DIURNAL BP VARIATIONS AMONG GENDER AND AGE GROUPS IN 1000 PATIENTS IN A CARDIAC FACILITY IN SOUTH-SOUTH NIGERIA

Abstract

Background Hypertension is a major risk for cardiovascular disease globally. Office blood pressure (OBP) is standard, but Ambulatory Blood Pressure Monitoring (ABPM) offers more comprehensive assessment, underutilized in southern Nigeria. Therefore, this study aims to systematically evaluate the blood pressure variables (BPV) using ABPM in a diverse group of people in south-south Nigeria.

Method Gender distribution and age categories were noted. ABPM variables, like average systolic and diastolic blood pressure, mean arterial pressure (MAP), and heart rate (HR), were measured during wake and sleep. Analysis identified gender and age-related ABPM differences.

Results There were more males than females (55% vs 45%). The study revealed significant differences in blood pressure measurements between genders and age group during wake and sleep periods. During wake, males had higher systolic and diastolic BP. The mean systolic blood pressure was 135.3 mmHg ± 14.3 and 131.4 mmHg ± 14.5 for males and females, respectively (p value = 0.000). During sleep, females exhibited lower diastolic blood pressure compared to males (73.5 mmHg ± 10.4 vs. 75.996 mmHg ± 10.9) (p value = 0.002). Age-related variations were observed, with older individuals (>60 years) showing higher average systolic BP compared to other age groups during wake (135.1 ±15.8) and sleep (129.4 ±18.01) periods (p = 0.0083, p = 0.0001, respectively).

Conclusion This study contributes to our understanding of the evolving trends in day and night ABPM variables among patients in South-South Nigeria. The findings show the importance of comprehensive cardiovascular assessments to accurately evaluate and manage cardiovascular health in diverse patient populations.

INTRODUCTION

Hypertension (HTN) is a prominent risk factor for cardiovascular disease (CVD) worldwide.(1,2) Low- and middle-income countries (LMICs), such as Nigeria, seem to bear a huge burden, with a higher prevalence of cases and limited awareness, treatment, and control rates compared to developed nations.(3–5)

According to the World Health Organization (WHO), an estimated 1.28 billion adults aged 30–79 years worldwide have HTN, two-thirds living in LMICs.(6) The collective estimated prevalence of hypertension in Africa stands at approximately 30.8%. As urbanization, unhealthy lifestyles increases, malnutrition and sedentary behavior, become more prevalent, it is anticipated that high blood pressure will continue to increase.(7) In Nigeria, HTN ranks as the most prevalent diagnosed CVD risk equivalent,(8) with HTN-related complications responsible for approximately a quarter of emergency hospital admissions in urban areas.(9) Previous research has indicated that one in four adult Nigerian suffers from hypertension.(10) While office blood pressure (BP) measurement continues to be the global standard in evaluating BP, it provides restricted information on the inherent biological rhythms associated with the disease process.(11–13)

Ambulatory Blood Pressure Monitoring (ABPM) provides a comprehensive and accurate assessment of blood pressure compared to Office Blood Pressure measurements (OBPM).(14) Different blood pressure patterns have been established and the diagnosis of hypertension has been made more reliably since the introduction of ABPM to medicine approximately thirty years ago.(15) This has improved the care of patients with hypertension and decreased cardiovascular morbidity and death from the condition. ABPM has the ability to obtain numerous measurements in a non-clinical environment.(16) Consequently, the National Institute for Health and Care Excellence (NICE), UK has endorsed the use of ABPM as standard clinical practice, a recommendation recently echoed by the Eighth Joint National Committee on Prevention, Detection , Evaluation and Treatment (JNC 8) (17) and European Society of cardiology (ESC).(13)

BP variability (BPV) has emerged as a significant risk factor for cardiovascular disease.(18,19) Blood pressure fluctuates throughout a 24-hour cycle, peaking during daytime and dipping at night, observed in individuals with both normal and elevated blood pressure levels.(11) Comprehending diurnal blood pressure (BP) variations is important for management of hypertension because these differences are commonly observed in many individuals with hypertension.(20)

While ABPM is recognized for its utility in assessing blood pressure fluctuations, especially in hypertensive patients, studies in this geographic context are scarce. This study therefore aims to systematically evaluate the blood pressure variables in a diverse groups of people according to gender and age groups in southern Nigeria.

