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BLOOD PRESSURE VARIATIONS ASSOCIATED WITH AGEING IN SUB-SAHARAN AFRICA

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Abstract:
Elderly persons who live in communities and appear to be in good health frequently experience postural hypotension, which is frequently asymptomatic. Uncertainty exists regarding the relationship between postural changes in blood pressure and numerical factors including age, gender, and body mass index. The goal of the current study is to identify the orthostatic blood pressure (OBP) changing patterns, symptoms, and related factors in various age groups. In this study, sixty participants ranging in age from 20 to 75 years old were used. To check for orthostatic hypotension in these groups, various blood pressure readings are taken in the lying and standing positions at intervals of one minute and three minutes. The findings demonstrated that in the elderly groups, symptoms of headache, blurred vision, dizziness, and lightheadedness were unrelated to orthostatic hypotension. These subjects' Body Mass Indexes were calculated based on their nutritional condition, and they were found to be 60% well-nourished, 6% under-nourished, and 34% overweight. The elderly person had systolic hypotension ($P<0.01$) more frequently than diastolic hypotension ($P>0.05$). In the senior group, standing hypotension was equally common in both sexes. BMI declines with aging in males as well, n=60. In all four groups, heart rate readings in the standing position were greater than the supine measurement. In the older population of Ndola which was the subject

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group of the study, 16.7% had OH. Age and the decline in diastolic blood pressure after three minutes of standing were positively correlated in all males. In all females, a positive link was seen between body mass index and a reduction in diastolic blood pressure after three minutes of standing. After 3 minutes of standing, all males showed a positive link between body mass index and a decrease in systolic blood pressure. Therefore, there is a link between body mass index and a drop in blood pressure readings when standing. On the basis of the current study, we draw the conclusion that orthostatic hypotension rises with age and that symptoms are unrelated to physical measurements.

Keywords: blood pressure, ageing, orthostatic hypotension, symptoms

1. Introduction

The systolic pressure, which the heart generates as it pumps blood through the arteries in a contracted condition, is recorded in the blood pressure reading instead of the diastolic pressure, which is the amount of pressure in the arteries when the heart is at rest in a dilated state (Freeman et al., 2011; Gibbons et al., 2017; Gupta & Lipsitz, 2007; Romero-Vecchione et al., 1993). Low blood pressure, often known as hypotension, is defined as a value of 90 or less systolic pressure or 60 or less diastolic pressure. This condition causes elation, dizziness, and fainting (Fu et al., 2009; Schatz et al., 1996; Low 2008; Richardson et al., 2009). The physical recording of orthostatic hypotension (OH) had no effect on the symptoms. Except for the autonomic reaction of an increase in heart rate upon standing, no significant changes in heart rate were observed with changes in body posture. Patients who are elderly and exhibiting any of the following signs require medical attention and treatment: tiredness, fainting, dizziness, inability to focus, blurred vision, and shallow breathing (Low, 2008). Age, a history of hypertension, and the use of antihypertensive medications were all linked to the altered orthostatic equilibrium (Fagard & De Cort, 2010).

1.1 Definition of Orthostatic Hypotension

Orthostatic hypotension is defined by the consensus committee of the American Autonomic Society and the American Academy of Neurology as a systolic blood pressure drop of at least 20 mm Hg or a diastolic blood pressure drop of at least 10 mm Hg within three minutes of standing up (Low, 2008). A measure of cardiovascular reactivity that reflects autonomic function is orthostatic blood pressure (OBP). The sympathetic nervous system often responds less quickly as we age due to physiologic changes (Gupta & Lipsitz, 2007). Romero-Vecchione et al. (1993) discovered an unusual pattern in the changes in sympathetic functions with aging, whereby they first increased from young to middle age and then began to drop as people aged.

1.2 Background

When a healthy person shifts from a supine to an upright position, there is a 700 mL increase in venous pooling in the lower extremities and splanchnic circulation, a decrease in venous return to the heart, a reduction in the ventricular filling, a temporary drop in cardiac output, and a rise in blood pressure (BP). This causes a baroreflex-mediated compensatory sympathetic activation and reduced parasympathetic activation, which raises the heart rate, vascular resistance, and venous return in an effort to boost cardiac output and blood pressure. OH eventually develops when one or more of these compensatory processes are impaired. Without these compensatory reflexes, patients with autonomic failure develop severe OH.

