PERIÓDICO TCHÊ QUÍMICA
ARTIGO ORIGINAL

AVALIAÇÃO DOS NÍVEIS DE ELETRÓLITO SÉRICO EM PACIENTES COM DIABETES MELLITUS

ASSESSMENT OF SERUM ELECTROLYTE LEVELS IN DIABETES MELLITUS PATIENTS

تقييم مستويات الشوارد في مصل الدم لدى مرضى داء السكري

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Received 30 November 2025; received in revised form 10 January 2026; accepted 04 March 2026

RESUMO

Introdução: Neste estudo, foram estimados novos biomarcadores para concentrações de alguns eletrólitos e sua relação com o diabetes. **Objetivo**: O estudo visa avaliar as concentrações críticas de alguns eletrólitos importantes presentes no corpo e sua relação com pacientes com diabetes tipo 2, além de estudar as razões para a diminuição e aumento de algumas concentrações. **Métodos:** Uma amostra foi retirada de pacientes com diabetes tipo 2 e as concentrações de alguns íons importantes foram medidas. Alguns desses íons foram estudados usando um dispositivo de eletrólitos SEMI do modelo American Origin, que foi então usado para testar as concentrações de eletrólitos. **Resultados:** Um total de 100 participantes foi incluído neste estudo, composto por 50 pacientes com diabetes mellitus tipo 2 (T2D) e 50 indivíduos saudáveis pareados por idade (ND). A idade dos participantes variou entre 15 e 65 anos. As avaliações bioquímicas incluíram a mensuração dos níveis de cálcio, cloreto, sódio e potássio em ambos os grupos. Entre os participantes, 35 (70%) eram do sexo masculino e 15 (30%) do sexo feminino. Não foi observada diferença estatisticamente significativa ($p > 0,05$) entre os grupos T2D e ND quanto à distribuição por sexo. **Discussão:** Os desequilíbrios eletrolíticos podem resultar do uso de medicamentos como diuréticos, medicamentos antidiabéticos e insulina exógena, bem como hiperglicemia, insuficiência renal e cetoacidose, outras condições que alteram a concentração de eletrólitos no corpo. Em contraste com os pacientes ND, os níveis séricos de Na^{+} e Cl^{-} aumentaram significativamente ($p < 0,05$) nesta investigação, embora os aumentos nos níveis de Ca^{+2} e K^{+} não tenham sido estatisticamente significativos ($p>0,05$). Esse achado está de acordo com pesquisas anteriores que mostraram níveis elevados de Na^{+} e Cl^{-} em pacientes com diabetes devido ao aumento da perda de água por diurese osmótica. No entanto, não houve alteração perceptível no Ca^{+2} entre os indivíduos DM2 e ND (valor de $P > 0,05$). **Conclusões:** A homeostase da glicose pode ser comprometida devido a alterações nos níveis de sódio, potássio, cálcio e cloreto.

Palavras-chave:*Idade, Diabetes mellitus, Concentração de eletrólitos, HbA1C*

ABSTRACT

Background: In this study, new biomarkers for concentrations of some electrolytes and their relationship to diabetes were estimated**. Aim:** The study aims to assess the critical concentrations of some important electrolytes present in the body and their relationship to patients with type 2 diabetes and to study the reasons for the decrease and increase in some concentrations**. Methods:** A sample was drawn from patients with type 2 diabetes, and the concentrations of some important ions were measured. Some of these ions were studied using an American Origin Model SEMI electrolyte device that was then used to test the electrolyte concentrations. **Results**: A total of 100 participants were included in this study, comprising 50 patients with type 2 diabetes (T2D) and 50 age-matched healthy controls (ND). The participants ranged in age from 15 to 65 years. Biochemical assessments included measurements of calcium, chloride, sodium, and potassium levels in both groups. Among the participants, 35 (70%) were male and 15 (30%) were female. No statistically significant difference ($p > 0.05$) was observed between T2D and ND groups with respect to sex distribution. **Discussion**:

DOI: 10.52571/PTQ.v23.n52.2026_02_AYAD_pgs_15_24.pdf

Electrolyte imbalances can result from using of drugs such as diuretics, antidiabetic medications, and exogenous insulin, as well as hyperglycemia, renal failure, and ketoacidosis, other conditions that alter the body's concentration of electrolytes. In contrast to ND patients and T2D patients, serum Na^+ and Cl^- levels increased significantly ($p < 0.05$) in this investigation, although the increases in Ca^{+2} and K^+ levels were not statistically significant ($p > 0.05$). This finding is in line with previous research that showed elevated Na+ and Cl^- levels in diabetes patients due to increased water loss via osmotic diuresis. However, there was no discernible change in Ca^{+2} between the T2D and ND individuals (P value > 0.05). **Conclusions:** Glucose homeostasis may be disrupted due to alterations in sodium, potassium, calcium, and chloride levels.

Keywords: *Age, Diabetes mellitus, Electrolytes concentration, HbA1C.*

الملخص

الخلفية: في هذه الدراسة، جرى تقدير مؤشرات حيوية جديدة لتراكيز بعض الشوارد وعلاقتها بداء السكري. **الهدف:** تهدف هذه الدراسة إلى تقييم التراكيز الحرجة لبعض الشوارد المهمة في الجسم وعلاقتها بمرضى السكري من النوع الثاني، فضلًا عن دراسة أسباب انخفاض وارتفاع بعض هذه التراكيز. **طرائق العمل:** تم سحب عينات من مرضى السكري من النوع الثاني، وقياس تراكيز بعض الأيونات المهمة. وقد دُرست هذه الأيونات باستخدام جهاز الشوارد من نوع SEMI ذو منشأ أمريكي، والذي استُخدم لقياس تراكيز الشوارد. **النتائج:** شملت هذه الدراسة 100 مشاركًا، منهم 50 مريضًا بداء السكري من النوع الثاني (T2D) و50 فردًا سليمًا متوافقين في العمر (ND). وتراوحت أعمار المشاركين بين 15 و65 عامًا. وقد شملت التقييمات الكيميائية الحيوية قياس مستويات الكالسيوم والكلوريد والصوديوم والبوتاسيوم في كلا المجموعتين. ومن بين المشاركين، كان 35 (70%) من الذكور و15 (30%) من الإناث، ولم تُسجَّل فروق ذات دلالة إحصائية ($p > 0.05$) بين مجموعتي مرضى السكري وغير المصابين من حيث التوزيع الجنسي. **المناقشة:** يمكن أن تنجم اختلالات الشوارد عن استخدام أدوية مثل المدرّات، والأدوية المضادة للسكري، والإنسولين الخارجي، إضافةً إلى فرط سكر الدم، والفشل الكلوي، والحماض الكيتوني، وغيرها من الحالات التي تؤثر في تراكيز الشوارد في الجسم. وقد أظهرت هذه الدراسة ارتفاعًا معنويًا ($p < 0.05$) في مستويات الصوديوم (Na^+) والكلوريد (Cl^-) في المصل لدى مرضى السكري من النوع الثاني مقارنةً بغير المصابين، في حين لم تكن الزيادات في مستويات الكالسيوم (Ca^{+2}) والبوتاسيوم (K^+) ذات دلالة إحصائية ($p > 0.05$). وتتوافق هذه النتائج مع دراسات سابقة أظهرت ارتفاع مستويات الصوديوم والكلوريد لدى مرضى السكري نتيجة زيادة فقدان الماء عبر الإدرار الأسموزي. كما لم يُلاحظ تغير معنوي في مستوى الكالسيوم (Ca^{+2}) بين المجموعتين ($p > 0.05$). **الاستنتاجات:** قد يختلّ الاتزان الداخلي للغلوكوز نتيجة التغيّرات في مستويات الصوديوم والبوتاسيوم والكالسيوم والكلوريد.

