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Research Article

Assessment of Micronutrients and Lipid Status of Hypertensive Patients, Receiving Treatment at Adeoyo State Hospital, Oyo State

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ABSTRACT
Hypertension is of great public health concern locally and internationally, contributing significantly to cardiovascular morbidity and mortality. Although, pharmacological treatments are widely used, micronutrient intake and lipid status remain underexplored factors influencing blood pressure control in the Nigerian context. This study assessed the micronutrients and lipid status of hypertensive patients attending Adeoyo State Hospital, Ibadan, Oyo State, Nigeria, and explored their associations with blood pressure control. A cross-sectional study was conducted among 340 hypertensive patients recruited from the hospital's hypertension clinic. Structured questionnaires captured socio-demographic and dietary information, while anthropometric and clinical measurements (BMI, blood pressure) were recorded. Venous blood samples were analyzed for serum micronutrients using ion selective electrode (ISE) machine and lipid profiles using standard enzymatic methods. Data were analyzed using descriptive and inferential statistics at a 5% significance level. Hypertensive patients were significantly older (57.3 ± 9.8 years) and had higher BMI (28.6 ± 4.9 kg/m²) compared with non-hypertensive controls ($p < 0.001$). The mean serum levels of sodium, potassium, calcium, and magnesium were lower in hypertensive patients but not statistically significant ($p > 0.05$). However, total cholesterol, LDL cholesterol, and triglycerides were significantly higher, while HDL cholesterol was significantly lower among hypertensive participants ($p < 0.001$). Lipid parameters showed significant correlations with blood pressure, whereas micronutrient levels did not. Dyslipidemia, rather than micronutrient imbalance, was the major biochemical disturbance associated with hypertension in this population. Integrating lipid management and lifestyle modification into hypertension care is essential for effective prevention of cardiovascular complications.

Keywords: Blood-pressure; Dyslipidemia; Hypertension; Lipid-profile; Micronutrients; Nigeria

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INTRODUCTION

Hypertension remains one of the leading causes of global morbidity and mortality, affecting more than one billion individuals worldwide (Stanaway *et al.,* 2018; Zhou *et al.,* 2021). It is strongly associated with cardiovascular diseases, stroke, and kidney dysfunction, and accounts for over 10 million deaths annually (World Health Organization, 2023). Defined clinically as persistent systolic blood pressure (SBP) of ≥140 mmHg or diastolic blood pressure (DBP) of ≥90 mmHg (Chiu *et al.,* 2021), hypertension is often referred to as a "silent killer" due to its asymptomatic onset and devastating long-term complications.

In Nigeria, hypertension has emerged as a critical public health challenge, with prevalence estimates ranging from 22% to 44%, depending on geographic and sociodemographic factors (Adeloye *et al.,* 2020). Recent projections suggest that more than 36 million Nigerians currently live with hypertension and its complications (Oseni *et al.,* 2023). Despite the availability of pharmacological treatments, the rates of awareness, treatment, and effective control remain unacceptably low. For instance, only 25% of patients achieve both SBP and DBP control (Adeloye *et al.,* 2020), contributing to high rates of sudden cardiac deaths, stroke, and renal failure in the population.

Although antihypertensive medications such as beta-blockers and ACE inhibitors form the mainstay of therapy, emerging evidence highlights the importance of non-pharmacological interventions, particularly diet and lifestyle modifications (Liu *et al.,* 2024). Among these, micronutrient intake—specifically calcium, magnesium, and potassium—plays a critical role in regulating vascular tone, maintaining fluid balance, and influencing blood pressure homeostasis (Bastola *et al.,* 2020; Xiong *et al.,* 2023). Studies have shown that deficiencies in these micronutrients are associated with increased risk of hypertension, whereas adequate intake may improve blood pressure control and enhance the effectiveness of pharmacological therapies (Iqbal *et al.,* 2019; Venkatakrishnan *et al.,* 2020).

Similarly, dyslipidemia is frequently observed in hypertensive patients and exacerbates cardiovascular risk by promoting atherosclerosis, endothelial dysfunction, and arterial stiffness (Haba *et al.,* 2019). Elevated low-density lipoprotein (LDL) cholesterol and reduced high-density lipoprotein (HDL) cholesterol have been strongly linked to poor hypertension outcomes, while diet-induced improvements in lipid profiles have demonstrated beneficial effects on blood pressure regulation (Cheteu *et al.,* 2022).

