Alqalam Journal of Medical and Applied Sciences. 2026;9(3):591-598
https://doi.org/10.54361/ajmas.269309

Original article

The Relationship Between Low and High Sodium and Potassium Levels and Blood Pressure in Both Genders of Different Ages

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Abstract
Hypertension is a major global health concern influenced by multiple factors, including electrolyte imbalances. Sodium and potassium play critical roles in blood pressure regulation, yet their effects may vary based on gender and age. This study investigates the relationship between sodium and potassium levels and blood pressure among males and females of different age groups to provide insights into hypertension risk factors and management strategies. A total of 90 participants were recruited and categorized into control and patient groups. The sample consisted of 50 males and 40 females, with 40 participants in the control group and 50 in the patient group. Blood samples were analyzed to determine sodium and potassium concentrations, and blood pressure measurements were recorded. The mean and standard deviation of these parameters were compared across gender and age groups. Pearson correlation analysis was performed to assess relationships between sodium, potassium, and blood pressure in male and female participants. The study found that sodium levels were generally higher in male participants compared to females, with a stronger correlation between sodium and blood pressure observed in female patients. Potassium levels showed a negative correlation with blood pressure, particularly in males, suggesting a protective effect. Additionally, older participants exhibited greater sensitivity to electrolyte imbalances, indicating that age plays a crucial role in blood pressure regulation. Statistical analysis revealed significant gender-based differences in how sodium and potassium levels influence blood pressure, supporting the need for personalized dietary and medical recommendations. The findings suggest that high sodium intake contributes to elevated blood pressure, especially in female patients, while increased potassium levels may help lower blood pressure, particularly in males. Age-related variations highlight the importance of monitoring electrolyte balance in older individuals. These results reinforce the importance of dietary modifications that reduce sodium and enhance potassium intake as part of hypertension management strategies. Future research should explore gender-specific and age-related interventions to optimize cardiovascular health.
Keywords: Blood Pressure, Sodium, Potassium, Hypertension, Gender Differences.

Introduction

Hypertension (HTN) remains the leading global cause of morbidity and mortality, contributing to approximately 10.4 million deaths annually [1]. The global prevalence of HTN among adults aged 30–79 years has doubled between 1990 and 2019 and is projected to reach 1.56 billion by 2025 [2]. HTN is a major risk factor for cardiovascular, cerebrovascular, and renal diseases and is strongly associated with increased all-cause mortality [3,4]. Despite advances in pharmacological treatment, global blood pressure control rates remain below 50%, particularly in low- and middle-income countries [5,6]. Therefore, effective preventive strategies remain a public health priority [7,8]. Among modifiable risk factors, dietary sodium and potassium intake play central roles in blood pressure regulation [9,10]. Modern dietary patterns are characterized by excessive salt consumption (9–12 g/day), substantially exceeding the World Health Organization (WHO) recommendation of less than 2 g sodium per day and a 30% population-level reduction target [11]. High sodium intake accounts for approximately 30% of hypertension cases and contributes to the rising disease burden [12].

Sodium, the predominant extracellular cation, regulates extracellular fluid volume and osmotic pressure [13]. Increased sodium intake expands extracellular and intravascular volume, elevates cardiac output, and increases blood pressure through renal mechanisms, including altered natriuresis and salt sensitivity [14–15]. Individual variability in salt sensitivity, influenced by renal function, aging, sympathetic activity, and renin–angiotensin system activation, determines the magnitude of blood pressure response to sodium intake [16,17]. In contrast, higher potassium intake has consistently been associated with blood pressure reduction, particularly in individuals with high sodium intake or salt sensitivity [18,19]. Potassium enhances urinary sodium excretion, modulates distal nephron sodium transport, and promotes vascular smooth muscle relaxation [20–21,22]. Increased potassium intake also mitigates the adverse cardiovascular effects of excessive sodium consumption [23,24]. Accordingly, WHO recommends a daily potassium intake of 90 mmol (3510 mg) [25], while other guidelines suggest up to 120 mmol (4700 mg) for adults [26,27].

Given the growing global burden of hypertension, dietary sodium reduction and adequate potassium intake represent fundamental, cost-effective strategies for blood pressure control and cardiovascular risk reduction [28,29].

