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Association between Blood Pressure Dipping Patterns and Left Ventricular Hypertrophy among Apparently Healthy Normotensive Nigerians

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Abstract

Background
Abnormal blood pressure dipping pattern has been associated left ventricular hypertrophy among Africans with systemic hypertension. However, more studies are required to show whether abnormal blood pressure (BP) dipping patterns are associated with left ventricular hypertrophy (LVH) in healthy normotensive patients. This study determined the association between BP dipping patterns and left ventricular hypertrophy among normotensive Nigerians.
Methods
This was a cross-sectional study in which 120 normotensive individuals with no co-morbidities had ambulatory blood pressure monitoring (ABPM) and echocardiography. We defined extreme dippers, normal dippers, non-dippers and reverse dippers as nocturnal systolic BP decline of (≥ 20%), (10% to 19%), (0 to 9%) and (<0%) respectively.
Results
Fifty-four (45%) were males, the mean age and body mass index were 37.0 ± 10.1years and 24.0 ±4.2 kg/m2 respectively. Sixty-nine (57.5%) were non-dippers and 71 (59.2%) had LVH. Reverse dippers had the highest left ventricular mass index, it was not statistically significant. Binary logistic regression showed age as the only predictor of left ventricular hypertrophy (OR=1.055, 95% CI=1.004-1.109; p-value = 0.033).
Conclusions
A high prevalence of non-dipping pattern and left ventricular hypertrophy was found among apparently healthy Nigerian normotensives. Increasing age was the only predictor of LVH in our study population. Hence, ABPM and echocardiography are recommended to accurately assess cardiovascular risk in apparently healthy Nigerian normotensives.

Keywords: Dipping patterns, healthy, normotensive, echocardiography, left ventricular hypertrophy, Nigeria.

1. Introduction

In healthy adults, blood pressure (BP) follows a circadian pattern during a 24-hour period with increasing BP level during day-time and BP decline during the night-time[1].

Ambulatory BP monitoring (ABPM) can be used to assess the 24-hour blood pressure. Meta-analyses revealed that Africans experience higher levels of systolic and diastolic blood pressure, both at night and during the day[2]. Ohasama et al showed that even in the presence of normal 24-hour BP values, reduced nocturnal BP decline was associated with an increased risk of cardiovascular mortality[3]. Moreso, non-dipping of nocturnal BP seems to be a determinant of cardiac hypertrophy and remodelling, and may result in a cardiovascular risk independent of ambulatory BP levels in normotensives[4].

Furthermore, the level of the echocardiographic left ventricular mass is a stronger predictor of death or non-fatal events than arterial pressure[5], indicating that a normotensive individual with LVH may be at increased risk of cardiovascular death. Notably also, evidence showed that Africans have worsening left ventricular hypertrophy compared with Whites[6]. LVH can be adaptive and related to an increase in left ventricular pressure or volume load, or can be related to a primary myocardial disease including sarcomeric, inflammatory or infiltrative disorders. The prevalence of left ventricular hypertrophy increases with age, and its presence is a risk factor for cardiovascular events and death[7]. ABPM, as well as echocardiographically-determined LVH have promising roles in risk stratification and understanding heterogeneous mechanisms of cardiovascular disease[8].

Locally, there is a dearth of studies on blood pressure dipping patterns among healthy normotensives individuals, and its association with left ventricular hypertrophy. Hence, this study determined the association between blood pressure dipping patterns and left ventricular hypertrophy among healthy normotensive Nigerians.