1.3 Pathophysiology of OH

Pure autonomic failure and multiple system atrophy are two examples of primary neurodegenerative autonomic diseases that can result in autonomic failure. These ailments are uncommon. Parkinson's disease and diabetes mellitus are the two conditions most frequently linked to peripheral autonomic nerve injury. A main autoimmune condition causing autoimmune autonomic failure or a paraneoplastic syndrome (small cell lung cancer, monoclonal gammopathies, light chain disease, or amyloid) needs to be checked out if a patient has a subacute onset of OH with rapid development. These ailments are all a part of the spectrum of OH-related autonomic neuropathies, commonly known as neurogenic OH (Xin et al., 2014; Fagard & De Cort, 2010). Elderly people who are fragile and have many diseases and polypharmacy are more likely to get OH, which has no clear etiology. The elderly are particularly vulnerable to developing OH because aging is linked to the degradation of a number of orthostasis-related compensatory mechanisms. Elderly people respond to changes in heart rate less quickly and with less baroreflex sensitivity (Xin et al., 2014).

Different definitions of orthostatic hypertension have been put forth over time. None are based on normative data or projected cardiovascular risks. Some definitions employed the exact difference in systolic and diastolic blood pressure between lying down or sitting and standing as the diagnostic standard. Others characterized orthostatic hypertension as the transition from normal blood pressure readings while lying flat to hypertensive blood pressure while standing. Obviously, the latter heavily depends on the definition of hypertension in use at the time. Recently, a panel of experts proposed two additional criteria for orthostatic hypertension: an absolute systolic blood pressure increase while standing of at least 20 mm Hg or greater than 140 mm Hg for people with normotension (Fedorowski et al., 2010). Diastolic blood pressure is a less reliable indicator of orthostatic hypertension because it typically rises by 5 to 10 mm Hg upon standing due to peripheral vasoconstriction and a decrease in cardiac stroke volume (Schroeder et al., 2002; Fedorowski et al., 2010; Ricci et al., 2015; Xin et al., 2014; Fagard & De Cort, 2010). Our knowledge of the dysregulations in standing blood pressure among diverse age groups has been considerably expanded by this research investigation. In the current study, we looked at how standing position affected systolic and diastolic blood pressure as well as heart rate. It was noted the blood hemoglobin % in various age groups. This greater understanding is essential since it significantly improves clinical care that is successful in geriatric settings.

2. Literature review

Numerous sizable prospective studies and meta-analyses have shown links between OH and harmful cardiovascular (CV) outcomes such as coronary artery disease, heart failure, atrial fibrillation, strokes, chronic renal disease, and venous thromboembolism in relation to the predictive function of OH. Additionally, compelling evidence, including recent meta-analyses, has revealed links with non-CV illnesses such as dementia, cognitive dysfunction, physical decline, falls, fractures, and late-life depression (Island, 2020; Richardson et al., 2009; Perlmuter & Greenberg, 1996). Most notably, substantial studies have shown that the presence of OH at baseline examination is an independent predictor of all-cause mortality, vascular death, and non-CV mortality, and subsequent meta-analyses have further supported this association. Younger people appear to have a stronger predictive role for OH, perhaps as a result of prolonged exposure to OH and lower burdens of comorbidities in these populations, which could mitigate the impact of OH (Rose et al., 2006; Crow et al., 2018). To explain the links between OH and unfavorable outcomes, some mechanisms have been put forth. Regular episodes of myocardial, cerebral, and renal ischemia brought on by orthostatic hypotension could result in long-term, irreparable damage to the heart, brain, and kidneys (Ricci, 2015b). Additionally, OH encourages elevated blood pressure variability and may be a factor in irregular dipping status (non-dipping or reverse dipping), which are risk factors for target organ damage and unfavorable CV outcomes (Xin et al., 2014; Fagard & De Cort, 2010). Orthostatic stress that is prolonged and repeated has the potential to raise RAAS activity and upregulate, which can lead to vasoconstriction, produce a prothrombotic state, hastening atherosclerosis, or compromise cardiac and renal function (Mancia et al., 2013; Grote et al., 2004). Similar to this, OH has been connected to increased endothelin and vasopressin activity, which results in vasoconstriction and may encourage atherothrombosis (Grote et al., 2004). However, OH is linked to a number of illnesses that have been identified as risk factors for worse prognosis in and of themselves, so even after statistical adjustments are made in the majority of OH studies, residual confounding cannot be completely ruled out. Furthermore, chronically heightened sympathetic activity, which has been linked to increased morbidity and mortality, may occur from autonomic dysfunction, which is frequently present in OH. Additionally connected to OH, arterial stiffness may play a role in mediating the link between OH and negative outcomes. Last but not least, OH may be a sign of frailty, deconditioning, and increasing disease burden, all of which worsen prognosis (Ricci et al., 2015a; Kanjwal et al., 2015; Shibao et al., 2013; Mattace-Raso et al., 2006). Since multiple relationships with unfavorable occurrences have been observed in significant observational studies, OH appears to have significant prognostic consequences.