Received*: 05-01-2026 -* ***Accepted****: 03-03-2026 -* ***Published****: 09-03-2026*

Methods

A cross-sectional observational study was conducted to investigate the association between serum sodium and potassium levels and blood pressure across different genders and age groups. A total of 90 adults (≥18 years) were recruited, including 50 hypertensive patients and 50 normotensive controls. Participants were eligible if they were adults with no history of chronic kidney disease or endocrine disorders affecting electrolyte balance, and not using antihypertensive or diuretic medications. Pregnant women, individuals with severe cardiovascular disease, and those on restrictive diets affecting electrolyte intake were excluded. Written informed consent was obtained from all participants, and the sample size was determined using power analysis to ensure adequate statistical power.

Demographic and clinical data, including age, sex, weight, height, BMI, and lifestyle factors (smoking, alcohol intake, and physical activity), were collected. Dietary intake was assessed using a 24-hour recall and food frequency questionnaire. Blood pressure was measured three times using an automated sphygmomanometer after at least 5 minutes of seated rest, and the average of the readings was used. Fasting venous blood samples were collected to measure serum sodium and potassium levels using ion-selective electrode analysis, with reference ranges of 135–145 mmol/L for sodium and 3.5–5.0 mmol/L for potassium. Data were analyzed using SPSS version 22.0. Descriptive statistics included mean, standard deviation, and frequency distributions. Pearson's correlation was used to assess relationships between electrolyte levels and blood pressure, while multiple linear regression adjusted for confounders such as age, BMI, and lifestyle factors. ANOVA was used to compare groups, and logistic regression identified potential predictors of hypertension and hypotension. Statistical significance was set at $p < 0.05$.

Ethical approval for this study was obtained from Al-Ajaylat Hospital, where the study participants were recruited and conducted in accordance with ethical guidelines. All participants provided written informed consent.

Results

The study included 90 participants (50 males and 40 females) divided into a patient group (n = 50) and a control group (n = 40). Among males, 29 were patients and 21 controls, while among females, 21 were patients and 19 controls. This balanced distribution allowed for a comprehensive analysis of the relationship between sodium and potassium levels and blood pressure across genders (Table 1, Figure 1).

Table 1. Total number of male and female participants in the current study, as distributed between the control groups and patients

Gender	Control group	Patients	Total
Male	21	29	50
Female	19	21	40
Total	40	50	90

In the control group, males had higher mean systolic (122.5 mmHg) and diastolic (74.9mmHg) blood pressure than females (120.3/70.1 mmHg), while sodium and potassium levels were similar across genders (Na: 139.7 vs. 139.0 mmol/L; K: 4.1 vs. 3.9 mmol/L). Patient participants were older, with females showing slightly higher mean age than males (61.1 vs. 57.6 years) (Table 2).

Table 2. Mean and standard deviation (SD) of different parameters measured among all participants.

Category	Gender	Age (Years) Mean/SD	Systolic BP Mean/SD	Diastolic BP Mean/SD	Na Mean/SD	K Mean/SD
Control group	Male	45.8 25.17	122.5 13.2	74.9 6.2	139.7 3.3	4.1 0.4
	Female	43.7 19.2	120.3 15.4	70.1 12.0	139 2.8	3.9 0.4
Patients	Male	57.6 27.3	128.5 30.6	79.8 15.9	137.8 6.8	4.08 0.8
	Female	61.1 25.5	126.8 28.9	75 13.1	138.3 6.39	4.17 0.6

Among patients, males exhibited higher systolic and diastolic blood pressure than females (128.5/79.8 vs. 126.8/75 mmHg), while sodium and potassium levels were relatively stable (Na: 138.3 vs. 137.8 mmol/L; K: 4.17 vs. 4.08 mmol/L) (Figures 2–3, 4–5).

Received*: 05-01-2026 -* ***Accepted****: 03-03-2026 -* ***Published****: 09-03-2026*