MATERIALS AND METHODS

Study Design

A retrospective analysis was conducted to investigate the day and night ABPM variables of 1000 individuals attending a cardiac center in Southern Nigeria.

Study Site

The study was conducted at Goodheart Medical Consultants Hospital Port Harcourt, Rivers State, Nigeria.

Procedure

Data from 1000 participants with complete ambulatory blood pressure monitoring (ABPM) result were retrieved from the electronic health records (EHRs) of Goodheart Medical Consultants Hospital. Participants were stratified into age categories (<18years, 18-39 years, 40-59 years and ≥60 years).

Height was measured without shoes to the nearest centimeter. Weight was measured to the nearest 0.1 kg with a scale while participants wore light clothing.

A 24-hour ABPM was conducted using the ASPEL ABPM machine on the non-dominant arm. The cuff size was determined by the circumference of the non-dominant arm. Measurements were taken every 20mins during the day from 6 a.m. to 10 p.m. and every 30mins at night from 10 p.m. to 6 a.m. Participants were advised to engage in routine activities, avoid vigorous physical activity, and remain still during measurements.

Data Analysis

Data were analyzed using STATA, Version 15.0. t-test and analysis of variance (ANOVA) were used for comparing variables**.** Significance level was set at $P \leq 0.05$ (two-sided).

RESULT

TABLE 1: DEMOGRAPHIC CHARACTERISTICS OF PARTICIPANTS.

Variables	**Counts (%)**
Gender	
Male	550 (55%)
Female	450 (45%)
Total	1000 (100%)
Age	
<18	6 (0.6%)
18-39	112 (12.2)
40-59	460 (46.0)
>60	412 (41.20)
Mean Age	55.21 ±14.6
Total	1000 (100)

A total of 1000 individuals were included in this study, with 550 (55%) male and 450 (45%) female. Majority of participants fell into the 40-59 age range (460 individuals, 46.0%), followed by those over 60 years old (412 individuals, 41.20%). A smaller proportion of participants were aged 18-39 (112 individuals, 12.2%), and only 6 individuals (0.6%) were under 18 years old. The mean age of the participants was 55.21 years with a standard deviation of ±14.6.

TABLE 2: BLOOD PRESSURE MEASUREMENTS DURING WAKE PERIOD ACCORDING TO GENDER (MEAN±SD)

VARIABLES	MALE	FEMALE	P VALUE
AVG SYSTOLIC	135.3±14.3	131.4±14.5	0.0000*
AVG DIASTOLIC	83.2±11.4	80.85±33.9	0.1276
AVG MAP	101.04±12.7	97.58±12.01	0.0000*
AVG HR	76.11±11.3	76.99±10.8	0.2092
MIN SYSTOLIC	104.4±17.7	96.78±18.5	0.0000*
MIN DIASTOLIC	58.2±12.8	52.998±12.4	0.0000*
MIN MAP	75.2±13.2	69.5±13.7	0.0000*
MIN HR	58.1±10.5	58.5±10.9	0.5260
MAX SYSTOLIC	172.3±25.98	170.98±69.03	0.6865
MAX DIASTOLIC	121.7±29.7	119.3±30.3	0.2121
MAX MAP	138.98±26.4	136.2±27.9	0.1081
MAX HR	116.001±34.7	121.1±69.5	0.1362

Table 2 presents blood pressure measurements during the wake period (6am – 10pm) categorized by gender. Among males, the mean systolic blood pressure was 135.3 mmHg ± 14.3, while females had a slightly lower mean systolic blood pressure of 131.4 mmHg ± 14.5. Similarly, males had higher mean values for average mean arterial pressure (MAP) compared to females (101.04 mmHg ± 12.7 vs. 97.58 mmHg ± 12.01) and minimum systolic blood pressure (104.4 mmHg ± 17.7 vs. 96.78 mmHg ± 18.5). However, there were no significant differences in average diastolic blood pressure, average heart rate, minimum diastolic blood pressure, minimum heart rate, maximum systolic blood pressure, maximum diastolic blood pressure, maximum MAP, and maximum heart rate between males and females.