Despite these associations, limited research in Nigeria has examined the dual influence of micronutrients and lipid profiles on blood pressure control among hypertensive patients. This knowledge gap is particularly relevant for clinical practice at the community level, where dietary habits, lifestyle factors, and limited healthcare resources may affect treatment outcomes. Adeoyo State Hospital in Ibadan, Oyo State, serves a large hypertensive population and provides an ideal setting for such an investigation.

This study, therefore, aimed to assess the serum levels of calcium, magnesium, and potassium, alongside lipid profiles, among hypertensive patients attending Adeoyo State Hospital. Furthermore, it sought to examine correlations between these biomarkers and blood pressure control, with the goal of generating evidence to inform dietary and clinical interventions for hypertension management in Nigeria.

MATERIALS AND METHODS

Study design and setting

This observational cross-sectional study was conducted at Adeoyo State Hospital, Ibadan, Oyo State, Nigeria. Adeoyo State Hospital is a major secondary-level facility serving urban and peri-urban populations and hosts a well-established hypertension clinic that provides routine follow-up and treatment to people living with hypertension. The hospital's location and services (including outpatient clinics and a laboratory capacity suitable for biochemical assays) made it an appropriate site for the investigation.

Study population and sampling

The study population comprised adult patients (≥18 years) attending Adeoyo State Hospital. A total of 340 participants were enrolled: 170 patients with clinically diagnosed hypertension (cases) and 170 non-hypertensive participants (controls). The sample size was calculated using the formula described by Israel (1992):

$n=Z^2×p×(1−p)/d^2$

Where *Z* is the z-score for a 95% confidence level (1.96), *p* is the estimated prevalence (0.331, from Ajayi *et al.,* 2016 for Ibadan North), and *d* is the desired precision (0.05). Substituting these values produced an estimated sample size of approximately 340 participants, which was used for recruitment.

Participants were recruited from the hypertension clinic and general outpatient departments. All participants provided informed consent before enrolment. A control group of 170 non-hypertensive participants was included to permit between-group comparisons of micronutrient and lipid status.

Inclusion and exclusion criteria

Inclusion criteria for hypertensive participants were: age ≥18 years and a clinical diagnosis of hypertension (systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg) who were attending the hospital clinic for treatment or follow-up. Controls were adult patients without a diagnosis of hypertension.

Exclusion criteria (applied to both groups) included pregnancy, known secondary causes of hypertension, current use of lipid-lowering drugs or nutritional supplements believed to affect micronutrient status, and histories of major chronic diseases that could confound results (documented heart disease, chronic kidney disease, diabetes mellitus, or thyroid disease). Participants who declined consent or could not comply with study procedures were also excluded.

Data collection procedures

Questionnaire and clinical data

A structured interviewer-administered questionnaire was used to collect socio-demographic information (age, sex, occupation, education), medical and medication history (duration of hypertension, antihypertensive medications), lifestyle factors (smoking, alcohol use, physical activity), and dietary information including use of micronutrient supplements and a food frequency component to capture intake of mineral-rich foods. Anthropometric measures (height and weight) were obtained and body mass index (BMI, kg/m^2) calculated. Waist circumference and other standard anthropometric measures were recorded as appropriate.

Blood pressure measurement

Blood pressure was measured using a validated sphygmomanometer with participants seated and rested for at least 5 minutes, following standard clinical guidelines. Systolic and diastolic pressures were recorded; where required the average of two or more readings was used per participant per the hospital protocol.

Biological sample collection and laboratory analysis

Sample collection

Fasting venous blood samples were drawn following standard aseptic techniques. Participants were instructed to fast for 9–12 hours prior to blood sampling for lipid analysis. Samples were processed and transported to the laboratory under appropriate conditions for serum separation and storage pending analysis.

Micronutrient assays

Serum concentrations of the key electrolytes and minerals of interest — sodium (Na), potassium (K), magnesium (Mg), and calcium (Ca) — were determined using Ion Selective Electrode (ISE machine).