https://doi.org/10.54361/ajmas.269309

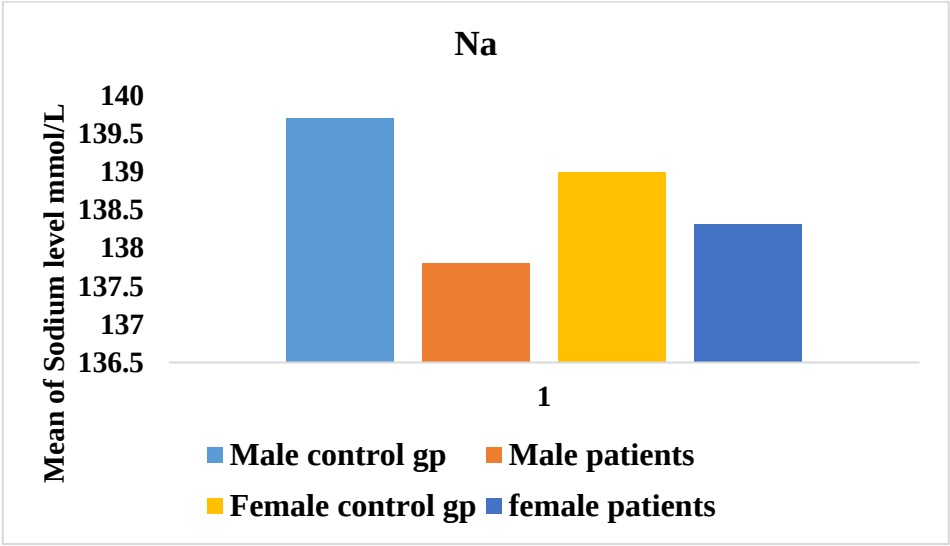

Figure 2. Mean of Sodium level among male and female participants (control groups/patients).

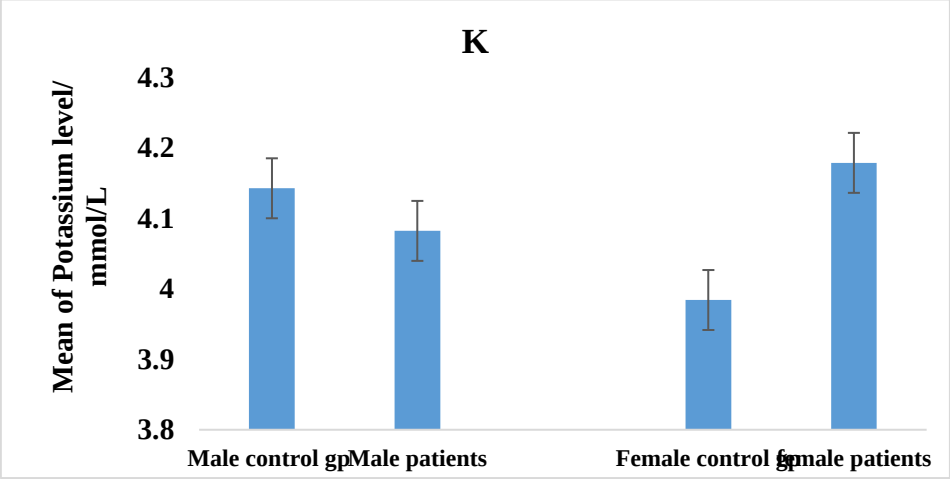

Figure 3. Mean of Potassium level among male and female participants (control groups/patients).

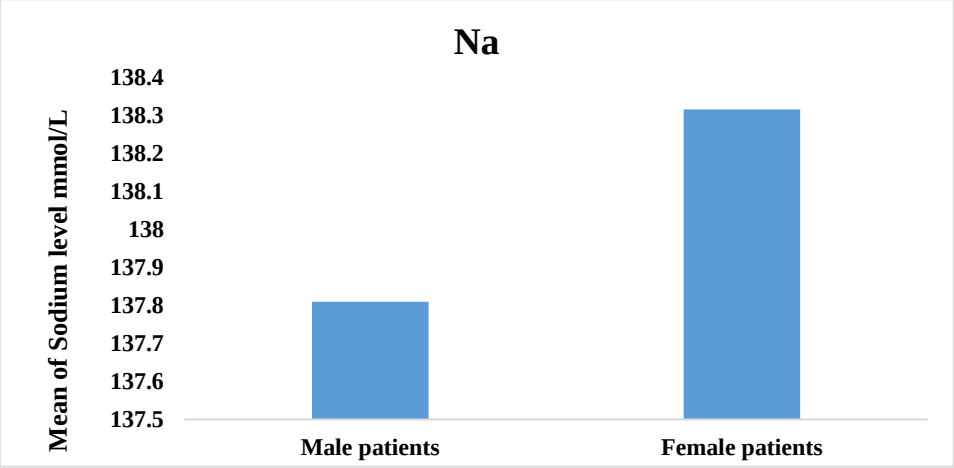

Figure 4. Comparison between the mean of the sodium level in the blood of male and female patient participants.