TABLE 3: BLOOD PRESSURE MEASUREMENTS DURING SLEEP PERIOD ACCORDING TO GENDER (MEAN±SD)

VARIABLES	MALE	FEMALE	P VALUE
AVG SYSTOLIC	127.51±16.5	125.9±15.9	0.1112
AVG DIASTOLIC	75.996±10.9	73.5±10.4	0.0002*
AVG MAP	93.54±13.7	92.01±13.2	0.0754
AVG HR	67.94±10.8	69.8±11.2	0.0070*
MIN SYSTOLIC	108.5±17.7	133.3±22.4	0.3118
MIN DIASTOLIC	60.65±11.2	58.8±10.6	0.0076*
MIN MAP	77.8±12.01	78.04±12.14	0.9068
MIN HR	58.9±10.3	60.78±11.7	0.0064*
MAX SYSTOLIC	147.5±20.8	147.17±21.8	0.8115
MAX DIASTOLIC	95.2±19.5	92.198±20.2	0.0160
MAX MAP	113.3±20.2	112.4±21.3	0.4903
MAX HR	84.6±19.99	86.8±20.4	0.0801

Table 3 displays blood pressure measurements during the sleep period (10pm – 6am) categorized by gender. While there were no significant differences in average systolic blood pressure, average MAP, and maximum systolic blood pressure between males and females, several significant differences were observed in other parameters. Females exhibited lower average diastolic blood pressure compared to males (73.5 mmHg ± 10.4 vs. 75.996 mmHg ± 10.9) and higher average heart rate (69.8 bpm ± 11.2 vs. 67.94 bpm ± 10.8). Additionally, females had lower minimum diastolic blood pressure (58.8 mmHg ± 10.6 vs. 60.65 mmHg ± 11.2) and higher minimum heart rate (60.78 bpm ± 11.7 vs. 58.9 bpm ± 10.3) compared to males. Furthermore, significant differences were observed in maximum diastolic blood pressure between males and females (92.198 mmHg ± 20.2 vs. 95.2 mmHg ± 19.5).

TABLE 4: BLOOD PRESSURE MEASUREMENTS DURING WAKE PERIOD ACCORDING TO AGE GROUP (MEAN±SD)

VARIABLES	<18	18-39	40-59	>60	P VALUE
AVG SYSTOLIC	132.8±8.1	130.3±13.9	132.99±13.4	135.1±15.8	0.0083*
AVG DIASTOLIC	74.3±6.4	81.2±10.1	83.4±10.7	81.2±35.7	0.4472
AVG MAP	95±7.5	97.7±11.5	100.1±11.7	99.4±13.5	0.2200
AVG HR	80.5±8.9	78.7±8.3	77.8±10.2	74.4±12.3	0.0000*
MIN SYSTOLIC	110.3±11.6	100.4±17.7	101.2±18.4	100.8±18.9	0.6334
MIN DIASTOLIC	48±17.6	54.5±11.96	57.5±13.5	54.6±12.2	0.0015*
MIN MAP	67.3±22.99	71.2±12.5	73.8±13.9	71.9±13.7	0.0800
MIN HR	61.2±8.82	58.5±8.97	58.9±10.2	57.6±11.6	0.0000*
MAX SYSTOLIC	164.3±11.1	164.6±28.5	172.9±25.0	172.5±25.4	0.4039
MAX DIASTOLIC	123.2±21.5	121.2±32.1	122.5±30.1	118.3±29.3	0.2188
MAX MAP	136±19.04	136.4±29.1	137.7±27.3	138.2±26.6	0.9352
MAX HR	122.8±18.9	122±35.2	121.1±34.9	113.99±31.9	0.2071

Table 4 provides insights into blood pressure measurements during the wake period according to age groups. Significant differences were observed in some parameters. Participants over 60 years old had elevated average systolic blood pressure compared to other age groups (p = 0.0083). Participants under 18 years old had elevated average heart rate and lower minimum diastolic blood pressure compared to other age groups (p = 0.0000, p = 0.0015, respectively). No significant differences were found in other parameters across age groups.