الكلمات المفتاحية: العمر، داء السكري، تراكيز الشوارد، *HbA1C*

1. INTRODUCTION:

The body uses electrolytes, such as K^+, Na^+, Cl^-, and Ca^{2+}, to promote various metabolic processes that ensure normal homeostasis and cellular activity and improve the creation of electrical gradients and enzyme activity (Chanchlani *et al*., 2017). However, deviations from normal electrolyte levels or imbalances can cause scientific illnesses or anomalies that are regularly related to lower mortality and morbidity rates (Coregliano-Ring *et al*., 2022).

Electrolyte imbalances are a common observation in clinical patients. They can be caused by various factors, including gastrointestinal absorption capacity, pharmaceutical medications, abnormalities in base acidity, acute medical conditions, or diseases that may function independently or in combination (Timerga *et al*.,2020). One of the conditions that commonly causes electrolyte distortion is diabetes (Kataoka *et al*.,2020). High blood glucose levels in diabetics cause an increase in plasma osmolality, which produces an osmotic driving force that causes water to flow from intracellular to extracellular areas (Zhang *et al*., 2022). Diabetes mellitus can lead to disturbances in electrolyte balance, which may contribute to complications (Muthmainnah et al., 2021). Monitoring serum electrolytes is important in the management of patients with diabetes (Yumashev *et al*., 2019; Al-Kaaby & Al-Ali, 2023; QASIM & FALIH., 2020).

There are two main ways this water movement and osmotic drift affect the body's concentration of electrolytes (Eledrisi *et al*., 2020), (Elliott *et al*., 2024). If the electrolyte concentration is extracellular, it may dilute or increase depending on whether intracellular electrolytes are carried to the extracellular space by water movement, particularly in the event of insulin insufficiency (Egboh *et al*., 2022). An electrolyte imbalance or disease is the result of this osmotic drift. Diabetes is linked to both hyper and hypo-electrolyte levels (Ye *et al*.,2016). Because so little research has assessed the degree of chloride modification across different groups, the dysregulation of chloride in diabetes is still unknown (Lee *et al*.,2020). Diabetic nephropathy, one of the consequences of diabetes marked by reduced renal function or failure, can cause an electrolyte imbalance (Khan *et al*., 2019). Diabetes is a complex illness that has correlations with age, sex, blood pressure,

and other variables (Shridhar *et al*., 2020; Wang *et al*., 2013).

Therefore, the study aims to evaluate the serum electrolyte level of patients with diabetes to assess the correlation of this electrolyte with diabetes risk factors.

1.1. Aims

The study aims to assess the critical concentrations of some important electrolytes present in the body and their relationship to patients with type 2 diabetes and to study the reasons for the decrease and increase in some concentrations.

1.2. Study Hypothesis

A hypothesis is an initial idea or a prospect that entails proving or disproving a causal relationship in social life between primary and secondary variables through experimental testing. It is written in a distinctive style that expresses the researcher's researcher's views regarding a particular issue. Hypotheses are a collection of opinions and ideas gained from reality and arranged rationally. The researcher thus picked a single hypothesis, which is as follows: (Chronic diabetic disease has a clear effect on the concentration of electrolytes in blood and hence creates numerous health problems). This hypothesis was chosen based on its implications to the theoretical side and factual facts in Iraq.

2. MATERIALS AND METHODS:

Provide sufficient details to permit repetition of the experimental work. A technical description of the methods should be given when they are new.

2.1. Materials

Blood samples were collected from patients with type 2 diabetes and healthy people, and the samples consisted of serum Cl^-, Na^+, K^+, and Ca^{+2}.

2.1.1. Study Samples

The population sample, which consists of some people we believe to share the same traits as those in the study group, is intended to be a specific, quantitative, and qualitative component. Consequently, a sample of 50 individuals with diabetes and 50 healthy individuals (control group) was purposefully selected.