Lipid profile assays

Lipid profile tests were conducted on the patients' blood which was collected after twelve hours overnight fast. The results were used to examine the lipid levels of the hypertension patients at Adeoyo State Hospital. These tests measured triglycerides, total cholesterol (TC), low-density lipoprotein (LDL), and high-density lipoprotein (HDL). Five mL of venous blood samples were collected into plain bottles. The blood samples were separated into serum using a centrifuge. The serum was then mixed with few drops of solution reagent XSYS0044. The vials swirled for about 2 minutes and later placed in Abbott c4000 automated analyzer where the light absorption of the sample after the reaction is considered as the readings for the triglycerides, total cholesterol low-density lipoprotein, and high-density lipoprotein. were taken.

Quality assurance and data handling

All laboratory analyses were subject to routine internal quality control, including the use of calibration standards and control sera. Equipment maintenance and calibration logs were available in the laboratory as described in the institutional procedures. Questionnaire data were checked for completeness at the point of collection. Laboratory and questionnaire data were double-entered into a secure database and cross-checked to minimize entry errors. Participants' records were anonymized using study identifiers to protect confidentiality.

Data Analysis

Descriptive statistics were used to assess the following variables: triglycerides, sodium, potassium, magnesium, calcium, height, weight, body mass index (BMI), total cholesterol, high-density lipoproteins (HDL), low-density lipoproteins (LDL), and total cholesterol. The level of significance of the parameters measured was determined at 0.05 probability ($p < 0.05$). The level of significance between the groups was analysed using independent sample t-tests on each of the continuous variables. Frequency distribution was used to analyze the participants' socio-demographic and clinical variables by group. The association between the variables and the hypertension status of the patients was determined using the Chi-square test. The association between the continuous variables was ascertained using Pearson correlation coefficient. The extent to which the independent variables predicted the triglyceride levels among the participants was analysed using multiple linear regression.

Ethical considerations

Ethical approval for the research was obtained from the Ethics Committees of Adeoyo State Hospital and Oyo State HREC. Participation was voluntary and informed written consent was obtained from all participants. Confidentiality was maintained by de-identifying participant data and storing records on password-protected systems accessible only to the research team. Participants found to have abnormal laboratory results during the study were referred to their attending clinicians for appropriate management.

RESULTS

Socio-demographic Characteristics of Respondents

A total of 340 participants were recruited for this study, consisting of 170 hypertensive and 170 non-hypertensive respondents. The mean age of all respondents was 54.8 ± 10.9 years. Hypertensive participants had a higher mean age (57.3 ± 9.8 years) than non-hypertensive participants (52.4 ± 11.2 years), and the difference was statistically significant ($p < 0.01$).

Females accounted for 62.9% of the total respondents. Among hypertensive participants, 64.7% were female compared with 61.2% in the control group; the difference in sex distribution was not statistically significant ($p = 0.52$).

Hypertensive participants had a significantly higher mean body mass index (BMI) (28.6 ± 4.9 kg/m^2) than non-hypertensive participants (25.3 ± 4.1 kg/m^2, $p < 0.001$). The prevalence of obesity (BMI ≥ 30 kg/m^2) was 34.7% among hypertensive participants compared with 17.1% among non-hypertensive participants. These are presented in Table 1.

Serum Micronutrient Levels of Respondents

The mean serum levels of sodium, potassium, magnesium, and calcium were slightly lower in hypertensive participants than in non-hypertensive controls; however, none of these differences were statistically significant ($p > 0.05$) (Table 2).

Table 1. Socio-demographic characteristics of respondents

Variable	Hypertensive (n = 170)	Non-Hypertensive (n = 170)	p-value
Age (years, mean ± SD)	57.3 ± 9.8	52.4 ± 11.2	.001*
Female sex, n (%)	110 (64.7)	104 (61.2)	.520
BMI (kg/m^2, mean ± SD)	28.6 ± 4.9	25.3 ± 4.1	.001*
Obesity (BMI ≥ 30 kg/m^2), n (%)	59 (34.7)	29 (17.1)	.001*

Table 2. Comparison of micronutrient levels between hypertensive and non-hypertensive participants

Parameter	t-statistic	df	p-value	Significance
Sodium	-0.132	338	0.895	Not significant
Potassium	0.750	338	0.454	Not significant
Magnesium	0.548	338	0.584	Not significant
Calcium	0.623	338	0.534	Not significant

These findings indicate that although there were mean differences in micronutrient levels between both groups, the variations were not statistically significant.

