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A cross-sectional analysis on hypertension: Exploring the impact of lifestyle modifications and antihypertensive drug adherence in Sudan

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Original Article

Abstract

BACKGROUND: Sudan has a high prevalence of hypertension or high blood pressure, a key risk factor for cardiovascular illnesses. Therefore, this study aimed to investigate the socio-demographic characteristics, antihypertensive medication adherence, lifestyle changes, and the relationships between these factors and blood pressure control.

METHODS: A cross-sectional study was conducted from March to August 2023 in tertiary care hospitals in Sudan. A structured questionnaire was used to gather information from 385 hypertensive individuals who participated in the study.

RESULTS: The results estimated a positive correlation between the independent variables measuring medication adherence. Diet, stress management, and exercise also moderately correlated with each other and the independent variables. Systolic and diastolic blood pressure levels had a high correlation at 0.93, and most variables correlated moderately with the dependent variable of blood pressure control. The regression model (R = 0.698) using the dependent variable (blood pressure control) as the outcome strongly correlated with the independent variables, explaining almost 49% of the variance in hypertension control. It was observed that blood pressure control was significantly predicted by adherence to antihypertensive medication, proper diet, exercise, and stress reduction among the participants.

CONCLUSION: The study emphasizes the significance of lifestyle changes for effective hypertension control, specifically adherence to antihypertensive medication, diet, exercise, and stress management. Hypertensive patients in Sudan experienced much better blood pressure control and a decreased risk of cardiovascular problems after changing their lifestyle.

Keywords: Adherence; Hypertension; Lifestyle modifications; Sudan

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Introduction

The socioeconomic progress of any nation is widely affected by non-communicable diseases, specifically illnesses related to cardiovascular diseases[1]. According to the latest report of the World Heart Federation, cardiovascular diseases continue to affect over half a billion people worldwide, accounting for 20.5 million deaths in 2021, nearly a third of all fatalities worldwide, and a total rise over the predicted 121 million deaths from cardiovascular diseases[2].

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Hypertension is the primary modifiable risk factor for cardiovascular disease deaths and one of the most prevalent non-communicable diseases in the world, affecting millions of individuals. It is a leading cause of cardiovascular illness-induced mortality and morbidity globally[3,4]. Hypertension is a chronic medical condition characterized by continuous high blood pressure in blood vessels[5].

WHO reported that 8.5 million global fatalities are attributed to hypertension, pre-hypertension, and other dangerous high blood pressure diseases, including stroke, ischemic heart disease, vascular diseases, and kidney disorders[6,7]. Around 1.28 billion people have high blood pressure, and two-thirds of the affected individuals live in low- and middle-income nations. This number is predicted to increase to 1.5 billion globally by 2025[8]. The incidence and prevalence of hypertension are defined by the ethical composition of the population and the criteria used to describe hypertension according to The British Hypertension Society in Table 1[9].

Classification of Hypertension

Since hypertension is a multifactorial illness, it is thought that the combination of a person's genetic composition and several environmental circumstances contributes to its etiology[10,11]. An important and unchangeable risk factor for hypertension is increasing age; thus, there is a lifetime risk of having hypertension. However, there are some other significant risk factors associated with hypertension, including being overweight, physically inactive or leading a sedentary lifestyle, excessive alcohol and cigarette consumption, stress, family history or presence of susceptible genes, high intake of salt, not having enough fruits and vegetables, and diabetes mellitus[12,13].

Sudan is located in the middle of Africa. Several studies have been conducted which show a high prevalence of hypertension in many regions and ethnicities. Bushara and his companions believed that the prevalence of hypertension is greater than 30% in northern Sudan[14], while another research reported the prevalence is between 15% and 38% in the rural population of Sudan[15]. In Sudan, hypertension is a major health concern, with a prevalence of undiagnosed high blood pressure at 26.2% and 79.2% of total hypertension[16]. Inadequate health systems are one of the reasons for the increasing number of individuals with undiagnosed, untreated, and uncontrolled hypertension, which results in strokes, cardiac failure, dementia, renal failure, and severe burdens on other health systems. However, with such a high prevalence rate, Sudan lacks an authorized national registration for hypertension and infrequently conducts evaluation studies. Some studies revealed that the shift in the nutritional diet of Sudanese has led to a rise in overweight individuals, which may be the cause of hypertension incidence[17]. Other researchers have asserted that the significant increase in renal insufficiency in Sudan can be attributed to the prevalence of hypertension[15]. Epidemiological studies on the risk factors, lifestyle, medication adherence, and awareness will be essential for designing control plans in Sudan. Therefore, the present study aimed to investigate lifestyle changes and antihypertensive medication adherence in Sudan and to determine the associations between these variables and blood pressure control. The findings may help to conduct focused programs for improving hypertension management and preventive methods.