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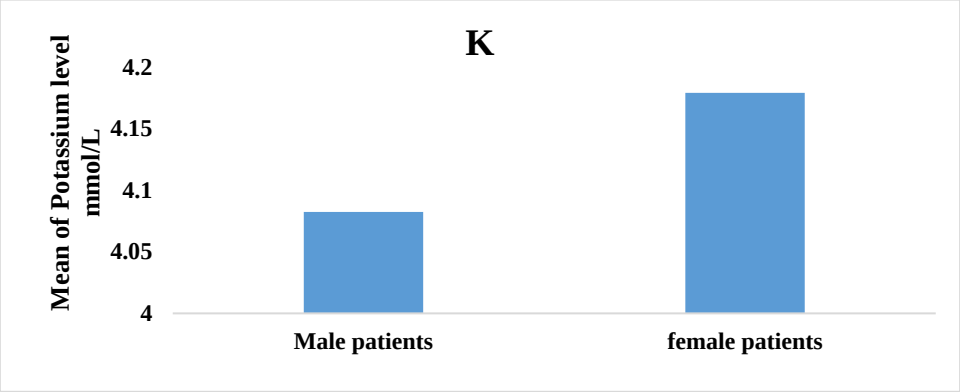

Figure 5. Comparison between the mean of Potassium level in the blood of male and female patient participants.

Correlation analysis revealed distinct patterns between control and patient groups. In male patients, systolic and diastolic blood pressure were significantly positively correlated with sodium levels (systolic: r = 0.517, p = 0.004; diastolic: r = 0.665, *p < 0.001*), while correlations with potassium were non-significant (Table 3).

Table 3. Correlation between the results of different parameters among male participants (control groups/patients).

Variables		Male Systole	Male Diastole	Male Na	Male K	Patient Male Systole	Patient Male Diastole	Patient Male N	Patient Male K
Male Systole	Pearson Correlation	1	.300	-.231	-.423	-.152	.004	-.014	.333
	Sig. (2-tailed)		.186	.313	.056	.510	.986	.951	.140
	N	21	21	21	21	21	21	21	21
Male Diastole	Pearson Correlation	.300	1	-.118	.033	.352	.584**	.482*	-.120
	Sig. (2-tailed)	.186		.611	.889	.117	.005	.027	.606
	N	21	21	21	21	21	21	21	21
Male Na	Pearson Correlation	-.231	-.118	1	.149	-.077	-.083	-.328	.044
	Sig. (2-tailed)	.313	.611		.518	.739	.719	.147	.850
	N	21	21	21	21	21	21	21	21
Male K	Pearson Correlation	-.423	.033	.149	1	.119	-.018	-.010	-.617**
	Sig. (2-tailed)	.056	.889	.518		.607	.939	.967	.003
	N	21	21	21	21	21	21	21	21
Patient Male Systole	Pearson Correlation	-.152	.352	-.077	.119	1	.554**	.517**	-.070
	Sig. (2-tailed)	.510	.117	.739	.607		.002	.004	.719
	N	21	21	21	21	29	29	29	29
Patient Male Diastole	Pearson Correlation	.004	.584**	-.083	-.018	.554**	1	.665**	-.131
	Sig. (2-tailed)	.986	.005	.719	.939	.002		.000	.497
	N	21	21	21	21	29	29	29	29
Patient Male N	Pearson Correlation	-.014	.482*	-.328	-.010	.517**	.665**	1	-.275
	Sig. (2-tailed)	.951	.027	.147	.967	.004	.000		.149
	N	21	21	21	21	29	29	29	29
Patient Male K	Pearson Correlation	.333	-.120	.044	-.617**	-.070	-.131	-.275	1
	Sig. (2-tailed)	.140	.606	.850	.003	.719	.497	.149	
	N	21	21	21	21	29	29	29	29

*** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed)*

In female patients, diastolic blood pressure was significantly associated with sodium (r = 0.538, p = 0.012), but potassium showed no significant correlations (Table 4).

Received*: 05-01-2026 -* ***Accepted****: 03-03-2026 -* ***Published****: 09-03-2026*

https://doi.org/10.54361/ajmas.269309

Table 4. Correlation between the results of different parameters among female participants (control groups/patients).

