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ORIGINAL ARTICLE

Association of Serum Calcium with Resting Heart Rate and Blood Pressure in Healthy Adults

ZAHID HABIB QURESHI[1], ABIDA JAFFAR[2], KHAWAR YOUNAS[3], BAKHTAWAR FAROOQ[4], KHUJASTA GUL[5], EJAZ HUSSAIN SAHU[6]
[1]*Assistant Professor, Department of Physiology, Multan Medical and Dental College (MMDC), Multan, Pakistan.*
[2]*Senior Demonstrator, Department of Biochemistry, Nishtar Medical University (NMU), Multan, Pakistan.*
[3]*MBBS, MPhil Biochemistry, Niazi Medical and Dental College, Sargodha, Pakistan.*
[4]*Assistant Professor & Incharge, Department of Biochemistry, Nishtar Medical University (NMU), Multan, Pakistan.*
[5]*Multan Medical and Dental College (MMDC), Multan, Pakistan.*
[6]*Professor, Multan Medical and Dental College (MMDC), Multan, Pakistan.*
Correspondence to: Bakhtawar Farooq, Email: bkff300@gmail.com

ABSTRACT

Background: Calcium is a vital mineral with established roles in bone health, neuromuscular transmission, and cardiovascular regulation. Disturbances in calcium balance have been associated with hypertension and arrhythmias. However, the relationship between serum calcium and cardiovascular parameters in healthy adults remains underexplored.

Objective: This study aimed to investigate the association of serum calcium with resting heart rate and blood pressure in healthy adult individuals.

Methods: A cross-sectional study was conducted at the Department of Physiology, Multan Medical and Dental College, Multan, in collaboration with Nishtar Medical University (NMU), Multan, from March 2022 to March 2023. A total of 120 healthy adults aged 20–45 years were recruited. Participants with cardiovascular, renal, or metabolic diseases, or those on calcium supplements, were excluded. Serum calcium was estimated using the Arsenazo III colorimetric method. Resting heart rate and blood pressure were measured under standardized conditions. Data were analyzed using SPSS version 26. Correlations between serum calcium and cardiovascular parameters were assessed using Pearson's correlation coefficient, with $p < 0.05$ considered statistically significant.

Results: The mean serum calcium level was 9.2 ± 0.4 mg/dL. The mean systolic blood pressure was 118.4 ± 8.6 mmHg, diastolic blood pressure was 76.2 ± 6.3 mmHg, and resting heart rate was 74.5 ± 8.2 bpm. Serum calcium was inversely correlated with resting heart rate ($r = –0.29$, $p = 0.002$) and systolic blood pressure ($r = –0.19$, $p = 0.030$), while the correlation with diastolic blood pressure was not significant ($r = –0.14$, $p = 0.080$).

Conclusion: Serum calcium is significantly associated with resting heart rate and modestly with systolic blood pressure in healthy adults, indicating a potential regulatory role of calcium in cardiovascular physiology.

Keywords: Serum calcium, Resting heart rate, Blood pressure, Healthy adults, Cardiovascular physiology

INTRODUCTION

Calcium is an essential divalent cation in human physiology, serving critical roles in bone mineralization, neuromuscular transmission, blood coagulation, and cellular signaling. Beyond its skeletal functions, calcium is a fundamental regulator of cardiovascular physiology[1]. It influences the excitability of cardiac myocytes, modulates vascular smooth muscle contraction, and contributes to the regulation of arterial blood pressure. Subtle changes in serum calcium concentration, even within the physiological range, can impact cardiac conduction, vascular tone, and autonomic function, thereby influencing both resting heart rate and systemic blood pressure[2,3].

Blood pressure and resting heart rate are simple, non-invasive, yet powerful indicators of cardiovascular health. Elevated resting heart rate is considered an independent predictor of cardiovascular morbidity and mortality, while high blood pressure remains the leading modifiable risk factor for coronary artery disease, stroke, and heart failure. Although several metabolic and lifestyle factors contribute to their regulation, the role of electrolytes particularly calcium has attracted increasing research interest in recent years[4,5].