Lipid Profile of Respondents

Table 3 presents the lipid profiles of hypertensive and non-hypertensive participants. Hypertensive respondents had significantly higher mean total cholesterol, low-density lipoprotein (LDL) cholesterol, and triglyceride levels, as well as significantly lower high-density lipoprotein (HDL) cholesterol levels compared with controls ($p < 0.001$ for all).

Correlation between micronutrients, lipid parameters, and blood pressure

Correlation analysis was performed to determine the relationship between serum micronutrients, lipid parameters, and blood pressure among hypertensive participants. The results revealed no significant correlation between serum sodium, potassium, magnesium, or calcium and either systolic or diastolic blood pressure ($p > 0.05$). However, lipid parameters showed significant associations with blood pressure. Total cholesterol, LDL cholesterol, and triglycerides were positively correlated with systolic and diastolic blood pressure ($p < 0.05$), while HDL cholesterol exhibited a negative correlation with both systolic and diastolic blood pressure (Table 4).

Table 3. Lipid Profile of Respondents

Parameter	t-statistic	df	p-value	Significance
Total Cholesterol	-9.636	338	< 0.001	Significant
HDL	9.327	338	< 0.001	Significant
LDL	-12.616	338	< 0.001	Significant
Triglycerides	-13.580	338	< 0.001	Significant

These results indicate a strong presence of dyslipidemia among hypertensive patients, with higher atherogenic lipid fractions and lower protective HDL levels.

Table 4. Correlation between serum micronutrients, lipid parameters, and blood pressure

Parameter	Systolic BP (r)	Diastolic BP (r)	p-value
Sodium	–0.037	–0.042	.71
Potassium	–0.058	–0.043	.54
Magnesium	–0.083	–0.072	.36
Calcium	–0.061	–0.058	.52
Total Cholesterol	.284	.216	< .05
LDL Cholesterol	.301	.228	< .05
HDL Cholesterol	–.205	–.178	< .05
Triglycerides	.273	.193	< .05

DISCUSSION

This study evaluated serum micronutrient and lipid status among hypertensive patients attending Adeoyo State Hospital, Ibadan, and compared them with non-hypertensive controls. The results revealed that while the mean serum levels of sodium, potassium, magnesium, and calcium were slightly lower in hypertensive patients, these differences were not statistically significant. In contrast, lipid parameters—total cholesterol, LDL cholesterol, HDL cholesterol, and triglycerides—showed statistically significant differences between hypertensive and non-hypertensive participants ($p < 0.001$). Furthermore, lipid fractions demonstrated significant correlations with blood pressure, whereas micronutrient levels did not.

The hypertensive respondents were significantly older and had higher BMI values than the non-hypertensive controls. This finding supports the established evidence that advancing age and obesity are major risk factors for hypertension. Age-related vascular changes, including arterial stiffness and endothelial dysfunction, are key contributors to increased systolic and diastolic pressures (Chobufo *et al.,* 2019). Similarly, obesity increases sympathetic nervous system activity, sodium retention, and activation of the renin–angiotensin–aldosterone system, thereby elevating blood pressure (Agyemang & Bhopal, 2019).

These observations align with several Nigerian and international studies that reported a high prevalence of hypertension among middle-aged and obese individuals (Adeloye *et al.,* 2020; Zhou *et al.,* 2021). The implication is that lifestyle interventions—particularly weight management and increased physical activity—remain essential in the prevention and control of hypertension in this population.

The study observed lower mean serum levels of magnesium, potassium, and calcium among hypertensive patients than non-hypertensive controls; however, the differences were not statistically significant ($p > 0.05$). This suggests that micronutrient imbalance may exist among hypertensive individuals but may not have reached clinically significant levels in this sample.