TABLE 5: BLOOD PRESSURE MEASUREMENTS DURING SLEEP PERIOD ACCORDING TO AGE GROUP (MEAN±SD)

VARIABLES	<18	18-39	40-59	>60	P VALUE
AVG SYSTOLIC	125 ±7.9	122.9±16.4	125.5±14.1	129.4±18.01	0.0001*
AVG DIASTOLIC	67.3 ±7.1	72.7±10.7	76.1±10.1	74.3±11.3	0.0016*
AVG MAP	87.5 ±7.9	897.3±11.8	92.3±13.2	94.6±14.04	0.0007*
AVG HR	73.8±11.3	68.8±8.9	69.4±10.4	68.1±12.19	0.2193
MIN SYSTOLIC	105.8±9.6	104.7±16.1	132.8±16.1	109.6±18.4	0.8016
MIN DIASTOLIC	52±6.7	58.5±11.003	61.1±10.5	58.8±11.3	0.0021*
MIN MAP	73.2±5.6	72.2±12.1	77.2±11.2	77.5±13.005	0.4687
MIN HR	61.2±11.2	58.3±9.4	60.6±10.7	59.1±11.7	0.0930
MAX SYSTOLIC	140.5±10.7	139.9±20.03	145.6±19.5	151.6±22.7	0.0000*
MAX DIASTOLIC	86.3±8.9	90.7±20.7	94.7±19.1	94.02±20.5	0.2011
MAX MAP	105.8±9.8	107.2±19.6	112.2±19.4	115.4±22.1	0.0009*
MAX HR	96.2±10.9	85.6±15.2	86.9±20.9	84.1±20.7	0.1162

Table 5 presents blood pressure measurements during the sleep period across different age groups. Participants under 18 years old displayed lower average systolic and diastolic blood pressure compared to older age groups (p = 0.0001, p = 0.0016, respectively). Additionally, individuals in this age group had lower minimum diastolic blood pressure (p = 0.0021) and maximum systolic blood pressure (p = 0.0000) compared to other age groups. Notably, significant differences were also found in average mean arterial pressure (p = 0.0007) and maximum mean arterial pressure (p = 0.0009), with younger participants exhibiting lower values.

DISCUSSION

This study comprehensively evaluates the ABPM variables among young (<18), young adult (18-39), middle age (40-59) and old (≥60) in south-south Nigeria.

The gender distribution in table 1 indicates that out of 1000 participants, 55% of the participants were males, while 45% were females, reflecting a slight male predominance in the study cohort. This gender distribution aligns with epidemiological trends suggesting that cardiovascular diseases often exhibit a higher prevalence in males compared to females.(21) However, it is essential to note that the gender ratio may also be influenced by various factors, including healthcare-seeking behavior and referral patterns. Regarding age distribution, most participants belonged to the 40-59 age group, comprising 46.0% of the total population, followed closely by individuals 60 years old and above, accounting for 41.20%. Notably, only a small proportion of participants were under 18 years old (0.6%), highlighting the predominance of adults in the study population. The mean age of the participants was 55.21 years ±14.6, indicating that most individuals undergoing cardiovascular assessment at the cardiac center were middle-aged or older.

The findings reveal significant differences in various blood pressure parameters between male and female patients (Table 2). Specifically, male patients exhibited significant higher average systolic blood pressure compared to females. Male patients also had significant higher minimum systolic blood pressure compared to females and a significant higher minimum diastolic blood pressure compared to females. These findings are similar to a study conducted in the middle east where there was a significant gender difference in both systolic and diastolic BP with the male being higher.(22) In men, androgens and testosterone have been proven to be the cause of higher blood pressure than in women, also female hormones (estrogen) may help shield women from having higher blood pressure as women's menopause is associated with elevated blood pressure.(23,24) In general, men are more susceptible to cardiovascular and renal diseases than are premenopausal women of same age. Recent research utilizing the 24-hour ambulatory blood pressure monitoring technique has demonstrated that men's blood pressure is greater than women's at identical ages.(23)

Additionally, the study found significant differences in average mean arterial pressure (MAP) between males and females, and a significant higher minimum MAP in males compared to females. This discrepancy in MAP indicates variations in overall arterial pressure regulation between genders, potentially influencing cardiovascular health outcomes. The difference in MAP probably signifies hormonal differences between males and females which affects blood pressure regulation. In an experimental study, it was discovered that estrogens has various effects on the renin-angiotensin system (RAS).(25) They decrease the activity of angiotensin-converting enzyme (ACE), leading to a reduction in the production of angiotensin II (Ang II), while simultaneously promoting the synthesis of ACE. ACE is primarily responsible for generating the vasodilatory peptide Ang (1-7).(25) Both actions contribute to lowering blood pressure, making them anti-hypertensive.