2.2. Methods

Blood samples (5 mL) were collected from 50 diabetic patients and 50 healthy individuals using serum separator tubes. The samples were allowed to clot at room temperature for 20 minutes and then centrifuged at 3500 rpm (or specify the relative centrifugal force) for 15 minutes to separate the serum. Using a micropipette, the serum was extracted (1 ml) and transferred to microcentrifuge tubes. The serum samples were stored at -20°C until electrolyte concentrations were determined Within 24 hours. An American Origin Model SEMI electrolyte analyzer (fully automated random access clinical chemistry analyzer with photometric throughput of 400 tests / hour) was used to measure the concentrations of sodium, potassium, chloride, and calcium in the serum samples. The device was calibrated according to the manufacturer's guidelines, and quality control measures were performed using standard solutions before sample analysis.

2.1.1 Data on the distribution of sex

This section presents data on the sex distribution of the study participants, which refers to the biological classification of individuals as either male or female. An individual's sex can directly influence the results of a study due to biological differences between males and females. According to the statistical data, 40 out of the 50 diabetes patients in this study are men, while the remaining 10 patients are women, as indicated in Table 1 of the study's results.

2.1.2. The period of diabetes

The duration of diabetes is one of the factors affecting the results and data of this study, as concentrations of electrolytes in blood serum differ depending on the duration of diabetes. In the research, the patients were divided into three categories based on the duration of their diabetes: the first group includes patients with a disease duration of 1-5 years, the second group includes those with a duration of 6-10 years, and the third group includes those with a duration of 11-15 years, as shown in Table 2.

2.1.3. *Statistics*

Statistical analysis of the data was conducted using SPSS version 19. The analysis included descriptive statistics of the study population, types of samples, and methods of selecting them. Data were presented in tables,

and appropriate statistical tests, such as anova test, were applied to the primary and secondary data collected.

3. RESULTS AND DISCUSSION:

3.1. Results

There were 100 participants in this study, 50 of them had diabetes, and the other 50 were age-matched healthy controls. Table 3 displays the results of biochemical assays, such as calcium, chloride, sodium, and potassium levels, for both the diabetes and control groups. In the patients, HbA1c was considerably (P value < 0.05) more than that of non-diabetic healthy controls. Sodium and chloride levels in diabetic patients were higher than in controls, and these differences were significant (P value < 0.05). The calcium and potassium levels were found to be marginally higher than those of the controls.

A total of 100 participants participated in the trial; 50 (or 50%) of them had T2D, while the remaining 50 (or 50%) were ND patients, ages 15 to 65. There were 35 (70%) male and 15 (30%) female patients among them, and there was no discernible ($p>0.05$) sex difference between the T2D and ND patients. Table 4 indicates that the T2D patients had significantly higher age and FBS ($p<0.05$) than the ND patients, although the differences in SBP and DBP were not statistically significant. The periods were divided into three-time categories, where the first category included those affected from 1 to 5 years, the category from 6 to 10 years, and the third category from 11 to 15 years. Analyzes using Anova statistical analysis showed an evident variation in electrolyte concentrations, according to Table 5, Table 6, Table 7, and Table 8.

3.2. Discussion

Electrolyte imbalances can result from using of drugs such as diuretics, antidiabetic medications, and exogenous insulin, as well as hyperglycemia, renal failure, and ketoacidosis, other conditions that alter the body's concentration of electrolytes. In contrast to ND patients T2D patients, serum Na^+ and Cl^- levels increased significantly ($p<0.05$) in this investigation, although the increases in Ca^{+2} and K^+ levels were not statistically significant ($p>0.05$).