		Female Systole	Female Diastole	Female N	Female K	Patient Female Systole	Patient Female Diastole	Patient Female N	Patient Female K
Female Systole	Pearson Correlation	1	.702**	-.339	-.170	.348	.260	.093	.103
	Sig. (2-tailed)		.001	.155	.487	.145	.281	.706	.674
	N	19	19	19	19	19	19	19	19
Female Diastole	Pearson Correlation	.702**	1	-.115	-.128	.476*	.376	.036	.288
	Sig. (2-tailed)	.001		.641	.602	.040	.112	.885	.232
	N	19	19	19	19	19	19	19	19
Female N	Pearson Correlation	-.339	-.115	1	.575*	-.101	.205	.006	.271
	Sig. (2-tailed)	.155	.641		.010	.681	.401	.980	.261
	N	19	19	19	19	19	19	19	19
Female K	Pearson Correlation	-.170	-.128	.575*	1	-.385	-.032	-.155	.177
	Sig. (2-tailed)	.487	.602	.010		.104	.896	.527	.468
	N	19	19	19	19	19	19	19	19
Patient Female Systole	Pearson Correlation	.348	.476*	-.101	-.385	1	.762**	.379	.002
	Sig. (2-tailed)	.145	.040	.681	.104		.000	.091	.991
	N	19	19	19	19	21	21	21	21
Patient Female Diastole	Pearson Correlation	.260	.376	.205	-.032	.762**	1	.538*	.157
	Sig. (2-tailed)	.281	.112	.401	.896	.000		.012	.498
	N	19	19	19	19	21	21	21	21
Patient Female N	Pearson Correlation	.093	.036	.006	-.155	.379	.538*	1	.226
	Sig. (2-tailed)	.706	.885	.980	.527	.091	.012		.324
	N	19	19	19	19	21	21	21	21
Patient Female K	Pearson Correlation	.103	.288	.271	.177	.002	.157	.226	1
	Sig. (2-tailed)	.674	.232	.261	.468	.991	.498	.324	
	N	19	19	19	19	21	21	21	21

*** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).*

In control groups, males and females showed weak or non-significant correlations between blood pressure and electrolytes, although sodium and potassium were positively correlated in female controls (r = 0.575, p = 0.010). Overall, the data suggest that sodium levels are more strongly associated with blood pressure in patient groups, while potassium levels remain relatively stable across genders and health status (Figures 6, 7).

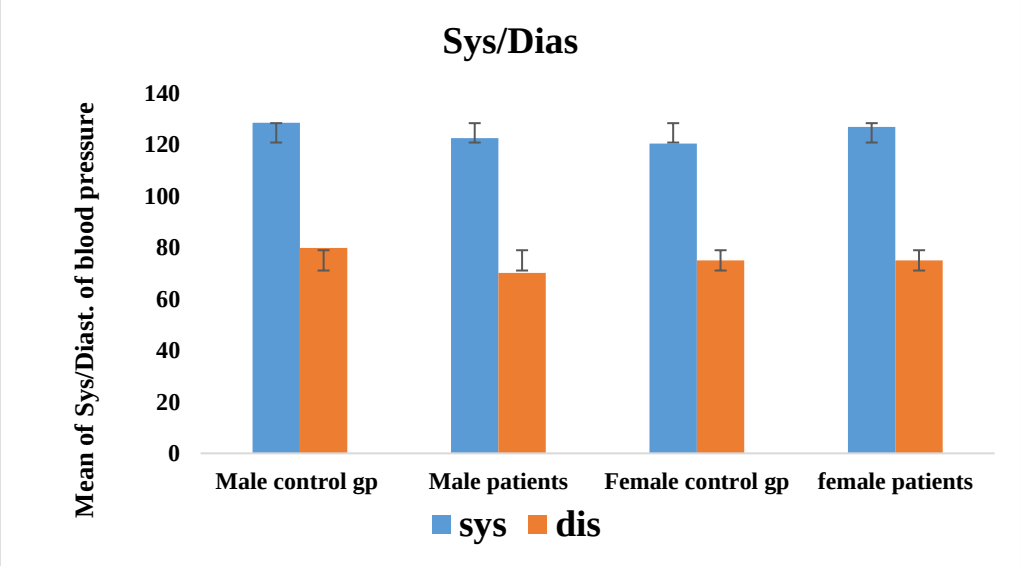

Figure 6. Mean of Systolic/Diastolic blood pressure levels among male and female participants (control groups/patients).