However, without randomized data evaluating the effect of OH treatment on hard clinical outcomes, it is challenging to determine whether OH represents a marker of the severity of particular diseases or impaired overall health status, an intermediary variable mediating the action of actual causes, or a true risk factor that independently affects prognosis and could become a novel therapeutic target in the future (Kamaruzzaman et al., 2010). It was thought that the dysfunction of the sympathetic adrenergic system contributed to the inability of the lower limbs and visceral arteries to contract promptly upon a change in body posture in OH patients (Fu et al., 2009).

3. Methodology

3.1 Study site

The study was conducted at Ndola Town, located in Ndola district of Copperbelt province, Zambia. Ndola is the second largest community located in the Copperbelt province of Zambia and has a population of 503649 in Ndola District (Ndola District).

3.2 Study population

This study was a descriptive cross-sectional study. The study population consisted of men and women between the age of 20 to 75 years from Ndola community, seeking no or outpatient medical care service at local health centers. The participants were selected on a simple random sampling basis. The study protocol was approved by Tropical Diseases Research Center (TDRC), TDRC Ethics Review Committee 2021, Ndola, and National Health Research Authority 2021 (NHRA), Lusaka, Zambia.

3.3 Study design

This study was community-based cross-sectional. Descriptive and correlational analysis done in the ambulatory apparently healthy adult population. To assess the burden of disease - OH and the health needs of the population so as to be useful in informing the planning/ allocation of health resources. Although it is currently difficult to determine, orthostatic hypotension can influence clinical management choices such as the selection of antihypertensive meds, antidepressants, anti-anxiety medications, and psychiatric medications. As a result, this problem demands additional attention.

3.4 Selection of study groups

The subjects selected are a total of 120 in number with age group 20 to >65 years of both sex and they are categorized into four groups based on their age

- Group-I: Subjects of age 20-35 years, number = 30;
- Group-II: Subjects of age 36-50 years, number = 30;
- Group-III: Subjects of age 51-65 years, number = 30;
- Group-IV: subjects of age >65 years, number = 30.

3.5 Inclusion criteria

The study includes ambulatory healthy subjects, of mixed socioeconomic status.

3.5.1 Female subjects

The menstruating female subjects participated recruited during the mid- follicular phase of their menstrual cycle around day 8.

3.6 Exclusion criteria

Subjects with diabetes mellitus, hypertension, any other incapacitating condition, cardio-respiratory disorders, and other diseases, as well as those who smoke, drink excessively, are taking medicine, or are unable to stand, were excluded from the study. Those who may have mobility restrictions have had their orthostatic hypotension previously diagnosed, are undergoing treatment for mental health issues, have had limbs amputated, have Parkinson's or Alzheimer's disease, are deaf, are unable to read or write, or have altered mental states. Subjects who had ever used steroids, were currently taking pharmaceuticals or had ever used any other drugs that could have an impact on the autonomic nervous system were excluded (Kaufmann 1996; Low 2008). The physical examinations of the subjects included taking their height, weight, and body mass index measurements (BMI). BMI is computed using Quetelet's index, which divides weight in kilos by height in square meters (Garrow & Webster, 1985). On ambulatory participants who appeared healthy, an orthostatic test was performed. BMI and blood pressure readings were taken while lying down and again while standing. Both readings were taken at the same time. Before breakfast, the exam was conducted between 7:30 and 9:00 am. Evaluation of past medical histories, medication use, and smoking behaviors was done by questionnaires. During the first three minutes of standing, orthostatic hypotension is defined as a drop in systolic blood pressure of at least 20 mm Hg or a drop in diastolic blood pressure of at least 10 mm Hg (Ricci et al., 2015a; Kanjwal et al., 2015; Shibao et al., 2013).