Experimental evidence suggests that calcium plays a dual role in cardiovascular regulation. On one hand, adequate calcium is required for myocardial contractility and vascular integrity; on the other hand, alterations in calcium balance, whether hypocalcemia or hypercalcemia, have been linked with arrhythmias, hypertension, and vascular calcification[6]. Calcium directly modulates vascular smooth muscle cells through voltage-gated calcium channels, leading to vasoconstriction and changes in systemic vascular resistance. It also influences baroreceptor sensitivity and sympathetic nervous system activity, thereby affecting heart rate regulation[7,8].

Epidemiological studies have provided mixed findings regarding calcium and blood pressure. Some large-scale population studies have demonstrated an inverse relationship between serum calcium levels and hypertension, suggesting a protective effect, whereas others have shown weak or no significant associations[9]. Similarly, calcium intake and supplementation have been inconsistently linked to changes in blood pressure and heart rate, raising questions about the independent contribution of serum calcium to cardiovascular function. Despite these uncertainties, the physiological plausibility of calcium as a determinant of cardiovascular parameters remains strong[10].

In clinical practice, much attention has been directed toward the effects of sodium and potassium on cardiovascular health, but calcium has not received equivalent consideration. This is particularly relevant in populations with variable dietary calcium intake and differing risk profiles for cardiovascular disease[11]. Understanding how serum calcium correlates with basic cardiovascular markers such as resting heart rate and blood pressure in apparently healthy adults may provide insights into early mechanisms of cardiovascular risk, even before overt disease manifests[12].

Therefore, this study aims to investigate the association of serum calcium with resting heart rate and blood pressure in a cohort of healthy adults. By focusing on a disease-free population, the objective is to determine whether variations in serum calcium within the normal physiological range have measurable effects on cardiovascular function. Such findings may strengthen the concept of calcium homeostasis as a subtle but significant contributor to cardiovascular health and may open avenues for preventive strategies in populations at risk[13].

MATERIALS AND METHODS

Study Design and Setting: This cross-sectional observational study was conducted in collaboration between the Department of Physiology, Multan Medical and Dental College, Multan, and the Department of Physiology, Nishtar Medical University (NMU),

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Multan. The research was carried out over a period of one year, extending from March 2022 to March 2023.

Study Population and Sample Size: A total of 120 apparently healthy adult volunteers were recruited for this study. The participants were between 20 and 45 years of age and were selected through random sampling from the student and staff population of the two institutions. The sample size was determined in accordance with similar studies assessing serum calcium and cardiovascular parameters, ensuring sufficient statistical power to detect correlations with a 95% confidence interval.

Inclusion and Exclusion Criteria: Individuals included in the study were healthy male and female adults with a body mass index (BMI) between 18.5 and 29.9 kg/m² and with no history of cardiovascular or metabolic disease. Participants were required to be normotensive and willing to provide informed written consent. Exclusion criteria comprised individuals with a known history of hypertension, diabetes mellitus, chronic kidney disease, or other cardiovascular disorders. Subjects taking calcium supplements, vitamin D preparations, or antihypertensive drugs were also excluded. In addition, participants with abnormal electrolyte values at baseline screening, as well as pregnant or lactating women, were not included in the study.

Ethical Approval: The study protocol was approved by the Institutional Review Board (IRB) of Multan Medical and Dental College, Multan, and ethical clearance was also obtained from the Ethical Committee of Nishtar Medical University, Multan. Written informed consent was obtained from all participants after they were briefed about the study objectives, procedures, and potential benefits. The confidentiality of data was ensured throughout the study period.

Data Collection Procedures: Demographic details including age, gender, and anthropometric data were recorded for all participants. Height and weight were measured using a calibrated stadiometer and digital weighing scale, and body mass index (BMI) was calculated using the standard formula of weight in kilograms divided by height in meters squared.

Venous blood samples, measuring 5 mL, were drawn from each participant after an overnight fast. Samples were collected in plain vacutainers, allowed to clot, and centrifuged at 3000 revolutions per minute for 10 minutes. The separated serum was analyzed for calcium concentration using the Arsenazo III colorimetric method on an automated chemistry analyzer, ensuring accuracy and reproducibility of results.