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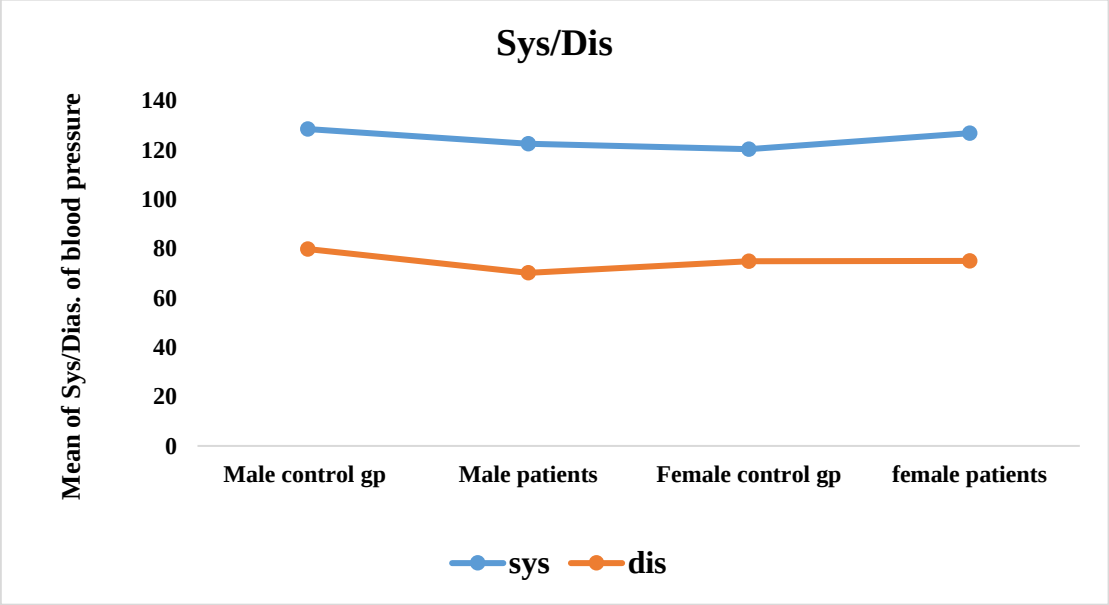

Figure 7. Mean of Systolic/Diastolic blood pressure levels among male and female participants (control groups/patients).

Discussion

Hypertension is often asymptomatic and is called a silent killer [30], defined as systolic BP ≥ 140 mmHg and diastolic BP ≥ 90 mmHg [31]. The study included 90 participants (50 males, 40 females), divided into control (21 males, 19 females) and patient groups (29 males, 21 females), allowing meaningful gender comparisons. Control participants were younger than patients, with male controls at 45.8 ± 25.17 years, female controls at 43.7 ± 19.2, male patients at 57.6 ± 27.3, and female patients at 61.1 ± 25.5. In controls, males had higher systolic and diastolic BP than females (122.5 ± 13.2 vs. 120.3 ± 15.4 mmHg; 74.9 ± 6.2 vs. 70.1 ± 12.0 mmHg), while in patients, male systolic BP (128.5 ± 30.6) and female systolic BP (126.8 ± 28.9), with diastolic BP in both genders (male 79.8 ± 15.9, female 75 ± 13.1).

Sodium levels decreased in patients compared to controls, more in males (male 137.8 ± 6.8 vs. 139.7 ± 3.3 mmol/L; female 138.3 ± 6.39 vs. 139 ± 2.8), while potassium varied slightly (male 4.08 ± 0.8 vs. 4.1 ± 0.4; female 4.17 ± 0.6 vs. 3.9 ± 0.4). Older age, reduced sodium, and minor potassium differences suggest age and electrolytes influence BP, with males more affected by sodium reduction [32–33]. Control males showed weak negative correlation of systolic BP with sodium (r = -0.231, p = 0.313) and stronger inverse correlation with potassium (r = -0.423, p = 0.056), while patient males had strong positive correlations of systolic and diastolic BP with sodium *(r = 0.517–0.665, p < 0.01)* and a negative correlation between sodium and potassium *(r = -0.617, p = 0.003).*

Control females had strong systolic–diastolic BP correlation *(r = 0.702, p = 0.001*) and positive sodium–potassium correlation *(r = 0.575, p = 0.010),* whereas patient females maintained systolic–diastolic correlation *(r = 0.762, p = 0.000)* and a significant positive correlation of diastolic BP with sodium *(r = 0.538, p = 0.012)* but no significant potassium relationships). These results indicate gender-specific differences in BP regulation, emphasizing sodium's role in female patients and the importance of balanced sodium-potassium levels in males. This section is not mandatory, but can be added to the manuscript if the discussion is unusually long or complex.