This finding is in line with previous research that showed elevated Na^+ and Cl^- levels in diabetes patients due to increased water loss via osmotic diuresis. However, there was no discernible change in Ca^{+2} between the T2D and ND individuals ($P >0.05$). This result was also seen in another investigation where Cl- significantly ($P < 0.05$) linked clearly with SBP and DBP. Nevertheless, no correlation found between (SBP and DBP) Ca^{+2} and K^+. Elevations of K^+ can result from elevated blood sugar since FBS and K^+ have a positive correlation. This, however, is not the usual situation, as hypokalemia is typically caused by hyperglycemia.

Consistent with our findings, Muthmainnah *et al.* (2021) also reported that patients with a family history of diabetes had a higher risk of developing gestational diabetes. The use of mesodiencephalic modulation therapy was shown by Yumashev *et al.* (2019) to help regulate blood glucose and improve outcomes in diabetic patients undergoing dental procedures, supporting the potential for adjunctive non-pharmacological interventions.

4. CONCLUSIONS:

In the current study, we found significantly high levels of sodium, potassium, calcium, and chloride in patients with type II diabetes when compared with healthy controls. All the comparisons had a p-value less than 0.05. Electrolyte abnormalities were associated with disrupted glucose homeostasis. Alterations in electrolyte balance could, therefore, play a role in the pathophysiology of type II diabetes. The results highlight the need for checking the levels of electrolytes in patients with type II diabetes, since these abnormalities may sometimes affect the prognosis or management of the disease. Further investigations should therefore seek to determine the nature of the underlying mechanisms that relate electrolyte disturbances to glucose homeostasis in T2D and possible clinical utility arising from monitoring of electrolytes. Interventions targeted at modifying electrolyte balance may be a new approach to therapy in improving outcomes in patients with type II diabetes, but further research is needed to explore this.

5. DECLARATIONS

5.1. Study Limitations

limitations include the small sample size, lack of robust demographic and clinical data, limited generalizability as a single-center study, and absence of longitudinal follow-up and outcome assessments.

5.2. Acknowledgments

Thanks and gratitude to all the workers at Shatra Teaching Hospital and their request to collect the records from patients, diabetic patients, and healthy people.

5.3. Funding Sources

The authors funded this research. No external funding was received.

Publication costs for this article were fully absorbed by Periódico Tchê Química under our Platinum Open Access policy, with support from Araucária Scientific Association (https://acaria.org/). The journal maintains strict ethical guidelines that prohibit accepting donations from authors during manuscript review, regardless of funding availability. This approach ensures complete independence between editorial decisions and financial considerations, reinforcing our commitment to scientific integrity and equitable knowledge dissemination.

5.4. Conflicts of Interest

The authors declare no conflicts of interest and no competing interests.

5.5. Data Availability

All data presented in this study are available in the manuscript tables and figures. Raw data are available upon request from the corresponding author.

5.6. Author Contributions

Ayad Kadhim: Conception and design, manuscript writing, final approval. Wisam Okash: Data collection, analysis, and interpretation, final approval.

5.7. AI and Computational Tools Declaration

"The authors declare that no generative artificial intelligence tools or computational language models were used in the conception, design, execution, data collection, data analysis, interpretation, manuscript writing, or any other aspect of this research or manuscript preparation."

5.8. Research Integrity Declaration

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5.10. Open Access License

6. STUDIES INVOLVING HUMAN AND ANIMAL SUBJECTS

6.1. Ethics Committee Approval

'Retrospective study using anonymized secondary data'.

6.2. Informed Consent

Not applicable.