There were significant differences in average diastolic blood pressure between males and females during sleep (Table 3). It also highlights gender-specific variations in minimum diastolic blood pressure and minimum heart rate during sleep. Male patients demonstrated significant higher minimum diastolic blood pressure compared to females during sleep. This suggests that females tend to have lower diastolic blood pressure during sleep compared to males, which may have implications for cardiovascular risk assessment and management.(26) Significant differences were observed in average heart rate between males and females. Females exhibit higher minimum heart rate compared to males. This discrepancy in heart rate during sleep may reflect underlying physiological differences between genders. For instance, hormonal fluctuations, such as those related to the menstrual cycle in females, can influence heart rate during sleep. Research suggests that heart rate variability (HRV) can vary throughout the menstrual cycle. Higher levels of estrogen during the follicular phase are associated with increased HRV, whereas during the luteal phase, marked by elevated progesterone levels, HRV may decline.(27)

Table 4 reveals several important findings regarding blood pressure metrics across age groups. Firstly, there is a noticeable trend of increasing average systolic blood pressure with advancing age. Patients in the older age group (>60) exhibited the highest average systolic blood pressure of 135.1 ±15.8 which is consistent with another study(28) which found people above 60 years to have higher average systolic BP than people of lower age group, however the mean in this study is higher than theirs. Individuals under 18 years old demonstrate the lowest average systolic blood pressure. This age-related increase in systolic blood pressure aligns with well-established trends in cardiovascular aging (29,30) and emphasizes on the importance of blood pressure management in older individuals. Average diastolic blood pressure tends to increase with age, with the highest values observed in the 40-59 age group and the lowest in the <18 age group. This age-related elevation in diastolic blood pressure reflects changes in vascular function and arterial stiffness associated with aging.(31)

Significant variations were noted in average heart rate across age groups. Older individuals (>60) exhibit the lowest average heart rate, while the youngest age group (<18) demonstrates the highest average heart rate. This inverse relationship between age and heart rate is consistent with the physiological changes in cardiac function and autonomic regulation that occur with aging such as decreased sympathetic activity. Aging is typically accompanied by a decline in sympathetic nervous system activity (32), which regulates heart rate.

Table 5 presents insights into how blood pressure parameters vary across different age cohorts during the nocturnal period. One of the key observations from the table is the variation in average blood pressure values across age groups during sleep. The results indicated that older individuals (>60) tend to have higher average systolic blood pressure compared to younger age groups. This finding aligns with a study highlighting age-related changes in nocturnal blood pressure regulation, including increased systolic blood pressure dipping among older individuals.(33)

Furthermore, the table highlights differences in diastolic blood pressure across age cohorts during sleep. While the 40-59 age group exhibited the highest average diastolic blood pressure, the youngest age group (<18) demonstrates the lowest average diastolic blood pressure. This age-related variation in diastolic blood pressure underscores the importance of considering age-specific factors in the assessment and management of nocturnal blood pressure patterns.

CONCLUSION

The study findings present significant insights into blood pressure dynamics during wake and sleep periods, shedding light on critical aspects of cardiovascular health. Firstly, gender-specific disparities in blood pressure measurements during wake and sleep periods suggest the influence of gender-specific physiological mechanisms on blood pressure regulation. This emphasizes the necessity for customized approaches to cardiovascular risk evaluation and treatment. Secondly, the investigation of blood pressure trends across age categories reveals age-related variations in nocturnal blood pressure patterns. Notably, older individuals (>60 years) exhibit elevated average systolic blood pressure during sleep compared to younger individuals, emphasizing the importance of age-tailored strategies in assessing cardiovascular risk and implementing interventions.

