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ASSOCIATION BETWEEN SALT SENSITIVITY AND BLOOD PRESSURE RESPONSE IN YOUNG ADULTS

Original Article

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ABSTRACT

Background: Salt sensitivity, a key determinant of individual blood pressure response to sodium intake, plays a critical role in the early pathogenesis of hypertension. Its prevalence and implications among normotensive young adults remain underexplored, especially in populations with high sodium consumption.

Objective: To assess the prevalence of salt sensitivity and its association with systolic and diastolic blood pressure responses among normotensive individuals aged 18–30 years in South Punjab.

Methods: A cross-sectional study was conducted over four months, involving 100 normotensive participants aged 18 to 30 years. Participants underwent two dietary phases: low sodium (<50 mmol/day) and high sodium (>200 mmol/day), each lasting seven days. Blood pressure was measured during both phases using a standardized automated device. Salt sensitivity was defined as a ≥10 mmHg increase in systolic or ≥5 mmHg in diastolic blood pressure between phases. Data were analyzed using descriptive statistics, t-tests, and Pearson correlation ($p<0.05$).

Results: Of the 100 participants, 41% were classified as salt-sensitive. Mean systolic and diastolic pressures increased from 112.3 ± 6.5 mmHg and 72.1 ± 4.8 mmHg during the low-sodium phase to 120.7 ± 7.2 mmHg and 78.9 ± 5.1 mmHg in the high-sodium phase, respectively. Salt-sensitive individuals showed a significantly higher mean systolic (Δ13.1 ± 2.9 mmHg) and diastolic (Δ7.6 ± 1.9 mmHg) response compared to salt-resistant individuals. Significant positive correlations were observed between sodium intake and both systolic ($r = 0.58$) and diastolic ($r = 0.51$) responses ($p<0.001$).

Conclusion: Salt sensitivity is prevalent among young, normotensive adults and significantly influences blood pressure variability. Early identification may inform dietary strategies to prevent future cardiovascular risks.

Keywords: Adult, Blood Pressure, Cross-Sectional Studies, Dietary Sodium, Hypertension, Normotensive, Salt Sensitivity, South Punjab, Sodium, Young Adults.

INTRODUCTION

Salt sensitivity is an important, yet often underrecognized, factor influencing blood pressure regulation, particularly among individuals who otherwise present as normotensive (1). As hypertension continues to be a leading risk factor for cardiovascular morbidity and mortality globally, growing attention has turned toward understanding its early determinants. Among these, salt sensitivity — the degree to which an individual's blood pressure responds to sodium intake — has emerged as a compelling area of investigation. Although the relationship between salt intake and hypertension has been well-documented, it is increasingly evident that this response is highly variable across individuals, pointing to the significance of salt sensitivity as a physiological phenotype (2). While much of the existing research on salt sensitivity has concentrated on hypertensive or older populations, the physiological underpinnings of this phenomenon often begin to manifest earlier in life (3). Identifying such traits in younger, normotensive individuals may serve as a valuable predictive tool for early cardiovascular risk assessment and prevention. In young adults aged 18 to 30 — a demographic often assumed to be at minimal risk for cardiovascular dysfunction — subtle variations in sodium handling could lay the foundation for future hypertensive states. However, this age group remains relatively understudied in the context of salt sensitivity, particularly in relation to its measurable effects on both systolic and diastolic blood pressure responses (4).