2. Method

A cross-sectional study that consisted of 120 apparently healthy individuals with normal blood pressure without co-morbidities, aged 18 years and above were recruited using a convenient sampling strategy. Ethical approval was obtained from the Ethics and Research Committee of University of Ilorin Teaching Hospital (UITH) with approval protocol number ERC/2015/06/07. Informed written consent was taken from all the participants. Participants were recruited from among the member of Staff of the UITH between June 2014 to December 2014. The participants in this study were adults whose both systolic blood pressure (SBP) and diastolic blood pressure (DBP) were less than 140mmHg and 90mmHg respectively. Whereas, individuals who have systemic hypertension and other co-morbidities, pregnant women were excluded from the study. ABPM and echocardiography were carried out on all the study participants. Each patient had the office blood pressure (BP) measured by the auscultatory method in both arms using the mercury sphygmomanometer while relaxed and sitting down with both feet resting on the floor. The arm with the higher reading was taken as the patients' BP after an average of three readings. Systolic and diastolic BP were determined to the nearest 2 mmHg. This was followed by 24-hour ABPM using CONTEC according to the recommendations of the European Society of Hypertension practise guidelines for ambulatory blood pressure monitoring[9]. The procedure and handling of the ambulatory blood pressure monitor were explained to the subjects after which patients´ details were entered and the monitor initialized. The machine was programmed to read half-hourly from 7 a.m. to 10 p.m. and hourly from 10 p.m. to 7 a.m. An appropriate cuff size was chosen and this was applied immediately to the subject´s non-dominant bare arm. Subjects were discharged home to continue their normal activities and return after 24 hours for retrieval of the ABP monitor. They were advised to remain still during measurements and to abstain from smoking, alcohol and consumption of caffeinated drinks throughout the period of study.

We defined extreme dippers, normal dippers, non-dippers and reverse dippers as nocturnal systolic BP decline of (≥ 20%), (10% to 19%), (0 to 9%) and (<0%) respectively.

2.1 **Echocardiography***:* Two-dimensional transthoracic echocardiography was carried out by an experienced cardiologist (Sonos-2,000, Philips Medical Systems, Amsterdam, Netherlands) using standardized protocols[10]. Left ventricular dimensions including left ventricular internal diameter in diastole (mm), interventricular septal thickness in diastole (IVSd, mm), and posterior wall thickness in diastole (PWTd, mm), were assessed according to American Society of Echocardiography (ASE) recommendations[10].

Left ventricular mass index (LVMI) was calculated using the ASE – cubed formula[10].

LVMI(g/m) = 1.04 [(LVEDD + PWTD + IVSD)3] – (LVEDD)3] - 0.8 + 0.6 / BSA

LVH was defined as increased LVMI ≥96 g/m2 in women and ≥116 g/m2 in men) [11, 12].

Statistical Analysis: The data were analysed using the Statistical Package for Social Sciences version 23. Categorical variables were expressed as proportions and percentages while continuous variables were expressed as means with standard deviations (SD). Participants' characteristics were calculated for the overall sample and stratified into three dipping patterns (normal dipping, non-dipping, and reverse dipping). Using analysis of variance (ANOVA), the mean of the 3 categories of blood pressure dipping patterns groups was compared and post-hoc analysis was done with the Tukey test for multiple pair-wise comparisons to determine where the significance lies. Binary logistic regression was used to determine the predictors of LVH. For all tests, a p-value < 0.05 was considered statistically significant.

3. Result

The general characteristics of the study population are presented in table 1: A total of 120 normotensive participants completed the study, which included 54 (45%) male and 66 (55%) female patients. The mean age was 37.0 ± 10.1 years and mean body mass index (BMI) of 24.0 ± 4.2 kg/m². Among the study population, 71 (59.2%) had LVH.

Table 1: General Characteristics of the Study Population.