Previous research has reported conflicting findings regarding the relationship between micronutrient status and hypertension. Some studies have demonstrated that low levels of magnesium and potassium are associated with higher blood pressure due to their roles in vascular tone regulation and endothelial function (Bastola *et al.,* 2020; Whelton *et al.,* 2018). Others, however, have reported no statistically significant relationship between these micronutrients and hypertension (Iqbal *et al.,* 2019).

The present findings are consistent with those studies that found no significant association. Nutrient intake variability in the diets of the individuals could vary widely based on personal preferences, cultural practices, socioeconomic status and geographical locations. However, the lack of statistical significance in this study could be due to adequate dietary intake among participants or the possibility that antihypertensive medications influenced electrolyte balance. Furthermore, the lack of consistent micronutrient intake across the study population might have diluted the observed effects. The mode of processing or preparing food can also affect the nutrient availability significantly in food, as well as when the participants consume processed foods that are low in micronutrients. The use of dietary supplements among the participants may cover the deficiencies among those consuming a varied diet thus, causing insignificant differences observed in the micronutrient status among the study population. It also emphasizes that, while micronutrients are biologically important in blood pressure regulation, their effect may be subtle or overshadowed by other dominant risk factors such as lipid imbalance, obesity, and genetic predisposition.

The medication effects can also be another factor causing non-significant differences of the micronutrients among the study participants when some medications affect the absorption and metabolism of nutrients intake. The dietary effects of micronutrient variations can be obscured if a large number of the study participants were on medications that can alter the nutrient levels. The metabolism and absorption of nutrients can as well be affected by underlying medical problems. However, the results from participants with metabolic abnormalities, chronic sickness, or ma;-absorption syndromes may be skewed and might not be typical representation of the overall study population.

Age, sex and ethnicity of the study sample can also have a big influence on the micronutrient intake. The non-significant variability in micronutrient might also be due to genetics, microbiota compositions and nutrient interactions in the body of the study participants causing variations in the bio-availability of the nutrients among the study participants. Socio economic and geographical differences can pose as environmental factors affecting the micronutrients of the study population.

The lower socio-economic status may correlate with less access to a variety of foods rich in micronutrients while, those with higher socio-economic status might compensate through diverse food options and supplementation. Different localities, ethnicities and tribes might have food with different levels of micronutrients. Some food can be rich in micronutrients while some might not be micronutrients rich based on locations. However, such variations in such food can lead to disparities in the micronutrients of the study population.

The non-significant findings in micronutrient research may stem from a complex interplay of dietary, physiological, and methodological factors. Future research should consider these aspects carefully, striving for robust designs that account for variability in dietary habits, medication influences, sample diversity, and meticulous measurement methodologies to better elucidate the role of micronutrients in health outcomes.

Unlike the micronutrients, lipid parameters showed clear and statistically significant differences between hypertensive and non-hypertensive participants. Total cholesterol, LDL cholesterol, and triglycerides were markedly higher among hypertensive patients, while HDL cholesterol was significantly lower. These findings confirm the presence of dyslipidemia among hypertensive individuals in this study population.

The coexistence of hypertension and dyslipidemia often termed “lipid hypertension syndrome” has been well-documented (Cheteu *et al.,* 2022). Elevated LDL cholesterol and triglycerides contribute to endothelial dysfunction, arterial stiffness, and atherosclerotic plaque formation, which, in turn, increase systemic vascular resistance and blood pressure. Conversely, low HDL cholesterol reduces reverse cholesterol transport and impairs endothelial repair mechanisms (Haba *et al.,* 2019).

The positive correlations observed between total cholesterol, LDL cholesterol, and triglycerides with both systolic and diastolic blood pressure in this study further substantiate these mechanisms. Similarly, the negative correlation between HDL cholesterol and blood pressure aligns with the protective role of HDL in cardiovascular health. These findings corroborate those of Ajayi et al. (2016) and Ige et al. (2019), who reported similar lipid abnormalities among hypertensive patients in southwestern Nigeria. Together, these results highlight the importance of integrating lipid management into hypertension care, as untreated dyslipidemia accelerates cardiovascular complications and worsens long-term prognosis.