The body's ability to regulate sodium balance and maintain vascular homeostasis is influenced by a complex interplay of genetic, hormonal, and environmental factors (5). Mechanisms involving the renin-angiotensin-aldosterone system (RAAS), sympathetic nervous system activity, and renal function all contribute to how individuals process sodium. When these mechanisms are imbalanced, even in subtle ways, a heightened blood pressure response to sodium intake may ensue (6). This sensitivity has been linked to structural changes in the vasculature, endothelial dysfunction, and altered sodium excretion — all of which can occur long before overt hypertension develops (7). Moreover, the implications of salt sensitivity extend beyond blood pressure alone. It has been associated with left ventricular hypertrophy, increased arterial stiffness, and even higher risk for chronic kidney disease. In light of these associations, the early identification of salt-sensitive individuals could have broad clinical value, not only in terms of hypertension prevention but also in mitigating other downstream cardiovascular and renal complications. For public health and clinical practice alike, recognizing salt sensitivity in young adults could transform the way dietary and lifestyle interventions are prioritized. Cultural dietary habits further compound the issue. In many populations, high sodium consumption begins early and is often sustained through adulthood due to processed food intake, low awareness, and limited dietary education. For salt-sensitive individuals, such a dietary pattern could have disproportionately harmful effects on cardiovascular health. Hence, understanding how normotensive young adults respond to dietary salt may provide insight into population-level strategies to combat hypertension before it begins (8).

Additionally, there is a growing need to refine our understanding of individual variability in salt sensitivity (9). While the “one-size-fits-all” approach to sodium restriction may benefit the general population, a more targeted strategy based on physiological responsiveness could lead to better outcomes (10). Young adults, due to their relatively intact cardiovascular systems, represent an ideal group in which to study this phenomenon without the confounding effects of chronic disease (11). Yet, studies in this cohort remain scarce, and the prevalence of salt sensitivity in this group is still unclear (12). Given this context, the present study seeks to assess the prevalence of salt sensitivity among normotensive individuals aged 18 to 30 years and to examine how this trait correlates with both systolic and diastolic blood pressure responses. By focusing on this understudied demographic, the research aims to shed light on the early cardiovascular implications of salt sensitivity and provide a foundation for future preventative strategies tailored to individual physiological profiles.

METHODS

This cross-sectional study was conducted over a four-month period in the South Punjab region, with the primary objective of assessing the prevalence of salt sensitivity and its association with systolic and diastolic blood pressure responses among normotensive young adults aged 18 to 30 years. The study was designed to ensure methodological rigor, enabling clear identification of physiological variability in blood pressure responses to salt intake among individuals without pre-existing hypertension.

Participants were recruited using a purposive sampling method from university campuses and community health outreach centers to ensure representation from various socioeconomic backgrounds. Eligibility criteria included individuals aged between 18 and 30 years who were normotensive at the time of screening, defined as having a systolic blood pressure less than 120 mmHg and diastolic pressure less than 80 mmHg, as per standard clinical guidelines. Exclusion criteria were carefully established to eliminate potential confounding variables. These included individuals with a history of diagnosed hypertension, cardiovascular disease, renal disorders, diabetes mellitus,

or those on any form of antihypertensive or diuretic medications. Pregnant women and individuals following specialized diets, including low-sodium regimens or weight-loss plans, were also excluded from participation.

Sample size estimation was conducted using a power analysis based on an assumed moderate effect size of 0.3, a confidence level of 95%, and a statistical power of 80%, suitable for correlational analysis. The minimum required sample size calculated under these parameters was 84 participants. However, to enhance statistical robustness and account for potential dropouts or data exclusions, a final sample size of 100 participants was targeted and successfully enrolled in the study.

Each participant underwent a two-phase dietary sodium intervention, adapted to assess salt sensitivity under controlled conditions. In the first phase, participants followed a low-sodium diet of less than 50 mmol/day for seven consecutive days. This was followed by a second phase in which they consumed a high-sodium diet exceeding 200 mmol/day for an additional seven days. Dietary compliance was supported through daily communication and pre-prepared dietary plans. Urinary sodium excretion was measured through 24-hour urine collection on the final day of each dietary phase to validate adherence and quantify sodium intake.

Blood pressure was measured using a validated automated oscillometric device (Omron HEM-7120) under standardized conditions. Participants were instructed to rest for at least five minutes in a seated position before measurements were taken. Blood pressure was recorded at the same time of day on three consecutive days during both dietary phases, with the average of three readings per day used for final analysis to reduce variability. The difference in blood pressure readings between the low-sodium and high-sodium phases was calculated to determine salt sensitivity. A participant was categorized as salt-sensitive if the change in systolic blood pressure was ≥10 mmHg or in diastolic blood pressure was ≥5 mmHg between the dietary phases.