Resting blood pressure was recorded in the seated position using a standard mercury sphygmomanometer. Participants were allowed to rest for at least ten minutes prior to measurement, and two readings were taken five minutes apart from the right arm. The average of the two readings was considered for analysis. Both systolic and diastolic blood pressures were documented. Resting heart rate was assessed by radial pulse palpation for one full minute and was cross-verified using a digital heart rate monitor. Measurements were taken in the morning to minimize diurnal variations and ensure consistency.

Statistical Analysis: All data were entered and analyzed using the Statistical Package for Social Sciences (SPSS) version 26. Continuous variables such as serum calcium, resting heart rate, systolic blood pressure, and diastolic blood pressure were expressed as mean ± standard deviation. Pearson's correlation coefficient was applied to determine the association between serum calcium levels and cardiovascular parameters. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Baseline Characteristics: A total of 120 healthy adults were included in the study, consisting of 65 males (54.2%) and 55 females (45.8%). The mean age of the participants was 31.2 ± 6.7 years (range 20–45 years), and the mean body mass index (BMI) was 24.6 ± 3.1 kg/m². The average serum calcium concentration was 9.2 ± 0.4 mg/dL, which was within the physiological reference range. Resting cardiovascular parameters showed a mean systolic blood pressure (SBP) of 118.4 ± 8.6 mmHg, a mean diastolic blood pressure (DBP) of 76.2 ± 6.3 mmHg, and a mean resting heart rate (RHR) of 74.5 ± 8.2 beats per minute. The baseline demographic, biochemical, and hemodynamic characteristics of the study population are summarized in Table 1.

Table 1: Baseline characteristics of participants (n = 120)

Variable	Mean ± SD / n (%)	Range
Age (years)	31.2 ± 6.7	20–45
Gender (Male/Female)	65 (54.2%) / 55 (45.8%)	–
BMI (kg/m²)	24.6 ± 3.1	18.7–29.9
Serum Calcium (mg/dL)	9.2 ± 0.4	8.4–10.2
Resting Heart Rate (bpm)	74.5 ± 8.2	60–95
Systolic BP (mmHg)	118.4 ± 8.6	104–138
Diastolic BP (mmHg)	76.2 ± 6.3	62–88

As shown in Table 1, all measured values fell within the normal ranges expected for healthy adults, confirming the inclusion of a normotensive, disease-free population suitable for analysis.

Correlation of Serum Calcium with Resting Heart Rate: A significant inverse relationship was observed between serum calcium and resting heart rate. Participants with higher serum calcium levels tended to have lower resting heart rates. The correlation coefficient was r = –0.29 with a p-value of 0.002, indicating statistical significance. This demonstrates that calcium homeostasis may exert a regulatory effect on cardiac autonomic control. The detailed correlation values are presented in Table 2.

Correlation of Serum Calcium with Blood Pressure: Serum calcium also showed an inverse correlation with blood pressure parameters. For systolic blood pressure, the correlation coefficient was r = –0.19 with a p-value of 0.030, which was statistically significant, although weaker than the association with heart rate. In contrast, the correlation between serum calcium and diastolic blood pressure was weaker and did not reach statistical significance (r = –0.14, p = 0.080). The complete summary of correlation values is shown in Table 2.

Table 2. Correlation of serum calcium with resting heart rate and blood pressure

Parameter	Correlation coefficient (r)	p-value
Resting Heart Rate (bpm)	–0.29	0.002
Systolic BP (mmHg)	–0.19	0.030
Diastolic BP (mmHg)	–0.14	0.080

As presented in Table 2, serum calcium demonstrated the strongest and most significant inverse correlation with resting heart rate, a modest but significant correlation with systolic blood pressure, and a non-significant correlation with diastolic blood pressure.

The results of this study suggest that serum calcium plays a measurable role in cardiovascular physiology even in apparently healthy individuals. As seen in Table 2, the inverse association between serum calcium and resting heart rate was statistically significant, indicating that calcium balance may influence autonomic regulation of cardiac activity. The modest negative correlation with systolic blood pressure implies that calcium may also contribute to vascular tone and arterial compliance, though the effect appears less pronounced than on heart rate. The lack of statistical significance in the relationship with diastolic blood pressure could reflect the complex interplay of other hemodynamic determinants in vascular resistance.