Materials and Methods

Study Design

A descriptive cross-sectional study design was used to analyze the socio-demographic characteristics, lifestyle modifications, and medication regimes among the individuals of Sudan. A population-based survey was conducted to answer the study questions and determine the correlations between the variables.

Table 1. Classification of Hypertension

Category	Systolic blood pressure mmHg	Diastolic blood pressure mmHg
Optimal	<120	< 80
Normal	<130	< 85
Normal Hypertension	130 – 139	85 -89
Mild Hypertension	140 - 159	90 – 99
Moderate Hypertension	160 – 170	100 – 109
Severe Hypertension	≥ 180	≥110

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Study Area and Population

The study was conducted in Sudan, particularly in the southern region, from March to August 2023. The population was comprised of various ethnicities with different sociocultural groups. According to the World Population Prospectus 2022, the total population of the region, comprising all ages and sexes, is around 10 million, as estimated in 2021. The data was collected from the tertiary care institutes, including two government hospitals and one private hospital, over 6 months.

Ethical Approval

Verbal informed consent was obtained from the participants, and their personal information was kept confidential and secure upon data collection. The study followed the ethical considerations of the Helsinki Declaration, 2013, and the data were only used for research purposes.

Sampling Technique

The population's minimum sample size was estimated using the sample size formula for proportion:

$n=Z^2 \cdot p \cdot (1-p) / E^2$

where,

n = sample size,

Z = level of confidence (1.96 for 95%)

p = proportion of the population

E = error of margin (5% or 0.05)

A sample size of 385 participants was determined for this study to achieve a 95% confidence level with a 5% margin of error. It is a representative sample size of southern Sudan's population that helped yield insightful information for the study.

Inclusion and Exclusion Criteria

Certain inclusion and exclusion criteria were implemented to seek accurate insights into the study variables. The study included all males and females who were permanent residents of the southern region of Sudan, aged between 20 and 50 years, whether hypertensive or not. This age range was purposely targeted because the research also focuses on early detection and prevention and understanding hypertension's impact on the working-age population. Children and those aged below 20 years and above 50 years were excluded from the study. Guests, visitors, and temporary inhabitants were also not included to maintain the geographical scope of the study within the targeted area.

Data Collection

A structured questionnaire, comprising Arabic and English, was designed to collect data from participants. The questionnaire was divided into two sections: socio-demographic information, such as age, gender, occupation, and marital status, was included in section one. The second section covered questions focusing on the participants' blood pressure levels, lifestyle modifications, and anti-hypertensive medication regimens. The questionnaire's psychometric properties were carefully evaluated to ensure reliability and validity, enhancing the accuracy and consistency of the collected data. Additionally, blood pressure measurements were obtained from all participants following a standardized protocol. A validated automated sphygmomanometer with participants' arms positioned at heart level was used. Two readings were taken at intervals of a few minutes, and the average of these readings was used for analysis. Data were entered into an electronic database, ensuring accuracy and confidentiality. Further means, standard deviation, and range of systolic and diastolic BP were calculated using this data.

Data Analysis

The data were analyzed using SPSS (Statistical Package for the Social Sciences) Inc.'s (Chicago, IL, USA) version 20.0. The collected data were tabulated to determine the relationships between the variables using appropriate statistical significance tests. Frequencies and percentages were used for the categorical variables, and descriptive analysis was performed to determine the frequency, mean, regression, and standard deviation. Descriptive statistics provided a comprehensive overview of socio-demographic characteristics and lifestyle modification. A correlation test, regression, and t-test were used to examine the significance of relationship variables and to identify predictors. Regression analysis was used. The p-value of ≤ 0.05 was considered statistically significant.

Results

Socio-demographic Characteristics of Participants

Table 2 presents an overview of the socio-demographic characteristics of the study participants. The sample comprised 385 individuals, with a higher representation of females (59.2%) compared to

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Table 2. Socio-demographic Characteristics of Participants

Factors		Frequency	Percentages
Gender	Male	154	39.5
	Female	231	59.2
Age	20 – 30 years	59	15.1
	31 – 40 years	136	34.9
	41 – 50 years	190	48.7
Marital Status	Single	100	23.3
	Married	236	60.5
	Divorced	58	14.9
Occupation	Student	80	20.7
	Employed	185	48.0
	Unemployed	120	31.1
Permanent Residency	Yes	303	77.7
	No	82	21.0

Table 3. Lifestyle Modifications of Participants

Variable Name	Mean	Std. Deviation	Variance
Diet	3.1	1.191	1.416
Exercise	3	1.342	1.801
Stress Management	3.1	1.193	1.424
Medication Adherence	3.1	1.191	1.416
Timing	3.2	1.342	1.801
Missed Doses	3.1	1.193	1.424

males (39.5%). Age distribution among participants showed that 15.1% were aged between 20 and 30 years, 34.9% were aged between 31 and 40 years, and the majority were aged between 41 and 50 years. Moreover, approximately 60.5% were married, while the remaining were single and divorced. Occupational status revealed 48% of participants were employed, 31.1% were unemployed, and 20.7% were students. Based on residency, 77.7% reported having a permanent residency, while 21% did not.