Demographic data, including age, gender, body mass index (BMI), smoking status, and physical activity levels, were collected using a structured questionnaire to account for potential confounders in the analysis. Height and weight were measured using standardized equipment, and BMI was calculated as weight in kilograms divided by the square of height in meters.

All data were analyzed using SPSS version 26. Descriptive statistics were used to summarize the baseline characteristics of the study population. Continuous variables were expressed as means and standard deviations, while categorical variables were reported as frequencies and percentages. To assess the correlation between salt sensitivity and blood pressure responses, Pearson's correlation coefficient was applied, as the data followed a normal distribution confirmed by the Shapiro-Wilk test. Independent t-tests were used to compare mean blood pressure changes between salt-sensitive and salt-resistant individuals. A p-value of less than 0.05 was considered statistically significant.

This methodological approach allowed for precise and reproducible identification of salt-sensitive individuals and provided a reliable framework for examining the relationship between sodium intake and blood pressure variation among young, normotensive adults in South Punjab.

RESULTS

The study included 100 normotensive participants aged 18 to 30 years, with a mean age of 23.4 ± 3.1 years. Males comprised 52% of the sample, while females represented 48%. The average body mass index (BMI) was 22.8 ± 2.6 kg/m². Among the participants, 18% reported being active smokers, whereas 82% were non-smokers. These baseline characteristics ensured a relatively homogenous and healthy population suitable for studying early cardiovascular variability without the influence of pre-existing chronic disease. The primary outcome measures focused on the changes in systolic and diastolic blood pressure following dietary sodium modulation. During the low-sodium phase, the mean systolic blood pressure was 112.3 ± 6.5 mmHg, which increased to 120.7 ± 7.2 mmHg during the high-sodium phase. A similar trend was observed in diastolic readings, with an increase from 72.1 ± 4.8 mmHg in the low-sodium phase to 78.9 ± 5.1 mmHg in the high-sodium phase. These shifts in blood pressure readings indicate that sodium intake had a measurable physiological effect even within a normotensive population.

Based on the defined criteria for salt sensitivity, 41 individuals (41%) were classified as salt-sensitive, and the remaining 59 participants (59%) were deemed salt-resistant. Among salt-sensitive individuals, the mean change in systolic blood pressure (Δ SBP) was 13.1 ± 2.9 mmHg, while the change in diastolic blood pressure (Δ DBP) was 7.6 ± 1.9 mmHg. In contrast, salt-resistant participants exhibited a lower Δ SBP of 4.3 ± 1.7 mmHg and Δ DBP of 2.1 ± 1.2 mmHg. These findings emphasize the variability in individual blood pressure responses to sodium intake despite normotensive baseline status.

Statistical analysis using Pearson's correlation revealed a moderate and statistically significant positive correlation between the change in sodium intake and systolic blood pressure response ($r = 0.58$, $p < 0.001$). A similarly significant correlation was observed between sodium intake and diastolic response ($r = 0.51$, $p < 0.001$). These results suggest a consistent and quantifiable relationship between dietary sodium manipulation and blood pressure alteration within the studied population. The distribution of salt sensitivity within the sample is visually represented in the pie chart, while the differences in systolic blood pressure under both sodium conditions are illustrated through a comparative bar chart. Collectively, these findings underscore a high prevalence of salt sensitivity in a young, normotensive cohort and demonstrate a meaningful association with blood pressure variability, supporting the hypothesis that early physiological markers of hypertension risk can be detected well before clinical disease manifests.