Variable	N=120 Mean ± SD
Gender	
Male, n (%)	54 (45)
Female, n (%)	66 (55)
LVH	
Yes, n (%)	71 (59.2)
No, n (%)	49 (40.8)
Age (years)	37.0 ± 10.1
Body Mass Index (Kg/m^2)	24.0 ± 4.2
Waist Circumference (cm)	82.7 ± 11.8
Waist-hip Ratio	0.86 ± 0.06
SBP (mmHg)	117.3 ± 11.7
DBP (mmHg)	72.5 ± 9.5
24-hour SBP (mmHg)	115.2 ± 8.8
24-hour DBP (mmHg)	68.1 ± 7.1
Daytime SBP (mmHg)	116.7 ± 3.3
Daytime DBP (mmHg)	69.7 ± 7.4
Night-time SBP (mmHg)	109.3 ± 9.8
Night-time DBP (mmHg)	62.1 ± 7.8
Left Atrial Dimension (cm)	3.33 ± 0.40
Left ventricular end diastolic diameter (cm)	4.6 ± 0.6
Left ventricular end systolic diameter (cm)	3.0 ± 0.5
Left ventricular mass (g)	204.6 ± 70.0
Left ventricular mass index (g/m^2)	116.4 ± 35.6
Relative Wall Thickness	0.43 ± 0.04
Ejection Fraction (%)	65.6 ± 7.7
Fractional shortening (%)	36.6 ± 6.3

(Keys: LVH – Left Ventricular Hypertrophy, SBP – Systolic Blood Pressure, DBP – Diastolic Blood Pressure).

Three (3) blood pressure dipping patterns were reported as no participant exhibited extreme BP dipping pattern. Dipping, non-dipping, and reverse dipping were reported in 34 (28.3%), 69 (57.5%), and 17 (14.2%) participants respectively, as shown in figure 1. The non-dipping pattern was the most prevalent of the circadian rhythm abnormalities.

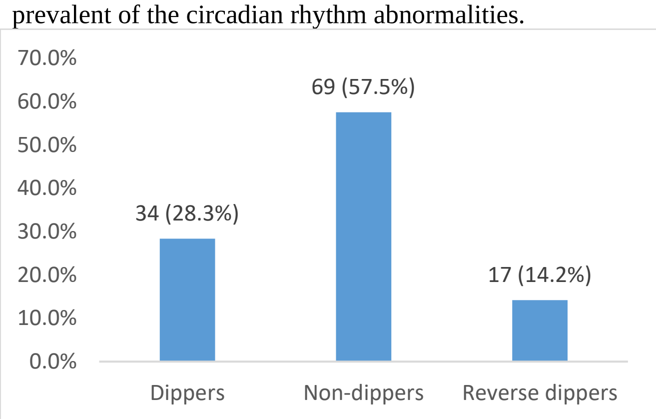

Figure 2: Blood pressure dipping patterns among the Study participants.

Clinical characteristics of the three BP dipping patterns are presented in table 2. The mean daytime SBP, and night-time SBP and DBP differ significantly among the three groups.

Table 2: Characteristics Stratified by Blood Pressure Dipping Patterns.