3.7 Sample

Sample location: Ndola city, Copperbelt

Sample groups:

- Medical science students Year II & III at CBU - **Group I**
- School of Medicine campus staff at CBU and hillcrest colony residents **- Group II**
- Residential population and local company staff of Ndola - **Group III**
- Elderly residents/Old age home residential population of Ndola - **Group IV**

3.8 Data management

Data was collected from voluntary subjects during the period from 15 September 2021 to 10 September 2022. Information is gathered through a typical data-based study and entered into a database that is password-protected. All paper entrance forms are kept in a lockable cabinet during entry to prevent illegal access. After entry was finished, the data was checked against the paper forms to make sure it was accurate and complete. By using double entries and comparisons, data authentication is made sure. During the conversation, diligent data collection from key informant interviews was done. Before the debate came to an end, unclear material was written down on paper and highlighted for clarification. Demographic information was collected through surveys and numerical information was collected through blood pressure forms. The participants underwent physical examinations, which included height and weight measurements. Body mass index (BMI), also known as Quetelet's index, was determined by dividing weight (in kilograms) by height (in square meters).

3.9 Measurements

After five minutes of resting in the supine position with the right arm supported at heart level, reclining on the examination table with the elbow extended, blood pressure was measured in the right arm using a mercury sphygmomanometer and stethoscope. For analysis, the greater of the two comparable BP measurements was chosen. The subject was told to get up immediately, and the same examiner took the subject's blood pressure after 1 and 3 minutes of unsupported standing, respectively. The study subject's blood pressure was calculated as the average of two measurements of systolic blood pressure (SBP) and two measurements of diastolic blood pressure (DBP). When there was a difference between the two readings of more than 10 mm Hg, a third reading was taken, and the three data were averaged. Previous research has shown that within the first minute of standing, the majority of hemodynamic changes associated with the assumption of a standing posture occur (Akselrod S. et al., 1997; Elissa Wilker et al. 2009). Postural changes in SBP and DBP were calculated as mean lying minus standing for SBP (ΔSBP) and DBP (ΔDBP). A person's accurate blood pressure was measured while standing by supporting their hand at heart level and maintaining it extended (Adiyaman A. et al. 1999). By palpating the radial artery for one minute and calculating the pulse rate, the heart rate (HR) was determined.

3.10 Statistical analysis

All data are expressed as mean ± standard deviation. A two-tail probability value ($p<0.05$) is considered significant. Data analysed using Excel and SPSS version 20.

4. Results

The symptoms of headache, blurred vision, falling, and lightheadedness were independent of OH in all three groups shown in Table 1. Based on the nutritional status, Body Mass Index was measured in these subjects and identified as 60% well-nourished; 6% under-nourished, and 34% overweight. OH significantly increased in group 4, less prevalent in group 2, and in group 1 (Figure 5). Table 2 shows the mean BP values measured in different age groups. Systolic OH ($P<0.01$) was more common among the elderly subjects than diastolic OH ($P>0.05$). The heart rate in the supine position compared with the standing position for group 3 is illustrated in Figure 1. In females, BMI has decreasing trend with age, n=60. In males, BMI is decreasing with age as well, n=60. Heart rate was higher in standing position in all four groups. Based on our results, the following observations were noted:

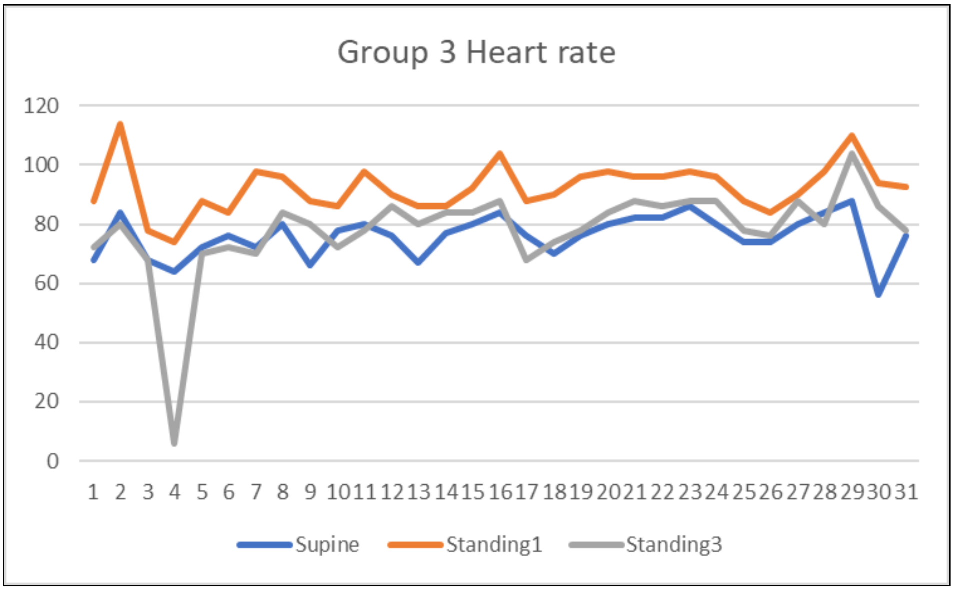

Figure 1: Heart rate in various postures

1) Only 5 out of the 30 elderly healthy subjects (Group 4) had OH and OH was observed in 2 subjects of Group 1 (Table 1).
2) Correlational analysis using Pearson coefficient: Positive correlation revealed between Age-to - fall in DBP3- among all males. A positive correlation was revealed between BMI-fall in DBP3- among all females. A positive correlation is observed between BMI-fall in SBP3- among all males.
3) No difference was noted between males and females in the t-test for a fall in SBP or DBP values.
4) Regression analysis for Group 1 indicates that SBP1 fall has no impact on SBP3 fall illustrated in Figure 2, SBP supine values have no impact on SBP1 fall, SBP supine has no effect on SBP3 fall, as a whole sample data analysis at P value 0.98. Similar results were noted in the other three groups.

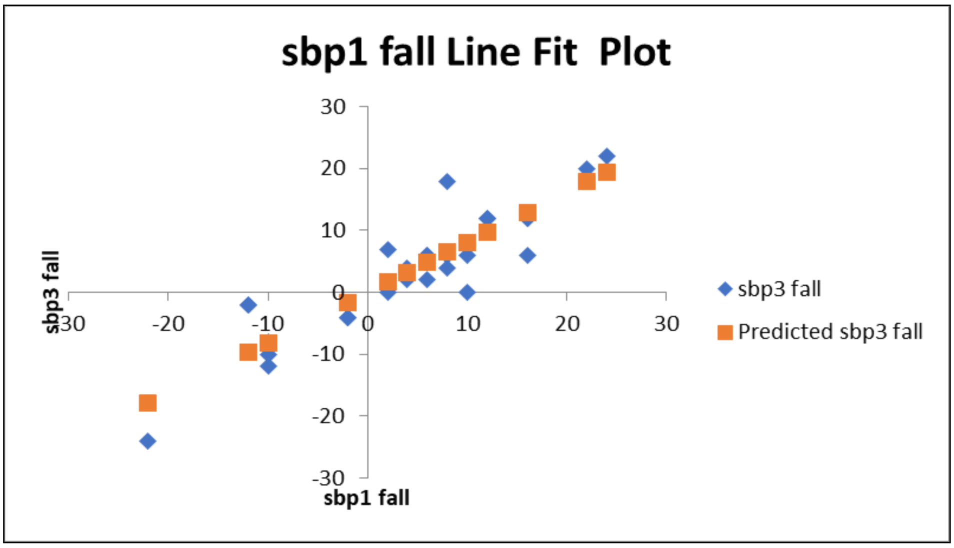

Figure 2: Regression analysis for Group 1

5) Figure 3 shows a normal probability plot for a fall in SBP3 values on standing for Group 1.