Table 1: Demographics Table

Variable	Mean ± SD / n (%)
Age (years)	23.4 ± 3.1
Gender (Male)	52 (52%)
Gender (Female)	48 (48%)
BMI (kg/m²)	22.8 ± 2.6
Smokers	18 (18%)
Non-Smokers	82 (82%)

Table 2: Blood Pressure Changes Table

Measurement	Mean ± SD
Systolic BP - Low Sodium (mmHg)	112.3 ± 6.5
Systolic BP - High Sodium (mmHg)	120.7 ± 7.2
Diastolic BP - Low Sodium (mmHg)	72.1 ± 4.8
Diastolic BP - High Sodium (mmHg)	78.9 ± 5.1

Table 3: Salt Sensitivity Classification Table

Group	n (%)	Mean Δ SBP (mmHg)	Mean Δ DBP (mmHg)
Salt-Sensitive	41 (41%)	13.1 ± 2.9	7.6 ± 1.9
Salt-Resistant	59 (59%)	4.3 ± 1.7	2.1 ± 1.2

Table 4: Correlation Between Sodium Intake and BP Response

Variable Pair	Correlation Coefficient (r)	p-value
Δ Sodium vs Δ SBP	0.58	<0.001
Δ Sodium vs Δ DBP	0.51	<0.001

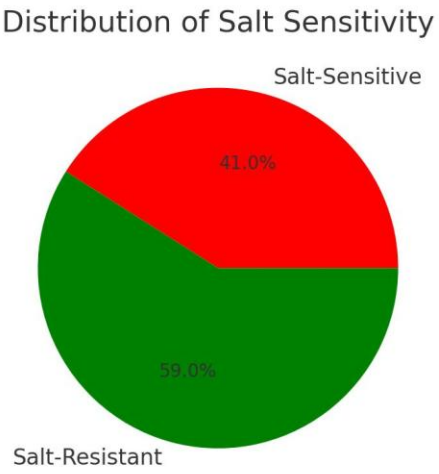

Figure 2 Distribution of Salt Sensitivity

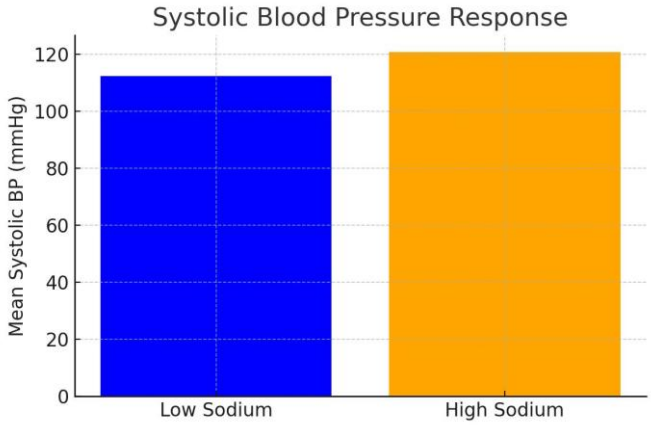

Figure 2 Systolic Blood Pressure Response

DISCUSSION

The findings of this study highlight a significant prevalence of salt sensitivity among young, normotensive adults, with 41% of participants demonstrating a clinically relevant increase in blood pressure in response to sodium loading (13). This observation reinforces the notion that salt sensitivity is not exclusive to hypertensive or older populations, but is also present in individuals considered to be at low cardiovascular risk (14). The clear increase in both systolic and diastolic blood pressure values following a high-sodium diet underscores the importance of early identification of this phenotype in order to guide preventive strategies before the onset of hypertension. The positive correlation between sodium intake and changes in systolic and diastolic blood pressure further substantiates the physiological responsiveness of certain individuals to dietary sodium. A correlation coefficient exceeding 0.5 suggests a moderately strong association, supporting the hypothesis that salt-sensitive individuals experience disproportionate hemodynamic changes even in the absence of clinically elevated baseline readings. These results offer valuable insight into subclinical cardiovascular dynamics that may progress to overt disease if not addressed during early adulthood (15). Comparison with prior research aligns with the observed prevalence of salt sensitivity. While many earlier studies focused on older adults or those with pre-existing comorbidities, the current findings extend the relevance of salt responsiveness into a younger demographic. The magnitude of blood pressure change in the salt-sensitive subgroup observed in this study is consistent with established thresholds used in clinical and research settings to define salt sensitivity, thus supporting the internal validity of the classification criteria applied. One notable strength of this study lies in its methodologically controlled dietary intervention, which employed both low- and high-sodium phases supported by compliance monitoring through 24-hour urinary sodium measurements. This approach ensured reliable differentiation between physiological states and minimized the likelihood of dietary non-adherence, a common confounder in salt sensitivity research. The use of validated automated blood pressure monitors, consistent measurement protocols, and repeated readings also strengthened the reliability of outcome measures (16).