Variable	Dippers (n = 34) Mean ± SD	Non-Dippers (n=69) Mean ± SD	Reverse Dippers (n=17) Mean ± SD	p-value
Gender				0.186
Male, n (%)	13 (24.1)	30 (55.6)	11 (20.4)	
Female, n (%)	21 (31.8)	39 (59.1)	6 (9.1)	
LVH				0.934
Yes, n (%)	21 (29.6)	40 (56.3)	10 (14.1)	
No, n (%)	13 (26.5)	29 (59.2)	7 (14.3)	
Age (years)	36.9 ± 9.7	36.5 ± 9.9	38.9 ± 11.9	0.681
Body Mass Index (Kg/m^2)	23.8 ± 4.1	24.5 ± 4.3	22.6 ± 3.6	0.228
Waist Circumference (cm)	83.9 ± 11.3	81.9 ± 12.2	83.6 ± 11.5	0.698
Waist-hip Ratio	0.9 ± 0.1	0.9 ± 0.1	0.9 ± 0.0	0.582
SBP (mmHg)	121 ± 10.2	115 ± 11.5	116 ± 13.7	0.052
DBP (mmHg)	73 ± 10.1	72.3 ± 8.7	71.9 ± 11.9	0.919
24-hour SBP (mmHg)	116.6 ± 7.8	115.1 ± 8.3	112.7 ± 12.1	0.324
24-hour DBP (mmHg)	69.1 ± 6.6	67.9 ± 6.8	67.1 ± 9.4	0.587
Daytime SBP (mmHg)	120.0 ± 7.9	116.4 ± 8.5	111.4 ± 12.0	0.006*α
Daytime DBP (mmHg)	71.9 ± 6.7	69.2 ± 6.9	67.2 ± 9.3	0.071
Night-time SBP (mmHg)	103.8 ± 8.4	110.0 ± 8.2	117.6 ± 12.2	<0.001* β
Night-time DBP (mmHg)	58.1 ± 6.6	63.0 ± 6.9	66.5 ± 10.2	<0.001*β
Left Atrial Dimension (cm)	3.24 ± 0.4	3.39 ± 0.4	3.33 ± 0.6	0.242
LVEDD (cm)	4.6 ± 0.5	4.6 ± 0.5	4.8 ± 0.8	0.152
LVESD (cm)	3.0 ± 0.4	3.0 ± 0.5	3.1 ± 0.5	0.367
LVM (g)	197.7 ± 59.1	198.8 ± 56.5	242.1 ± 118.0	0.057
LVMI (g/ m^2)	113.1 ± 26.0	113.7 ± 32.6	134.1 ± 55.8	0.086
RWT	0.4 ± 0.0	0.4 ± 0.0	0.4 ± 0.0	0.529
Ejection Fraction (%)	65.1 ± 7.7	65.7 ± 7.3	65.9 ± 9.5	0.921
FS (%)	36.3 ± 6.4	36.6 ± 6.0	37.0 ± 6.3	0.933

(Keys: *- Statistically significant, LA - left atrium, LVEDD - left ventricular internal dimension in diastole, LVESD - left ventricular internal dimension in systole, FS - fractional shortening, EF - ejection fraction, LVM - left ventricular mass, LVMI - left ventricular mass index. Where the significance lies: α – normal dippers significantly greater than reverse dippers; β – reverse dippers significantly greater than non-dippers and dippers, ∞ - normal dippers significantly greater than non-dippers, - reverse dippers significantly greater than normal dipping patterns, LVH – Left Ventricular Hypertrophy, SBP – Systolic Blood Pressure, DBP – Diastolic Blood Pressure).

Table 3 demonstrated the characteristics stratified by the presence or absence of LVH. The age and body mass index of those with LVH were significantly higher than those without LVH.

Table 3: Characteristics stratified by the presence of Left Ventricular Hypertrophy.

Variable	LVH (n=71) Mean ± SD	NO LVH (n=49) Mean ± SD	p-value
Age (years)	38.8 ± 11.0	34.4 ± 8.0	0.018*
Body mass index (kg/m^2)	24.7 ± 4.5	23.1 ± 3.7	0.048*
Waist circumference (cm)	83.3 ± 12.2	81.8 ± 11.3	0.471
Waist-hip ratio	0.9 ± 0.1	0.9 ± 0.1	0.635
Office SBP (mmHg)	116.9 ± 12.4	117.7 ± 10.6	0.724
Office DBP (mmHg)	73.1 ± 9.8	71.6 ± 9.2	0.385
Ambulatory 24-hour SBP (mmHg)	115.3 ± 8.6	115.0 ± 9.2	0.877
Ambulatory 24-hour DBP (mmHg)	68.1 ± 7.3	68.2 ± 6.9	0.967
Ambulatory daytime SBP (mmHg)	116.8 ± 8.70	116.6 ± 10.1	0.917
Ambulatory daytime DBP (mmHg)	69.6 ± 7.3	69.8 ± 7.5	0.850
Ambulatory night-time SBP (mmHg)	109.5 ± 10.6	109.2 ± 8.6	0.880
Ambulatory night-time DBP (mmHg)	62.3±8.4	61.8±6.8	0.688

(Keys: SBP- systolic blood pressure, DBP -diastolic blood pressure, LVH- left ventricular hypertrophy, *-statistically significant).

