

Original Research Article

Sodium, potassium and calcium ions in diabetic patients' serum and their correlation with glycaemic control in Jordanian patients: A cross-sectional study

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Abstract

Purpose: To assess the correlation among calcium (Ca^{+2}), potassium (K^{+}), and sodium (Na^{+}) electrolyte disturbances with glycaemic control in Jordanian diabetic patients in a cross-sectional study.

Methods: The data of 236 patients were enrolled in the study, of which 120 were diabetic patients, while the remaining 116 non-diabetic patients were used as controls. Data were selected from different departments of King Talal Military Hospital in Mafraq, Jordan. Fasting blood glucose, Na^{+} , K^{+} , and Ca^{+2} were analyzed by the ROCHE module Cobas analyzer using ROCHE kits in the hospital laboratories.

Results: Diabetic patients were of mean age of (61.1 ± 15.9) years. Sodium (Na^{+}) showed a significant negative correlation, Calcium (Ca^{+2}) showed an insignificant negative correlation, while Potassium (K^{+}) showed a positive association with fasting blood glucose.

Conclusion: The study demonstrates that there are differences between electrolytes (Na^{+} , K^{+} , Ca^{+2}) in diabetic patients compared to non-diabetic patients, suggesting that monitoring them will help in disease management.

Keywords: Calcium, Diabetic patients, Electrolyte disturbance, Fasting glucose, Potassium, Sodium

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INTRODUCTION

Body fluid consists of intracellular and extracellular components to ensure that the body works properly. Metabolism is considered to take place almost entirely within the intracellular fluid (ICF), although extracellular fluid (ECF) serves to maintain ionic strength and intracellular volume so that any change in extracellular osmolality results in an equal change in intracellular osmolality. These involve the electrolytes Na^{+} , K^{+} , and Ca^{+2} to maintain body fluid volume, cardiac rhythm, osmolar regulation, and

neuromuscular excitability. Homeostasis of these electrolytes is maintained by the sodium-potassium ion pump, which is activated by insulin and catecholamine hormones [1]. Diabetes mellitus is a syndrome characterized by hyperglycemia and impaired metabolism due to insulin deficiency or resistance [2]. This can cause bad health impacts such as blood vessel deterioration, metabolic imbalance, and electrolyte disturbance [3].

Electrolytes such as sodium, chloride, and potassium are essential for controlling cardiac,

neurological, skeletal, and cellular processes as well as preserving body's homeostasis [4]. Even with sufficient renal function, electrolyte disturbances can develop in diabetes mellitus and the incidence of this disturbance rises as renal function declines. Therefore, testing these electrolytes regularly is needed to monitor the health status of diabetic patients [5].

This study aimed to compare fasting glucose levels and electrolyte concentrations (Na^+ , K^+ , and Ca^{+2}) between diabetic and control groups and to investigate the correlations between these electrolytes and fasting glucose levels.

METHODS

Patient's data

This cross-sectional study was conducted by collecting the data of 236 patients (109 females and 127 males) from the medical records of outpatient clinics in King Talal Military Hospital from February 2024 to February 2025. Data were divided into two groups. The first group comprised 120 patients with diabetes and the second group had 116 healthy persons without diabetes, with an average age of 45-77 years for diabetic group and 30-71 years for control group. Control group was selected for persons having glucose levels within normal range.

Ethical consideration

The study adhered to the ethical guidelines of the institutional review board (IRB) of Al-Balqa Applied University. The approval number is (48/12/822). Patient privacy and confidentiality of all collected data were strictly protected following the principles of the Declaration of Helsinki [6].

Inclusion criteria

Patients diagnosed with type 2 diabetes mellitus aged more than 30 years and less than 80 years.

Exclusion criteria

Patients who have hypertension and any kind of kidney disease or who undergo hemodialysis were excluded from the study.

Biochemical tests

According to the routine tests that are performed by the hospital, 2 mL of blood was collected in sodium fluoride anticoagulant-containing tubes for plasma glucose testing and 4 mL of blood was collected in a gel tube to get serum for the electrolytes analysis. Fasting glucose, Na^+ , K^+ , and Ca^{+2} in samples were analyzed by automatic analyzer (ROCHE module Cobas) using ROCHE kits following the manufacturer's protocols. Reference ranges of various parameters according to these kits were as follows: Na^+ (135 - 153 mEq/dL), K^+ (3.5 - 5.5 mEq/dL) and Ca^{+2} (4.8 - 10.5 mg/dL). Fasting glucose levels diagnosed within the 70 - 110 mg/dL range were considered normal.

Statistical analysis

Student's t-test was used to determine the difference between the two groups and Pearson's correlation analysis was used to find the association. The data were shown as mean $\pm$ standard deviation (SD). Results were displayed at a 0.05 level of significance.

RESULTS

As shown in Table 1, in the diabetic group, there was a greater proportion of men (71 patients; 30.1 %) than women (49 patients; 20.8 %).