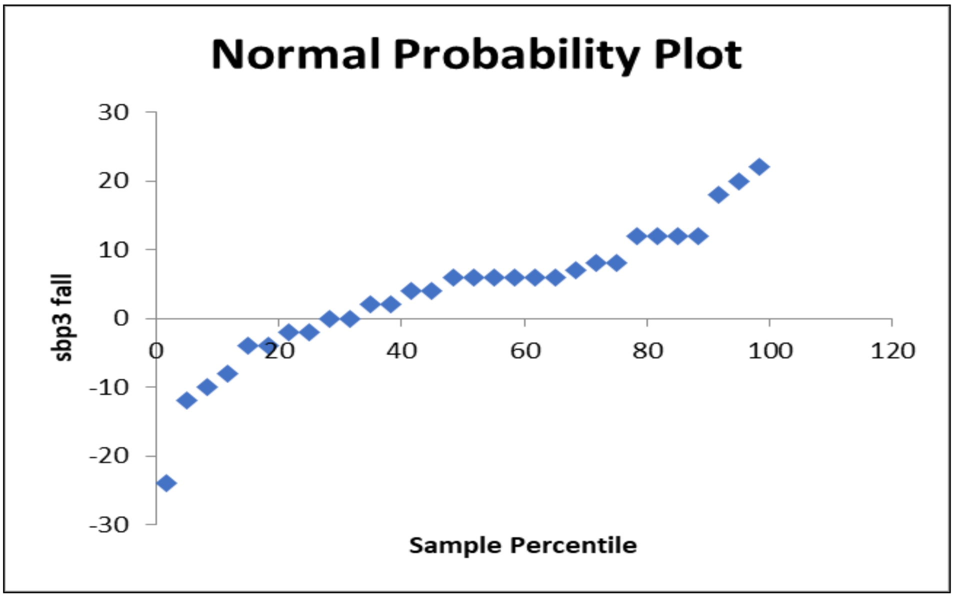

Figure 3: Probability plot for fall in SBP3 values on standing for Group 1

6) The mean systolic and mean diastolic blood pressures were higher in older subjects when compared to the younger subjects (Table 2).
7) Symptoms of OH like headache, blurred vision, falls and lightheadedness were independent of OH in Groups 1, 2, and 3 as shown in Table 1, Figure 4.

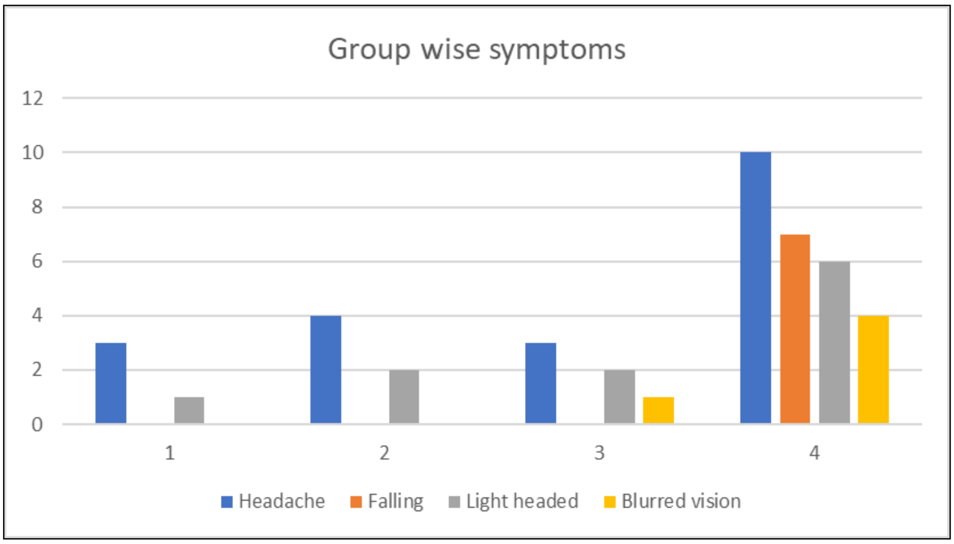

Figure 4: Symptoms of OH in various groups

8) Figure 5 depicts the recorded orthostatic hypotension in all four aged groups.

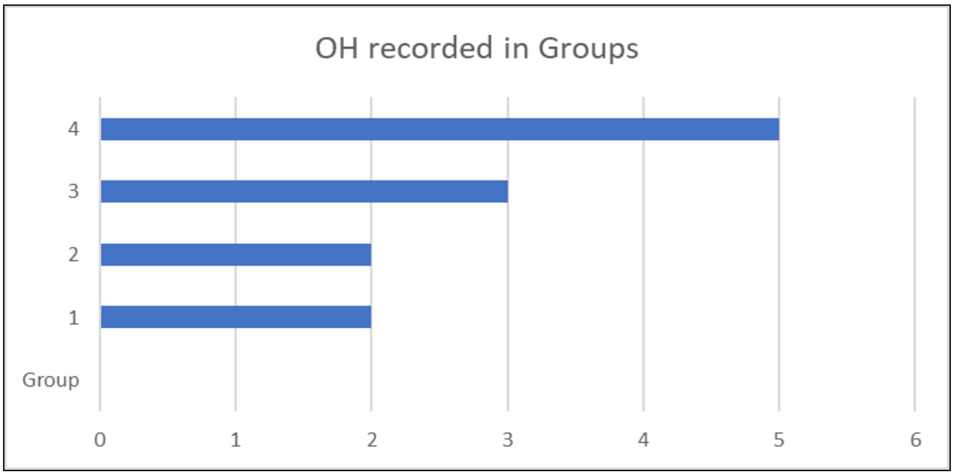

Figure 5: Orthostatic hypotension recorded in various groups

9) Heart rate variability was obvious during the comparison of supine with standing posture in all 4 groups. Figure 6 shows Group 4.