Lifestyle Modifications of Participants

Table 3 presents descriptive statistics for 385 participants' lifestyle modifications, medication, habving mean scores ranging from 3.0 -3.2 on a 5-point Likert scale. Diet, stress management, and medication adherence all have mean scores of 3.1 with standard deviations around 1.19, indicating moderate adherence and some variability. Exercise adherence has the lowest mean at 3.0 and the highest variability with a standard deviation of 1.342. Moreover, stress management, medication adherence and missed doses are approximately similar in having mean values of 3.1 and variation of around 1.4. Overall, despite having moderate adherence to the life style modifications and medication schedules, prominent variability has been noticed.

Systolic and diastolic blood pressure levels were measured among the 385 study participants. The average systolic blood pressure was 130.5 mmHg with a standard deviation of 12.3 mmHg, indicating a relatively high level of systolic pressure. The mean diastolic blood pressure was 82.7 mmHg with a standard deviation of 8.5 mmHg. Based on the systolic blood pressure criteria, a significant portion of the participants, 45.2%, were classified as having hypertension.

Correlation Matrix of Study Variables

Table 4 shows the Pearson correlation coefficients between various lifestyle modifications. It is evident from the table that variables like missed doses, medication timing, and adherence showed strong correlations, ranging from 0.65 to 0.67. In contrast, diet, exercise, and stress management exhibited moderate correlations with each other and with the medication adherence variables, with coefficients ranging from 0.27 to 0.45. Systolic and diastolic BP have a very high correlation of 0.93, reflecting their close association in physiological nature. Blood pressure control is moderately linked with lifestyle and medication adherence variables.

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Table 4. Correlation Matrix of Lifestyle Modifications, Antihypertensive Drug Adherence, and Blood Pressure Variables

Variable	Diet	Exercise	Stress Management	Medication Adherence	Timing	Missed Doses	Systolic BP	Diastolic BP	BP Control
Diet	1.00								
Exercise	0.45	1.00							
Stress Management	0.34	0.42	1.00						
Medication Adherence	0.28	0.32	0.35	1.00					
Timing	0.29	0.31	0.33	0.67	1.00				
Missed Doses	0.27	0.30	0.32	0.66	0.65	1.00			
Systolic BP	0.31	0.32	0.34	0.55	0.56	0.54	1.00		
Diastolic BP	0.32	0.33	0.35	0.57	0.58	0.56	0.93	1.00	
BP Control	0.30	0.31	0.32	0.54	0.55	0.53	0.91	0.92	1.00

Table 5. Regression Analysis of Predictors of Blood Pressure Control in Hypertensive Patients

Model	B	Std. Error	Beta	t	Sig.
(Constant)	1.132	0.132			
Diet	0.123	0.034	0.145	3.599	0
Exercise	0.098	0.032	0.109	3.075	0.002
Stress	0.088	0.031	0.099	2.842	0.005
Freq.	0.158	0.037	0.183	4.26	0.001
Timing	0.138	0.033	0.164	4.164	0.001
Missed	0.128	0.036	0.148	3.576	0.001
Systolic	0.198	0.042	0.211	4.702	0.001
Diastolic	0.178	0.039	0.194	4.582	0.001
Pressure	-0.028	0.045	-0.027	-0.624	0.533

The regression model using the dependent variable—BP control as the outcome variable—strongly correlates with the independent variables, explaining nearly 49% of the BP control variance. The adjusted R square is slightly lower at 0.479, indicating that the model is simple enough. The standard error of the estimate is 0.8431, indicating the precision with which the model predicts the dependent variable. This model accounts for nearly half of the variability in BP control, with relatively high correlation and precision of prediction.

ANOVA analysis revealed a regression sum of squares of 94.813 with 9 degrees of freedom, yielding a mean square of 10.54, whereas the residual sum of squares is 99.787 with 375 degrees of freedom, resulting in a mean square of 0.266. The F-statistic for the model is 39.65, with a corresponding significance value of less than .001 ($p < .001$), showing a highly statistically significant model. The independent variables collectively have a strong predictive capability for the dependent variable and significantly predict the dependent variable.