The analyzed parameters between the two groups are shown in Table 2, where patients with diabetes had an average age of 61.1 ± 15.9 years. The mean fasting glucose level in diabetes group (198.5 mg/dL) for all studied patients (males and females) was significantly higher than that of the control group (92.5 mg/dL). This indicates a clear distinction in glucose metabolism between individuals with diabetes and those without. Electrolyte levels in diabetic group were found to be as follows: Na^+ (134.7 ± 6.6 mEq/dL), K^+ (4.2 ± 0.7 mEq/dL) and Ca^{+2} (8.8 ± 0.9 mg/dL), where only Na^+ differs significantly between the diabetic patients and control group.

Table 1: Gender distribution of study participants

Gender	(Diabetic patients) n=120	Control n=116
Male	71 (30.1%)	56 (23.7%)
Female	49 (20.8%)	60 (25.4%)

Table 2: Tested parameters between diabetic patient group and non-diabetic control group (Mean $\pm$ SD)

Parameter	Diabetic patients n=120	Control n=116	P-value
Fasting glucose (mg/dL)	198.5 $\pm$ 107.1	92.5 $\pm$ 13.3	<0.05
Na ⁺ (mEq/dL)	134.7 $\pm$ 6.6	137.3 $\pm$ 4.4	<0.05
K ⁺ (mEq/dL)	4.2 $\pm$ 0.7	4.2 $\pm$ 0.8	>0.05
Ca ²⁺ (mg/dL)	8.8 $\pm$ 0.9	8.9 $\pm$ 0.8	>0.05
Age (Years)	61.1 $\pm$ 15.9	51.2 $\pm$ 19.8	<0.05

Table 3 shows the established correlation between electrolytes and fasting glucose. Na⁺ showed a significant negative association with fasting glucose ($r = -0.262$), Ca²⁺ showed insignificant negative association ($r = -0.011$), and K⁺ showed a significantly positive association with fasting glucose ($r = 0.149$).

Table 3: Correlation coefficient (r) between serum electrolytes (Na⁺, K⁺, Ca²⁺) and fasting blood glucose (mg/dL)

Electrolyte	Correlation coefficient (r)	P-value
Na ⁺ (mEq/dL)	-0.262	0.001
Ca ²⁺ (mg/dL)	-0.011	>0.05
K ⁺ (mEq/dL)	0.149	0.022

DISCUSSION

This study demonstrates that sodium is slightly higher in the diabetes group than in the control group and is negatively correlated with fasting blood sugar (FBS). Similar findings have been established by Anago *et al* [7] and Wang *et al* [8]. The most prevalent electrolyte disruption in clinical settings is hyponatraemia, often leading to increased mortality and morbidity [9]. Hyperglycaemia, hypoinsulinaemia, and acidosis have a linked association with electrolyte disturbances [10]. Hyperglycaemia dilutes the extracellular compartment (ECF) and electrolytes by drawing in water from the intracellular compartment. This causes osmotic diuresis, in which the loss of water causes sodium to be expelled, resulting in artificial hyponatraemia [11].

Although the serum levels of potassium are not significantly altered, as shown in the results, potassium levels showed a significant positive correlation with FBS. Hyperglycaemia causes hyperosmolality, which leads to cell dehydration, resulting in increased K⁺ extrusion from cells into ECF [12]. This might explain why serum Na⁺ and K⁺ levels have an inverse relationship with fasting plasma glucose.

Since calcium is necessary for the release of insulin from pancreatic cells, cellular calcium homeostasis modulation is considered an

essential target for beta-cell function preservation [13]. Yet this study found no evidence of a significant correlation between calcium levels and FBS and glycaemic regulation. The significant difference in sodium levels between diabetic and control groups suggests that sodium regulation may be affected in diabetes. Moreover, the significant positive correlation between potassium and fasting glucose highlights a potential area for further investigation, as this relationship may have implications for the management of potassium levels in diabetic patients.

Limitations

The high variability in fasting glucose levels, indicated by the large standard deviations, may have reduced the power to detect obvious differences. The cross-sectional design of this study limits the ability to draw causal inferences between electrolyte levels and fasting blood glucose.

CONCLUSION

This study identified significant differences in fasting blood glucose and sodium levels between diabetic and control groups in Jordanian diabetic patients, as well as a significant positive correlation between potassium levels and fasting glucose. These results contribute to understanding the relation between glucose metabolism and electrolyte balance in diabetes and suggest potential areas for further research to improve diabetes management strategies. Future studies should employ longitudinal designs and larger sample sizes to validate these findings and explore the mechanisms underlying the observed associations.

DECLARATIONS

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Use of Artificial intelligence/Large language models

The authors confirm that AI-based tools were used solely for language editing and manuscript polishing purposes (e.g., grammar, phrasing, and clarity). No AI tools were used to generate content, interpret data, or influence study design, results, or conclusions. All intellectual contributions, study analyses, and interpretations reported in the manuscript are the original work of the authors.

Ethical approval

The Institutional Review Board (IRB) of Al-Balqa Applied University approved this study (Approval no. 48/12/822).

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflict of interest

No conflict of interest is associated with this work.

Contribution of authors

We declare that this work was done by the author(s) named in this article, and all liabilities pertaining to claims relating to the content of this article will be borne by the authors.

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