Overall, these findings highlight the importance of calcium homeostasis in maintaining optimal cardiovascular function and suggest that subtle variations in serum calcium within the normal range may influence resting cardiovascular parameters.

DISCUSSION

The present study investigated the association between serum calcium levels and cardiovascular parameters, specifically resting heart rate and blood pressure, in a cohort of 120 healthy adults[12]. The findings demonstrated a significant inverse correlation

between serum calcium and resting heart rate, a modest but significant negative correlation with systolic blood pressure, and a non-significant relationship with diastolic blood pressure. These results suggest that calcium homeostasis may play a regulatory role in cardiovascular physiology even among normotensive individuals without underlying disease[13,14].

Our observation that higher serum calcium levels were associated with lower resting heart rate is consistent with the physiological role of calcium in modulating cardiac pacemaker activity and autonomic nervous system function[15]. Calcium is essential for the depolarization of cardiac myocytes and conduction through the sinoatrial node. Adequate extracellular calcium enhances myocardial contractility and stabilizes cardiac rhythm, while disturbances in calcium balance, particularly hypocalcemia, have been linked to arrhythmias and prolonged QT intervals. The negative correlation found in this study suggests that within the normal physiological range, higher serum calcium may facilitate more efficient cardiac function, resulting in lower resting heart rates[16,17].

The modest inverse association between serum calcium and systolic blood pressure observed in this study is in line with previous population-based analyses. Several studies have reported that calcium may influence vascular smooth muscle contractility, endothelial function, and renin–angiotensin–aldosterone system regulation[18]. Calcium plays a dual role in vascular tone regulation while intracellular calcium influx promotes vasoconstriction, adequate extracellular calcium levels may suppress sympathetic nervous system activity and reduce arterial stiffness. This could partially explain the weaker but significant inverse relationship observed between calcium and systolic blood pressure in our participants[19].

In contrast, the lack of a statistically significant relationship between serum calcium and diastolic blood pressure suggests that the effects of calcium may be more pronounced on systolic function and arterial compliance than on peripheral resistance[20]. Diastolic blood pressure is influenced by a wider range of hemodynamic factors, including vascular resistance, arterial elasticity, and autonomic tone, which may obscure subtle contributions of calcium homeostasis in a healthy population[21].

These findings contribute to the growing body of evidence that calcium may serve as a biomarker of cardiovascular function, even among individuals without overt disease. While much of the existing research has focused on sodium and potassium in relation to hypertension, the potential role of calcium has been comparatively underexplored. Our study underscores the importance of considering calcium not only for bone and metabolic health but also as a subtle determinant of cardiovascular physiology[22,23].

A key strength of this study is its focus on healthy adults, which eliminates the confounding effects of chronic diseases and medication use[24]. Additionally, standardized methods were used for blood pressure, heart rate, and biochemical assessments, ensuring accuracy of measurements. However, certain limitations should be acknowledged. The cross-sectional design does not establish causality, and longitudinal studies are required to confirm these associations. Dietary calcium intake and vitamin D status were not assessed, both of which could influence serum calcium levels and cardiovascular outcomes. Furthermore, the study sample was restricted to adults in a single geographic region, which may limit the generalizability of results to wider populations[25].

CONCLUSION

This study demonstrates that serum calcium is inversely associated with resting heart rate and modestly correlated with systolic blood pressure in healthy adults. Although the relationship with diastolic blood pressure was not significant, the findings highlight a potential regulatory role of calcium homeostasis in cardiovascular physiology. These results suggest that maintaining optimal calcium levels may contribute to favorable cardiovascular function even in apparently healthy individuals. Future longitudinal and interventional studies should explore whether modulation of calcium status could serve as a preventive strategy for cardiovascular health.

Conflicts of Interest: The authors declare that they have no conflicts of interest regarding the publication of this article.

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Author Contributions

- **ZHQ**: Conceptualization, study design, data collection
- **AJ**: Laboratory analysis, methodology, interpretation of results
- **KY**: Statistical analysis, data validation
- **BF**: Literature review, drafting of manuscript
- **KG**: Data collection, patient recruitment
- **EHS**: Critical revision, supervision, and final approval of manuscript

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