The inclusion of a healthy, normotensive population as the study sample adds another layer of significance. It allowed the uncovering of latent blood pressure variability in the absence of pharmacological or disease-related influences (17). By identifying salt-sensitive individuals within this age group, the study contributes to the growing body of evidence supporting early preventive cardiology. Lifestyle modification in this window of time may offer long-term cardiovascular protection, particularly in populations exposed to sodium-rich diets from a young age (18). However, several limitations warrant consideration. Despite the adequate sample size and statistical power, the non-randomized sampling method may introduce selection bias, limiting the generalizability of the findings. Recruitment from a specific geographic region may also mean that dietary habits, genetic predispositions, and lifestyle factors unique to South Punjab played a role in shaping the observed outcomes (19). Furthermore, the short duration of dietary intervention may not capture long-term adaptability in sodium handling or chronic vascular remodeling associated with prolonged salt exposure. Another limitation lies in the

reliance on self-reported dietary compliance beyond the measured urinary sodium data, as complete dietary control in non-laboratory settings remains inherently challenging. Although the classification thresholds used to define salt sensitivity are widely accepted, they may not fully capture the spectrum of physiological variability, particularly among borderline responders whose clinical implications remain uncertain. Additionally, confounding factors such as physical activity levels, stress, and unrecognized dietary components could have influenced blood pressure responses. Although demographic and lifestyle data were collected, more robust control or stratification by these variables may have enhanced the precision of the results. Future studies could benefit from larger, more diverse samples, longer follow-up durations, and exploration of biomarkers associated with salt sensitivity to strengthen risk stratification (20).

Despite these limitations, the study offers important contributions to understanding blood pressure physiology in young adults and emphasizes the need to consider individual variability in dietary recommendations (21). The high prevalence of salt sensitivity observed, alongside its measurable effects on blood pressure, suggests that personalized nutrition guidance may be more appropriate than broad population-level sodium guidelines (22). Future research should explore the underlying genetic, metabolic, and vascular factors contributing to salt sensitivity in youth. Investigations into whether early intervention in salt-sensitive individuals can alter long-term cardiovascular outcomes would be particularly valuable (23). Additionally, longitudinal designs tracking the progression of salt-sensitive normotensive individuals over time would help clarify the clinical trajectory and inform screening policies in routine health assessments. Overall, the findings demonstrate that salt sensitivity is a relevant and measurable phenomenon in young, healthy adults and deserves attention as a modifiable risk marker in the early prevention of hypertension and related cardiovascular disorders (24).

CONCLUSION

This study reveals a substantial prevalence of salt sensitivity among normotensive young adults, with clear associations between sodium intake and blood pressure response. These findings highlight the need for early identification of salt-sensitive individuals, even in seemingly low-risk populations, to guide targeted dietary interventions. Addressing salt sensitivity at a younger age could play a critical role in preventing future hypertension and cardiovascular disease.

AUTHOR CONTRIBUTION

Author	Contribution
Mohammad Abuzer Abbas*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Maheen Zulfiqar	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Ahmed Arbaz	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Shabana Tahir	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Tahir Hafeez	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Hira Sulemani	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Eman Aslam	Contributed to study concept and Data collection Has given Final Approval of the version to be published

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