Conclusion

This study examined the relationship between sodium and potassium levels and blood pressure among male and female participants in control and patient groups. The results show that sodium and potassium levels are closely associated with blood pressure regulation, with effects varying by gender, age, and health status. Patients were generally older and showed lower potassium and slightly lower sodium levels, while males exhibited higher systolic and diastolic BP than females across groups. Correlation analysis indicated a strong relationship between systolic and diastolic BP in both genders, with sodium showing a greater impact on female patients and potassium having a stronger inverse association with BP in males. Age amplified sensitivity to electrolyte imbalances, contributing to hypertension risk. These findings emphasize the importance of maintaining a balanced sodium-to-potassium ratio and suggest that dietary interventions to reduce sodium and increase potassium could be particularly beneficial, especially for older adults and female hypertensive patients. Gender-specific differences in BP regulation highlight the need for personalized dietary and medical strategies to prevent and manage hypertension.

Received*: 05-01-2026 -* ***Accepted****: 03-03-2026 -* ***Published****: 09-03-2026*

Recommendations

Based on the study findings, it is recommended that clinicians emphasize dietary strategies to reduce sodium intake, particularly for female patients, due to its significant association with diastolic blood pressure. Increasing potassium intake through fruits, vegetables, and legumes may provide additional protective effects, especially in males. Older adults should receive targeted guidance and regular monitoring of blood pressure and electrolytes, as they are more sensitive to imbalances. Gender-specific approaches are suggested, given that males and females respond differently to sodium and potassium levels. Future research should explore the mechanisms behind these gender and age differences, ideally using longitudinal studies with larger samples to clarify causal effects. Overall, maintaining a balanced sodium-to-potassium ratio and applying personalized, age and gender-specific interventions can optimize blood pressure management and inform clinical and public health strategies. A more balanced gender representation in future studies is also recommended to minimize bias.

Conflict of interest. Nil

References

1. GBD 2017 Risk Factor Collaborators. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2018 Nov 10;392(10159):1923-1994.
2. NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in hypertension prevalence and progress in treatment and control from 1990 to 2019: a pooled analysis of 1201 population-representative studies with 104 million participants. Lancet. 2021 Sep 11;398(10304):957-980.
3. Justin J, Fayol A, Bruno RM, et al. International guidelines for hypertension: resemblance, divergence and inconsistencies. J Clin Med. 2022 Mar 25;11(7):1975.
4. Kearney PM, Whelton M, Reynolds K, et al. Global burden of hypertension: analysis of worldwide data. Lancet. 2005 Jan 15-21;365(9455):217-223.
5. Kim HC, Cho SMJ, Lee H, Lee HH, Baek J, Heo JE. Korea hypertension fact sheet 2020: analysis of nationwide population-based data. Clin Hypertens. 2021 Jan 5;27(1):8.
6. Zhou B, Carrillo-Larco RM, Danaei G, Riley LM, Paciorek CJ, Stevens GA, et al. Worldwide trends in hypertension prevalence and progress in treatment and control from 1990 to 2019: a pooled analysis of 1201 population-representative studies with 104 million participants. Lancet. 2021;398(10304):957-980.
7. Mills KT, Stefanescu A, He J. The global epidemiology of hypertension. Nat Rev Nephrol. 2020 Apr;16(4):223-237.
8. Mills KT, Bundy JD, Kelly TN, et al. Global disparities of hypertension prevalence and control: a systematic analysis of population-based studies from 90 countries. Circulation. 2016 Aug 9;134(6):441-450.
9. Ezzati M, Lopez AD, Rodgers A, et al. Selected major risk factors and global and regional burden of disease. Lancet. 2002 Nov 2;360(9343):1347-1360.
10. Lee HY, Shin J, Kim GH, Park S, Ihm SH, Kim HC, et al. 2018 Korean Society of Hypertension guidelines for the management of hypertension: part II-diagnosis and treatment of hypertension. Clin Hypertens. 2019;25:20.
11. Campbell, N. R. C., Lackland, D. T., Niebylski, M. L., Orias, M., Redburn, K. A., Nilsson, P. M., Zhang, X.-H., Burrell, L., Horiuchi, M., Poulter, N. R., Prabhakaran, D., Ramirez, A. J., Schiffrin, E. L., Schutte, A. E., Touyz, R. M., Wang, J.-G., & Weber, M. A. (2016). 2016 dietary salt fact sheet and call to action: The World Hypertension League, International Society of Hypertension, and the International Council of Cardiovascular Prevention and Rehabilitation. Journal of Clinical Hypertension, 18(11), 1082–1085. https://doi.org/10.1111/jch.12894
12. Campbell NR, Neal BC, MacGregor GA. Interested in developing a national programme to reduce dietary salt? J Hum Hypertens. 2011 Dec;25(12):705-710.
13. Bie P. Mechanisms of sodium balance: total body sodium, surrogate variables, and renal sodium excretion. Am J Physiol Regul Integr Comp Physiol. 2018 Nov 1;315(5):R945-R962.
14. Bernal A, Zafra MA, Simón MJ, Mahía J. Sodium homeostasis, a balance necessary for life. Nutrients. 2023 Jan 11;15(2):395.
15. Felder RA, White MJ, Williams SM, Jose PA. Diagnostic tools for hypertension and salt sensitivity testing. Curr Opin Nephrol Hypertens. 2013 Jan;22(1):65-76.
16. Elijovich F, Weinberger MH, Anderson CA, et al. Salt sensitivity of blood pressure: a scientific statement from the American Heart Association. Hypertension. 2016 Sep;68(3):e7-e46.
17. Koomans HA, Roos JC, Boer P, Geyskes GG, Mees EJ. Salt sensitivity of blood pressure in chronic renal failure. Evidence for renal control of body fluid distribution in man. Hypertension. 1982 Mar-Apr;4(2):190-197.
18. Staruschenko A. Beneficial effects of high potassium: contribution of renal basolateral K(+) channels. Hypertension. 2018 Jun;71(6):1015-1022.
19. Rodrigues SL, Baldo MP, Machado RC, et al. High potassium intake blunts the effect of elevated sodium intake on blood pressure levels. J Am Soc Hypertens. 2014 Apr;8(4):232-238.
20. Wade JB, Fang L, Coleman RA, et al. Differential regulation of ROMK (Kir1.1) in distal nephron segments by dietary potassium. Am J Physiol Renal Physiol. 2011 Jun;300(6):F1385-F1393.
21. Rieg T, Vallon V, Sausbier M, et al. The role of the BK channel in potassium homeostasis and flow-induced renal potassium excretion. Kidney Int. 2007 Sep;72(5):566-573.
22. World Health Organization. Guideline: Potassium intake for adults and children. Geneva: WHO Press; 2012. p. 1-46.

