they can be assured of the veracity of the readings. This observation is consistent with that of Muntner et al. (2019), who stated that validated digital blood pressure monitors can produce readings comparable to the traditional mercury sphygmomanometer when used under standardized conditions. However, minor differences were observed between the right and left arm readings, which is in agreement with Adebayo et al. (2024), who reported that inter-arm systolic difference of 5 mmHg or less is considered normal. Such variations, though small, can become clinically important when used to diagnose or monitor hypertension, hence the need to consistently use the same arm during follow-up measurements.

The study also examined the influence of demographic factors such as age, sex, and BMI on blood pressure variation across positions. Age was found to significantly affect blood pressure changes with posture, particularly among participants aged 55 years and above, who showed more pronounced systolic and diastolic fluctuations across different positions. This may be attributed to reduced arterial compliance and increased vascular resistance in older adults, which cause slower adaptation of blood pressure to positional changes (Fagard & Pardaens, 2008). The finding underscores the importance of taking extra care when measuring blood pressure in older adults, as changes in body posture could easily lead to overestimation or underestimation of true blood pressure values.

In the findings of the effect of sex on blood pressure variation across positions sex, male participants (both adult and students alike) had consistently higher systolic and diastolic blood pressure values than females across most positions with an average of 10mmHg, with the differences being statistically significant ($p < 0.0001$). This observation corresponds with reports from Muntner et al. (2019) which attribute these differences to variations in cardiovascular physiology, hormonal regulation, and body composition. Males typically have higher cardiac output and peripheral resistance, which may explain the higher readings obtained. The results also support evidence that sex should be considered when interpreting blood pressure results, especially in clinical assessments involving posture.

The influence of body mass index (BMI) on blood pressure readings was also evident in this study. Overweight participants generally showed higher blood pressure values than those with normal BMI, irrespective of body/arm position. Irrespective of the fact that the variation across positions was less marked in the overweight group ($p = 0.0058$ for systolic BP), their overall mean BP was significantly elevated compared to normal-weight individuals. This agrees with Wan et al. (2021) and Tuncer & Khorshid (2023), who found that overweight individuals tend to have increased peripheral vascular resistance and sympathetic activity, which contribute to elevated blood pressure levels.

The study also found that positions involving unsupported back or crossed legs resulted in significantly higher BP values. These findings correspond with those of Pinar and Oğuz (2012), who explained that crossing the legs increases venous return and systemic vascular resistance, while an unsupported back leads to isometric contraction of trunk muscles, both of which transiently elevate BP. This has practical implications for home and community health settings, where patients often adopt non-standard postures during measurement. Even seemingly minor deviations such as resting the arm on the lap, talking, or sitting without back support can increase systolic or diastolic pressure by 5–10 mmHg, potentially leading to misclassification of normotensive individuals as hypertensive (Everyday Health, 2024; American Heart Association, 2018). The implication of this finding is that blood pressure should be taken in a suitable setup, and importantly, tables used to support the patients' arm should not be too high or too low for the patient to ensure that the patient's arm is at heart level.

The findings of this study therefore highlight once again the importance of standardization in blood pressure measurement. The seated position, with back support, feet flat on the floor, legs uncrossed, and the arm supported at heart level, consistently produced the most reliable and stable readings. This confirms the recommendations of the American Heart Association (AHA) and European Society of Cardiology (ESC), which have repeatedly emphasized that correct positioning is essential to ensure valid BP assessment (Muntner et al., 2019).

Incorrect postural techniques do not only distort readings but also have serious clinical consequences. For example, a misclassified hypertensive diagnosis can lead to unnecessary economic burden, pharmacologic treatment, and even anxiety while underestimation of BP may delay treatment in patients who truly need it.

The findings of this study further underscore the need for continuous education and retraining of healthcare workers on proper BP measurement procedures. Even among trained professionals, noncompliance with standard techniques remains widespread, as shown in studies by Parati et al. (2014). This study findings reiterate how simple errors in patient positioning can significantly affect blood pressure readings and its consequences.

Generally, this research reiterates that accurate blood pressure measurement is not just a standard operating procedure, but a clinical skill requiring accuracy and awareness of physiological and environmental factors. Body and arm positioning have a considerable impact on blood pressure values. Adherence to standardized measurement conditions is essential to ensure diagnostic accuracy, proper treatment decisions, improved cardiovascular health outcomes and quality of life of the patient.

5.1 CONCLUSION

In conclusion, this study reiterates that body and arm positioning have significant effects on blood pressure readings, regardless of sex, age, or BMI. Improper positioning such as unsupported back, crossed legs, or arm below heart level results in elevated readings that may lead to overestimation of blood pressure and potential misdiagnosis of hypertension. By demonstrating how specific postures affect BP measurement, this study contributes to improving clinical accuracy there by reducing diagnostic errors.

Healthcare professionals must be properly trained and reminded to maintain consistent positioning to reduce variability and enhance the reliability of BP readings.

On average, men have a higher blood pressure than women with a difference of about 10mmHg.

Digital sphygmomanometers can provide reliable results if proper blood pressure measurement techniques are followed.

5.2 RECOMMENDATIONS

Based on the findings of this study which align with standardized blood pressure measurement protocols, the following recommendations are given to guide clinical practice.

- Blood pressure should always be measured in a seated position, with the back supported, feet flat on the floor, and arm at heart level.
- Health workers and students in the medical field should receive regular retraining on proper BP measurement techniques.
- Patients should be trained on the correct posture and the import of correct posture during home BP monitoring.

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APPENDIX

POSITIONAL BLOOD PRESSURE READINGS FROM A SAMPLE OF VOLUNTEERS IN A NIGERIAN UNIVERSITY

SOCIODEMOGRAPHIC DATA

SEX; MALE [ ] FEMALE [ ]

AGE; <25 [ ] 25- 34 [ ] 35 -44 [ ] 45- 54 [ ] 55+[ ]

EDUCATIONAL LEVEL: NIL [ ] PRIMARY [ ] SECONDARY [ ] TERTIARY [ ]

OCCUPATION : GOVT WORKER [ ] SELF EMPLOYED [ ] STUDENT [ ] RETIRED [ ]

WEIGHT(Kg): .... HEIGHT(M) .... BMI(Kg/M²)...........

BODY/ ARM POSITION	MEAN DIGITAL SPHYGMOMANOMETER READING
SITTING WITH FEET FLAT ON THE FLOOR, LEFT ARM AT HEART LEVEL AND BACK SUPPORT.	
SITTING WITH FEET FLAT ON THE FLOOR, RIGHT ARM AT HEART LEVEL AND BACK SUPPORT.	
SITTING WITH FEET FLAT ON THE FLOOR, LEFT ARM ABOVE HEART LEVEL AND BACK SUPPORT.	
SITTING WITH FEET FLAT ON THE FLOOR, LEFT ARM BELOW HEART LEVEL AND BACK SUPPORT.	
SITTING WITH NO BACK SUPPORT, LEFT ARM AT HEART LEVEL AND FEET FLAT ON THE FLOOR	
SITTING WITH NO BACK SUPPORT, RIGHT ARM AT HEART LEVEL AND FEET FLAT ON THE FLOOR.	
SITTING WITH LEGS CROSSED, LEFT ARM AT HEART LEVEL AND BACK SUPPORT.	

SITTING WITH LEGS CROSSED, RIGHT ARM AT HEART LEVEL AND BACK SUPPORT.	
LEFT ARM AT HEART LEVEL, STANDING.	
RIGHT ARM AT HEART LEVEL, STANDING.	