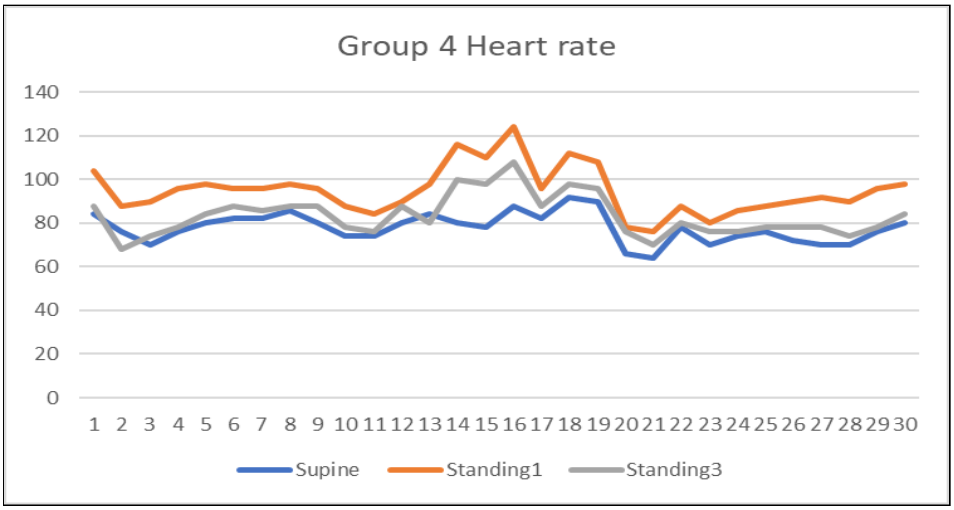

Figure 6: Heart rate variability for Group 4

10) Based on our results, OH incidence increases with an increase in age (Figure 5) and symptoms are independent of physical recording (Table 1).

Table 1: Group-wise clinical characteristics

		Symptoms					
Group	Number	Headache	Falling	Light headed	Blurred vision	OH Recorded	BMI mean
1	30	3	0	1	0	2	28.78
2	30	4	0	2	0	2	26.25
3	30	3	0	2	1	3	28.04
4	30	10	7	6	4	5	25.28

11) Systolic and diastolic blood pressure values were recorded in supine and standing postures, shown in Table 2.

Table 2: Group wise Blood Pressure in various postures

		Lying position		Standing position				
Groups	**Age mean ± SD**	**SBP mm**	**DBP mm**	**SBP at 1 min**	**DBP at 1 min**	**SBP at 3 min**	**DBP at 3 min**	**BMI mean ± SD**
1	21.933 ± 2.95	111.73 ± 9.30	77.8 ± 10.28	107.07 ± 5.06	73.93 ± 9.23	107.97 ± 6.07	74.8 ± 8.95	28.77 ± 6.20
2	41.8 ± 3.73	116.47 ± 6.98	78 ± 8.10	106.2 ± 10.03	73 ± 7.94	109.67 ± 10.10	76.27 ± 8.99	26.25 ± 5.65
3	56.1 ± 3.92	111.67 ± 8.84	78.33 ± 9.41	106.73 ± 6.42	74.6 ± 8.44	108.43 ± 6.44	75.8 ± 8.87	28.04 ± 6.32
4	69.47 ± 3.13	117.07 ± 7.50	79.53 ± 7.93	106 ± 7.86	73.2 ± 8.58	109.67 ± 9.07	77 ± 9.02	25.28 ± 4..70

12) Table 3 reveals One way ANOVA for diastolic blood pressure at 1 minute of standing for total sample using SPSS 20.