Table 5 analyzed predictors of blood pressure control in hypertensive patients, finding that diet adherence and medication frequency significantly predicted control. Exercise and stress management regimens were also identified as unique predictors of control. Both systolic and diastolic blood pressure levels predicted control, with diastolic having a stronger relationship. Maintaining healthy numeric ranges during the study period was linked to achieving control. Blood pressure variability did not significantly contribute to the model, suggesting it does not offer additional predictive value beyond other factors. The analysis revealed multiple behavioral and clinical determinants of control that clinicians could target, including diet, medication use, exercise, stress management, and systolic/diastolic pressure levels.

Discussion

The present study offers helpful insights into the lifestyle, clinical, and socio-demographic traits that affect hypertension patients' ability to control their blood pressure. Existing literature showed that lifestyle changes, including diet and exercise, were well-established factors for controlling and treating hypertension[18,19]. Exercise and DASH

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(Dietary Approaches to Stop Hypertension) diets with low sodium are beneficial for decreasing blood pressure in hypertensive people[20]. The concept that lifestyle adjustments were critical for controlling cardiovascular risks and lowering blood pressure was supported by a systematic review[21].

The study found that the major hypertensive population is middle-aged, married women with permanent residency, which aligns with previous findings that hypertension is more prevalent in females and older age groups[22,23]. This high prevalence among females is influenced by hormonal factors, such as a decline in estrogen, menopause, and increased body fat[24,25]. Age is also an important factor in increasing hypertension prevalence among individuals due to age-related cardiovascular system changes[26]. The residency status also impacted hypertension prevalence because permanent residents might have easier access to resources and healthcare services that aid in blood pressure management[27].

The study by Kim et al. (2021) also found moderate adherence to lifestyle modifications and medication regimens among the participants for diet, stress management, and medication adherence[28]. The control of blood pressure indicated effective hypertension management through lifestyle modifications and medication adherence[29]. The results of the present study are similar to a cross-sectional study carried out in Ethiopia on 404 hypertension patients, as both studies focused on lifestyle adjustment activities aimed at controlling and preventing hypertension[30]. Warren-Findlow et al. (2012) found that adherence to the medication regimen, low salt diet intake, and physical activity are the best self-care interventions for hypertension. Food changes and physical activity are the most realistic self-care strategies[31].

The present study indicates that the most considerate factors strongly correlate with the dependent variable, BP control. The correlations among these factors implied that hypertension management was improved by blood pressure control. Bivariate correlations showed favorable connections between independent variables[32]. The substantial correlation between medication adherence components highlights their independence[33]. A comprehensive approach to disease care with moderate correlations is seen between diet, exercise, and stress management. The systolic and diastolic blood pressure showed a strong correlation, as predicted when used as joint measures of total pressure[34]. Most significantly, a correlation was found between blood pressure control and lifestyle, medication, and clinical factors, offering preliminary evidence of their impact[35].

Numerous independent factors of control were found using multiple linear regression. The most powerful behavioral determinant was diet, which emphasizes diet's potential to improve hypertension outcomes because it is adjustable. Treatment adherence was highlighted by the strong prediction of control from the frequency of medication intake[36]. Exercise and stress management were also significant, indicating that control benefits from balance in psychological and physical self-care domains[37]. Unexpectedly, there was no additional predictive value added by blood pressure variability. A long-term and broader variation capture might be required to identify the influence of blood pressure variability. The regression model with treatment-based and realistic lifestyle modification factors explained almost half of the control variability, suggesting that focusing on them may improve the patient's health. The study provides clinically relevant beginning points, such as dietary modifications, exercise encouragement, and medication reinforcement, to be prioritized in consultations.

Conclusion

This study concludes that middle-aged women with stable residency are most affected by hypertension. The study found a positive correlation between lifestyle changes and medication regime adherence for successful blood pressure control. It highlights the significance of dietary modifications, treatment adherence, exercise, and stress management in effective hypertension control. Thus, focusing on medication adherence and leading a healthy lifestyle can significantly improve blood pressure control in hypertensive patients.

Limitations

The study has limitations, including a cross-sectional design making causal inferences impossible and potential generalizability issues due to the setting and population. However, it emphasizes the importance of objectively assessed clinical correlates and multiple behavioral or social determinants, providing valuable insights for an integrated care approach.

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Conflict of interests

The authors declare no conflict of interest.

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Author's Contributions

AA: Conceptualization, Methodology and Drafting; HAP: Data collection; SS: Data collection; AEKEM: Data collection; ESH: Methodology; EAA: Drafting; Final draft is reviewed and approved by all the authors.

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