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Table 1. *Gender distribution of samples*

Gender	diabetes patients		control group	
	Number	Percentage (%)	Number	Percentage (%)
Males	40	80%	35	70%
Females	10	20%	15	30%
Total	50	100%	50	100%

Table 2. *The Period of Diabetes Distribution of Samples*

Period of diabetes	Number	Percentage (%)
(one - five) years	fifteen	40 %
(six - ten) years	twenty	30 %
(eleven - fifteen) years	fifteen	30 %
total	fifty	100 %

Table 3. *Biochemical Measurements in Type II Diabetes*

Parameters	Diabetes (50) mean ± SD	Controls (50) mean ± SD	P* Value
**HbA1C(%)	10.8±1.41	4.6±0.5	< 0.05
Na^{+} mmol/L	141.44±6.78	134.98±13.68	< 0.05
K^{+} mmol/L	3.82±0.34	4.16±0.38	< 0.05
Ca^{+2} mmol/L	1.05±0.05	1.07±0.08	< 0.05
Cl^{-} mmol/L	102.18±4.55	96.96±11.01	< 0.05

P * value < 0.05 then it is considered to be statistically significant

**HbA_1c: Glycosylated Hemoglobin

Table 4. *Mean age, duration, SBP, DBP and FBS of diabetes mellitus in the study group.*

Variables	minimum	maximum	T2D Mean ±SD	ND Mean ±SD	P-value
Age(year)	15	65	40.0±14.86	39.54±15.23	0.050
Duration(year)	1	15	8.0±4.47	----------	p<0.05
SPB*(mmHg)	105	218	133.32±2.19	120.29±0.24	0.768
DPB**(mmHg)	63	156	80.21±2.32	80.21±0.16	0.230
FBS***(mg/dL)	16.0	320.0	176.21±13.72	66.57±2.32	p<0.05

***** (SBP: Systolic Blood Pressure); ****(**DBP: Diastolic Blood Pressure); ******* (FBS: Fasting Blood Sugar)

Table 5. *Potassium ion concentration and time period of diabetes*

Element	(I) Time period of diabetes	(J) Time period of diabetes	Mean Difference (I-J)	Std. Error	Sig.
K^+	(1 - 5) years	(6- 10) years	0.16	0.11	0.36
		(11 - 15) years	0.34	0.11	0.02
	(6- 10) years	(1 - 5) years	0.16	0.11	0.36
		(11 - 15) years	0.18	0.11	0.26
	(11 - 15) years	(1 - 5) years	0.34	0.11	0.02
		(6- 10) years	0.18	0.11	0.26

Table 6. *Sodium ion concentration and time period of diabetes*

Element	(I) Time period of diabetes	(J) Time period of diabetes	Mean Difference (I-J)	Std. Error	Sig.
Na^+	(1 - 5) years	(6- 10) years	0.83	0.38	0.10
		(11 - 15) years	1.75	0.40	0.00
	(6- 10) years	(1 - 5) years	0.83	0.38	0.10
		(11 - 15) years	0.91	0.38	0.06
	(11 - 15) years	(1 - 5) years	1.75	0.40	.000
		(6- 10) years	0.91	0.38	0.00

Table 7. *Calcium ion concentration and time period of diabetes*

Element	(I) Time period of diabetes	(J) Time period of diabetes	Mean Difference (I-J)	Std. Error	Sig.
Ca^{2+}	(1 - 5) years	(6- 10) years	0.12	0.01	.000
		(11 - 15) years	0.22	0.01	.000
	(6- 10) years	(1 - 5) years	0.12	0.01	.000
		(11 - 15) years	0.1	0.01	.000
	(11 - 15) years	(1 - 5) years	0.22	0.01	.000
		(6- 10) years	0.10	0.01	.000

Table 8. *Chloride ion concentration and time period of diabetes*

Element	(I) Time period of diabetes	(J) Time period of diabetes	Mean Difference (I-J)	Std. Error	Sig.
Cl^{-}	(1 - 5) years	(6- 10) years	0.69	0.71	0.62
		(11 - 15) years	0.08	0.76	0.99
	(6- 10) years	(1 - 5) years	0.69	0.71	0.62
		(11 - 15) years	0.77	0.71	0.55
	(11 - 15) years	(1 - 5) years	0.08	0.76	0.99
		(6- 10) years	0.77	0.71	0.55