Received: *05-01-2026* - ***Accepted***: *03-03-2026* - ***Published***: *09-03-2026*

23. Aburto NJ, Hanson S, Gutierrez H, et al. Effect of increased potassium intake on cardiovascular risk factors and disease: systematic review and meta-analyses. BMJ. 2013 Apr 3;346:f1378.
24. Park Y, Kwock C, Kim K, Kim J, Yang Y. Interaction between single nucleotide polymorphism and urinary sodium, potassium, and sodium-potassium ratio on the risk of hypertension in Korean adults. Nutrients. 2017 Mar 2;9(3):235.
25. National Coordinating Committee on Food and Nutrition (NCCFN). Recommended nutrient intakes for Malaysia. Ministry of Health Malaysia. 2017.
26. Institute of Medicine (IOM). Dietary reference intakes: the essential guide to nutrient requirements. Washington (DC): The National Academies Press; 2011.
27. Nohara-Shitama Y, Adachi H, Enomoto M, et al. Twenty-four-hour urinary potassium excretion, but not sodium excretion, is associated with all-cause mortality in a general population. J Am Heart Assoc. 2018 Apr 19;7(9):e007369.
28. Kim HL, Lee EM, Ahn SY, et al. The 2022 focused update of the 2018 Korean Hypertension Society guidelines for the management of hypertension. Clin Hypertens. 2023 Feb 3;29(1):11.
29. P2PM. Laporan Kinerja Direktorat Jenderal Pencegahan dan Pengendalian Penyakit. Kemkes. 2022. p. 1-114. Available from: https://e-renggar.kemkes.go.id/file2018/e-performance/1-465827-3tahunan-768.pdf
30. Yusuf S, Joseph P, Rangarajan S, et al. Modifiable risk factors, cardiovascular disease, and mortality in 155,722 individuals from 21 high-income, middle-income, and low-income countries (PURE): a prospective cohort study. Lancet. 2020 Mar 7;395(10226):795-808.
31. Zehnder C. Sodium, potassium and hypertension. Rev Med Clin Las Condes. 2010;21(4):508-515.
32. Putri EH, Kartini A. Hubungan asupan kalium, kalsium dan magnesium dengan kejadian hipertensi pada wanita menopause di Kelurahan Bojongsalaman, Semarang. J Nutr Coll. 2014;3(4):580-586.

Received*: 05-01-2026 -* ***Accepted****: 03-03-2026 -* ***Published****: 09-03-2026*