Correlation analysis in this study demonstrated that lipid parameters had stronger associations with blood pressure than micronutrients. Specifically, total cholesterol, LDL, and triglycerides correlated positively with systolic and diastolic blood pressure, whereas HDL cholesterol showed an inverse relationship. In contrast, serum sodium, potassium, magnesium, and calcium levels were not significantly correlated with blood pressure. This indicates that, within this study population, lipid abnormalities exerted a greater influence on blood pressure regulation than micronutrient variations. The result is consistent with other Nigerian studies that identified dyslipidemia as a major metabolic disturbance in hypertensive patients (Ajayi *et al.,* 2016; Oseni *et al.,* 2023). These findings reinforce the multifactorial nature of hypertension, suggesting that the pathophysiology extends beyond electrolyte balance to include lipid metabolism and metabolic syndrome components.

The findings of this study have direct clinical relevance. The significant dyslipidemia observed among hypertensive patients underscores the need for routine lipid profile screening as part of hypertension management. Addressing dyslipidemia through dietary counseling, physical activity, and lipid-lowering agents can help prevent cardiovascular complications.

Furthermore, while micronutrient differences were not statistically significant, maintaining adequate intake of magnesium, potassium, and calcium remains beneficial for vascular health and blood pressure stability. Clinicians should continue to educate patients on balanced diets rich in fruits, vegetables, and whole grains. At the public health level, these results support the inclusion of nutrition and lipid management strategies in hypertension control programs in Nigeria.

The cross-sectional design of this study limits causal inference, as it cannot determine whether dyslipidemia preceded or resulted from hypertension. Dietary data were self-reported, which may introduce recall bias. Additionally, the study did not assess other potentially relevant parameters such as sodium intake, vitamin D, or oxidative stress markers. Despite these limitations, the study provides valuable insights into the biochemical profile of hypertensive patients in a Nigerian context.

CONCLUSION

This study assessed the serum micronutrient and lipid status of hypertensive patients attending Adeoyo State Hospital, Ibadan, and compared them with non-hypertensive controls. The findings revealed that hypertensive patients were significantly older and had higher body mass index values compared with non-hypertensive participants, confirming age and obesity as major predisposing factors for hypertension in this population. Although the mean serum concentrations of sodium, potassium, magnesium, and calcium were lower among hypertensive patients, the differences were not statistically significant. This indicates that, within this study population, electrolyte and micronutrient imbalances did not play a dominant role in the development or maintenance of hypertension.

In contrast, lipid abnormalities were both prevalent and significant among hypertensive patients. Total cholesterol, LDL cholesterol, and triglyceride levels were markedly higher, while HDL cholesterol levels were lower compared with the control group. Furthermore, lipid fractions showed significant correlations with blood pressure, demonstrating that dyslipidemia exerts a strong influence on hypertension status. These findings highlight dyslipidemia as a major biochemical disturbance associated with hypertension in this Nigerian population. Effective management of hypertension should therefore not rely solely on pharmacological control of blood pressure but should also include screening and management of lipid disorders, alongside lifestyle and dietary modifications.

Routine lipid profile testing should be incorporated into the clinical evaluation of all hypertensive patients to detect and manage dyslipidemia early. Treatment protocols should combine pharmacological therapy with non-pharmacological approaches such as weight control, dietary modification, and increased physical activity. Patients should be encouraged to adopt diets rich in fruits, vegetables, and whole grains to support cardiovascular health and maintain adequate micronutrient intake.

Public enlightenment campaigns should emphasize the roles of diet, physical activity, and lipid control in preventing hypertension and its complications. National hypertension management guidelines should include specific recommendations on lipid profile screening and nutritional assessment for hypertensive patients. Government and health institutions should ensure that lipid profile and basic biochemical tests are affordable and available at primary and secondary healthcare levels.

Further research should explore the long-term relationships between lipid profiles, micronutrient levels, and hypertension outcomes in diverse Nigerian populations. Controlled trials evaluating dietary or pharmacological lipid-lowering interventions among hypertensive patients would provide stronger evidence for causal relationships. Future studies should include additional biomarkers such as vitamin D, inflammatory cytokines, and oxidative stress indices to better understand the metabolic complexity of hypertension.

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