The analysis of blood pressure metrics during wake periods according to age cohorts exposes significant discrepancies in blood pressure parameters among different age groups. These findings underline the importance of individualized blood pressure management strategies that account for age-specific risk factors and physiological changes.

Moving forward, continued research endeavors in ABPM would help in unraveling the underlying mechanisms driving fluctuations in day and night ABPM variables across different age groups and genders. Such endeavors will aid in the development of targeted interventions aimed at enhancing cardiovascular outcomes in this demographic.

REFERENCE

1. Forouzanfar MH, Liu P, Roth GA, Ng M, Biryukov S, Marczak L, et al. Global Burden of Hypertension and Systolic Blood Pressure of at Least 110 to 115 mm Hg, 1990-2015. JAMA. 2017 Jan 10;317(2):165.

2. Mills KT, Stefanescu A, He J. The global epidemiology of hypertension. Nat Rev Nephrol. 2020 Apr;16(4):223–37.

3. Vijver S van de, Akinyi H, Oti S, Olajide A, Agyemang C, Aboderin I, et al. Status report on hypertension in Africa - Consultative review for the 6th Session of the African Union Conference of Ministers of Health on NCD's. Pan Afr Med J [Internet]. 2014 May 6 [cited 2024 Mar 2];16(1). Available from: https://www.ajol.info/index.php/pamj/article/view/103299

4. Diemer FS, Baldew SSM, Haan YC, Aartman JQ, Karamat FA, Nahar-van Venrooij LMW, et al. Hypertension and Cardiovascular Risk Profile in a Middle-Income Setting: The HELISUR Study. Am J Hypertens. 2017 Nov 1;30(11):1133–40.

5. Chow CK, Nguyen TN, Marschner S, Diaz R, Rahman O, Avezum A, et al. Availability and affordability of medicines and cardiovascular outcomes in 21 high-income, middle-income and low-income countries. BMJ Glob Health. 2020 Nov;5(11):e002640.

6. Hypertension [Internet]. [cited 2024 Mar 2]. Available from: https://www.who.int/news-room/fact-sheets/detail/hypertension

7. Bosu WK, Reilly ST, Aheto JMK, Zucchelli E. Hypertension in older adults in Africa: A systematic review and meta-analysis. PLOS ONE. 2019 Apr 5;14(4):e0214934.

8. Dokunmu TM, Yakubu OF, Adebayo AH, Olasehinde GI, Chinedu SN. Cardiovascular Risk Factors in a Suburban Community in Nigeria. Int J Hypertens. 2018 Apr 1;2018:e6898527.

9. Ogah OS, Arije A, Xin X, Beaney T, Adebiyi A, Sani MU, et al. May Measurement Month 2017: screening for hypertension in Nigeria—Sub-Saharan Africa. Eur Heart J Suppl J Eur Soc Cardiol. 2019 Apr;21(Suppl D):D86–8.

10. Adeloye D, Basquill C, Aderemi AV, Thompson JY, Obi FA. An estimate of the prevalence of hypertension in Nigeria: a systematic review and meta-analysis. J Hypertens. 2015 Feb;33(2):230–42.

11. Pickering TG, Shimbo D, Haas D. Ambulatory Blood-Pressure Monitoring. N Engl J Med. 2006 Jun;354(22):2368–74.

12. O'Brien E, Parati G, Stergiou G, Asmar R, Beilin L, Bilo G, et al. European Society of Hypertension Position Paper on Ambulatory Blood Pressure Monitoring. J Hypertens. 2013 Sep;31(9):1731–68.

13. Williams B, Mancia G, Spiering W, Agabiti Rosei E, Azizi M, Burnier M, et al. 2018 ESC/ESH Guidelines for the management of arterial hypertension: The Task Force for the management of arterial hypertension of the European Society of Cardiology and the European Society of Hypertension. J Hypertens. 2018 Oct;36(10):1953–2041.

14. Banegas JR, Ruilope LM, De La Sierra A, Vinyoles E, Gorostidi M, De La Cruz JJ, et al. Relationship between Clinic and Ambulatory Blood-Pressure Measurements and Mortality. N Engl J Med. 2018 Apr 19;378(16):1509–20.