Table 3: One-way ANOVA for diastolic blood pressure at 1 minute of standing for total sample

ANOVA					
Diastolic					
	Sum of Squares	**Df**	**Mean Square**	**F**	**Sig.**
Between Groups	14.700	1	14.700	.203	.653
Within Groups	8529.267	118	72.282		
Total	8543.967	119			

13) Table 4 shows diastolic blood pressure at 1 minute standing for total sample using SPSS 20.

Table 4: Diastolic blood pressure at 1 minute standing for whole sample

Diastolic								
	N	**Mean**	**Std. Deviation**	**Std. Error**	**95% Confidence Interval for Mean**		**Minimum**	**Maximum**
					Lower Bound	**Upper Bound**		
Female	60	74.03	7.030	.908	72.22	75.85	60	84
Male	60	73.33	9.754	1.259	70.81	75.85	54	92
Total	120	73.68	8.473	.774	72.15	75.21	54	92

14) Table 5 shows the test of homogeneity of variance for diastolic blood pressure at 1 minute standing.

Table 5: Test of Homogeneity of Variances

Diastolic			
Levene Statistic	df1	df2	Sig.
10.025	1	118	.002

15) Table 6 shows the non-parametric Spearman's correlation coefficient for gender and diastolic blood pressure at 1 minute standing for the total sample population.

Table 6: Non-parametric Spearman's correlation coefficient for gender and diastolic blood pressure

Correlations				
			Gender of Participant	**Diastolic**
Spearman's rho	Gender of Participant	Correlation Coefficient	1.000	-.032
		Sig. (2-tailed)	.	.729
		N	120	120
	Diastolic	Correlation Coefficient	-.032	1.000
		Sig. (2-tailed)	.729	.
		N	120	120

4. Discussion

Orthostatic hypotension is a risk factor for cardiovascular diseases and all-cause of mortality (Luukinen H. et al., 1999; Shin C. et al., 2004). The prevalence of OH among elderly persons has significantly increased in developed countries during the past decade (Shin C. et al., 2004).

Gupta D. and Nair M.D. (2008) and Rutan G.H. et al. (1992) found that OH is a frequently encountered problem affecting about 30 % of the population more than 60 years. Luukinen H. et al. (1999) observed that systolic OH was associated with low BMI. An increase in BMI positively influenced BP among the studied adult population (Vuvor, 2017). A positive correlation was observed between BMI and a fall in SBP at 3 minutes of standing among all males in the present study. A positive correlation was observed between BMI and a fall in DBP at 3 minutes among all females. OH in elderly subjects was not associated with anti-hypertensive medication use (Ooi W.L. et al., 1997). But in the present study, OH was associated with anti-hypertensive medication use in group 3 (Low P.A., 2008). Orthostatic symptoms were independent of OH in all age groups. Past history of Hypertension and history of medications were the most common underlying conditions. Two subjects of Group 3 who were already suffering from hypertension showed a fall in SBP after 3 minutes of standing, but no difference was observed in 1 minute of standing (Weiss A. et al. 2002; Artur Fedorowski et al., 2010). Three middle-aged subjects of Group III who were on anti-hypertensive medications showed similar falls in SBP (Harris T. et al. 1991). An earlier study on the elderly showed medications such as antihypertensives and diuretics can cause or aggravate OH (Hajjar I., 2005). Two other elderly subjects showed a fall in DBP and had no history of hypertension. In neurological diseases such as diabetic neuropathy, the chance of OH is significantly increased by Parkinson's disease, multiple system atrophy, and autonomic neuropathies (Low P.A., 2008). Age, a history of hypertension, and the use of antihypertensive medications were all linked to the altered orthostatic equilibrium (Low P.A., 2008; Artur Fedorowski et al., 2010; Li et al., 2020). The participants in Group I did not have diabetes, hypertension, alcoholism, or smoking, and their average age was lower. Except for one male who claimed to have consistently low blood volume due to hypovolemia, none of the participants in this group had OH.

7. Conclusion

16.7% of the studied elderly population of Ndola residents had OH recorded. Symptoms were independent of OH physical recording. BMI was found to have a relation to a fall in BP values on standing. No significant changes were noted in heart rate with a change in body posture except the autonomic response of a rise in the rate of standing. Further research needs to be done to confirm these findings in a larger group of geriatric subjects to represent the local Zambian population. The results indicate that the underlying age-related disease process plays a major role in orthostatic hypotension in the elderly and middle-aged groups.

Conflict of Interest Statement
The authors declare no conflicts of interest.

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