Table 4 showed age as the only predictor of left ventricular hypertrophy in the study population (Odd ratio=1.055, 95% confidence interval =1.004-1.109, p-value=0.033). Every unit increase in age increased the likelihood of developing LVH by 5%.

Table 4: Predictor of left Ventricular hypertrophy in the Study Population.

Variables	OR	95% CI	p-value
Age (years)	1.055	1.004 - 1.109	0.033*
Waist circumference (cm)	0.955	0.893 - 1.021	0.955
Office SBP (mmHg)	0.969	0.928 – 1.012	0.156
Office DBP (mmHg)	1.015	0.966 – 1.067	0.556
Ambulatory day-time SBP (mmHg)	0.504	0.146 – 1.737	0.278
Ambulatory day-time DBP (mmHg)	0.861	0.301 – 2.459	0.780
Ambulatory night-time SBP (mmHg)	0.826	0.597 – 1.142	0.248
Ambulatory night-time DBP (mmHg)	0.963	0.723 - 1.284	0.799

(Keys: SBP, systolic blood pressure, DBP, diastolic blood pressure, OR, odd ratio; CI, confidence interval; *= statistically significant).

4. Discussion

In this study, there was a high prevalence of non-dipping pattern (57.5%) and left ventricular hypertrophy (59.2%) in apparently healthy normotensive individuals.. Secondly, even though the reverse dippers had the greatest left ventricular mass index, it was not statistically significant and there was no association between blood pressure dipping patterns and LVH. Lastly, increasing age was the only predictor of left ventricular hypertrophy.

Previous study has documented the high prevalence of non-dipping pattern (50%) even in the absence of nocturnal or daytime hypertension[13]. Africans have demonstrated less BP dipping compared with Caucasians[14]. Accounting for this racial differences are stress, social integration, poor social support, low socioeconomic status, sleep quality and quantity, apnoea, anger and personality types which may be present in our study participants[14]. For instance, the reverse dipping pattern has been associated with obstructive sleep apnoea, CV death than other dipping patterns[15]. Additionally, evidence showed that Africans have worsening left ventricular hypertrophy compared with Whites[6]. LVH can be adaptive and related to an increase in left ventricular pressure or volume load, or can be related to a primary myocardial disease including sarcomeric, inflammatory or infiltrative disorders. Also, our study revealed that those with LVH were older and had higher BMI than those without LVH, while increasing age was the only independent predictor of LVH. The prevalence of left ventricular hypertrophy increases with age, and its presence is a risk factor for cardiovascular events and death[7].

In summary, it can be assumed that apparently "healthy" populations may not always be truly healthy. Hence, the need for further cardiovascular risk assessment using ABPM and echocardiography. Therefore, abnormal diurnal BP variation could be a marker of some abnormalities in normotensive individuals. Notably, normotensive individuals with abnormal dipping patterns may have other pathological conditions of the autonomic nervous system and circulating volume, which may be associated with early target organ damage even in normotensives. The proposed underlying pathophysiologic mechanisms include factors such as abnormal neurohormonal regulation, lack of exercise, consumption of excess dietary sodium, and tobacco smoking have been implicated in the decline in nocturnal BP [16].

However, further prospective studies will be needed to evaluate the clinical implications of abnormal dipping pattern in normotensive Nigerians.

5. Conclusions

A high prevalence of non-dipping pattern and left ventricular hypertrophy was found among apparently healthy Nigerian normotensives. However, there was no association between the dipping patterns and LVH in our study. Increasing age was the only predictor of LVH in our study population. Hence, ABPM and echocardiography are recommended to accurately assess cardiovascular risk in apparently healthy Nigerian normotensives with advanced age.

Limitation

The data in this study are cross-sectional, hence causal inference is weak, but hypotheses generated from it can be tested in other parts of the country.

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DBF, OJA, OOD were involved in the conception and design of the study and data collection. DBF, OJA, OOD were involved in the collation, data analysis, data interpretation, and manuscript proofreading.

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