15. Nwafor CE, Adebiyi AA, Ogah OS, Falase AO. Relationship between 24-hour Blood Pressure Pattern and Left Ventricular Structure and Function in Hypertensive Nigerians. Ethn Dis. 2013;23(4):474–9.

16. Kaul U, Arambam P, Rao S, Kapoor S, Swahney JPS, Sharma K, et al. Usefulness of ambulatory blood pressure measurement for hypertension management in India: the India ABPM study. J Hum Hypertens. 2020 Jun;34(6):457–67.

17. Carey RM, Whelton PK, for the 2017 ACC/AHA Hypertension Guideline Writing Committee. Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults: Synopsis of the 2017 American College of Cardiology/American Heart Association Hypertension Guideline. Ann Intern Med. 2018 Mar 6;168(5):351.

18. Floras JS. Blood Pressure Variability: A Novel and Important Risk Factor. Can J Cardiol. 2013 May;29(5):557–63.

19. Rothwell PM. Does Blood Pressure Variability Modulate Cardiovascular Risk? Curr Hypertens Rep. 2011 Jun 1;13(3):177–86.

20. Kawano Y. Diurnal blood pressure variation and related behavioral factors. Hypertens Res. 2011 Mar;34(3):281–5.

21. Gao Z, Chen Z, Sun A, Deng X. Gender differences in cardiovascular disease. Med Nov Technol Devices. 2019 Dec 1;4:100025.

22. Alhawari HH, Al-Shelleh S, Alhawari HH, Al-Saudi A, Aljbour Al-Majali D, Al-Faris L, et al. Blood Pressure and Its Association with Gender, Body Mass Index, Smoking, and Family History among University Students. Int J Hypertens. 2018 May 29;2018:e4186496.

23. Reckelhoff JF. Gender Differences in the Regulation of Blood Pressure. Hypertension. 2001 May;37(5):1199–208.

24. Reckelhoff JF, Zhang H, Srivastava K, Granger JP. Gender Differences in Hypertension in Spontaneously Hypertensive Rats. Hypertension. 1999 Oct;34(4):920–3.

25. Role of angiotensin-converting enzyme 2 and angiotensin(1–7) in 17β-oestradiol regulation of renal pathology in renal wrap hypertension in rats - Ji - 2008 - Experimental Physiology - Wiley Online Library [Internet]. [cited 2024 Mar 6]. Available from: https://physoc.onlinelibrary.wiley.com/doi/full/10.1113/expphysiol.2007.041392

26. Reckelhoff JF. Gender Differences in the Regulation of Blood Pressure. Hypertension. 2001 May;37(5):1199–208.

27. Rugvedh P, Gundreddy P, Wandile B. The Menstrual Cycle's Influence on Sleep Duration and Cardiovascular Health: A Comprehensive Review. Cureus. 15(10):e47292.

28. Adeoye A, Adebusoye L, Fakunle A, Aderonmu O, Adebayo O, Michael O, et al. Day and night blood pressure variability among older persons in South-Western Nigeria. Niger Postgrad Med J. 2022;29(3):206.

29. Chrysant SG, Chrysant GS. The Age-Related Hemodynamic Changes of Blood Pressure and Their Impact on the Incidence of Cardiovascular Disease and Stroke: New Evidence. J Clin Hypertens. 2014;16(2):87–90.

30. Baksi AJ, Treibel TA, Davies JE, Hadjiloizou N, Foale RA, Parker KH, et al. A Meta-Analysis of the Mechanism of Blood Pressure Change With Aging. J Am Coll Cardiol. 2009 Nov 24;54(22):2087–92.

31. Mikael L de R, de Paiva AMG, Gomes MM, Sousa ALL, Jardim PCBV, Vitorino PV de O, et al. Vascular Aging and Arterial Stiffness. Arq Bras Cardiol. 2017 Sep;109(3):253–8.

32. Balasubramanian P, Hall D, Subramanian M. Sympathetic nervous system as a target for aging and obesity-related cardiovascular diseases. GeroScience. 2018 Dec 5;41(1):13–24.

33. Singh JN, Nguyen T, Kerndt CC, Dhamoon AS. Physiology, Blood Pressure Age Related Changes. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 [cited 2024 Mar 8]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK537297/