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High Prevalence of Hypomagnesemia and Hypocalcemia in Ajdabiya, Libya: Implications for Electrolyte Homeostasis

Husam Dakheel*, Hadeel Ahmed

Department of Biology, Faculty of Science, University of Ajdabiya, Ajdabiya, Libya.

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ABSTRACT

Electrolyte homeostasis is essential for maintaining vital physiological functions, including neuromuscular activity, cardiovascular stability, and metabolic regulation. Among the key electrolytes, magnesium (Mg^{2+}) and calcium (Ca^{2+}) play critical roles in numerous biochemical and cellular processes. However, data on their abnormalities in eastern Libya remain limited. This study aimed to evaluate serum magnesium (Mg^{2+}) and calcium (Ca^{2+}) levels and to determine the prevalence of their abnormalities within the context of electrolyte balance in individuals from Ajdabiya, Libya. A retrospective cross-sectional study was conducted at Al-Masarra Medical Analysis Laboratory between 2024 and 2025. A total of 100 serum samples were analyzed for major electrolytes, including sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}), calcium (Ca^{2+}), and magnesium (Mg^{2+}). Electrolyte levels were measured using ion-selective electrode (ISE) analysis and spectrophotometric methods. The results showed that sodium (Na^{+}), potassium (K^{+}), and chloride (Cl^{-}) levels were predominantly within normal ranges. In contrast, abnormalities in magnesium (Mg^{2+}) and calcium (Ca^{2+}) were more prevalent. Hypomagnesemia was the most common electrolyte disturbance (41.9%), followed by hypocalcemia (17.9%). Increased susceptibility was observed in younger (<15 years) and older (≥55 years) age groups, with no statistically significant differences between genders ($p > 0.05$). Magnesium (Mg^{2+}) deficiency represents a significant and underrecognized health concern in this population, with potential implications for electrolyte homeostasis and overall health. These findings highlight the importance of routine monitoring of magnesium and calcium levels and underscore the need for further research into underlying dietary and environmental factors.

ارتفاع معدل انتشار نقص المغنيسيوم والكالسيوم في اجدابيا - ليبيا: الآثار المترتبة على توازن الكهارل

حسام دخيل* وهديل احمد

قسم الأحياء، كلية العلوم، جامعة أجدابيا، أجدابيا، ليبيا.

الكلمات المفتاحية:
الانتشار المرتبط بالعمر.
نقص الكالسيوم.
اختلال توازن الكهارل.
نقص المغنيسيوم.
تحليل مصل الدم.

الملخص

يعد توازن الكهارل ضروريًا للحفاظ على الوظائف الفسيولوجية الحيوية، بما في ذلك النشاط العصبي العضلي، واستقرار القلب والأوعية الدموية، وتنظيم عمليات الأيض. ومن بين الكهارل الرئيسية، يلعب المغنيسيوم (Mg^{2+}) والكالسيوم (Ca^{2+}) أدوارًا حاسمة في العديد من العمليات الكيميائية الحيوية والخلوية. ومع ذلك، لا تزال البيانات المتعلقة باضطرابات مستوياتهما في شرق ليبيا محدودة. هدفت هذه الدراسة إلى تقييم مستويات المغنيسيوم (Mg^{2+}) والكالسيوم (Ca^{2+}) في مصل الدم، وتحديد مدى انتشار اضطراباتهما في سياق توازن الكهارل لدى أفراد من أجدابيا، ليبيا. أُجريت دراسة مقطعية استرجاعية في مختبر المسرة للتحاليل الطبية خلال الفترة من 2024 إلى 2025. وتم تحليل 100 عينة مصل دم للكشف عن الكهارل الرئيسية، بما في ذلك الصوديوم (Na^{+})، والبوتاسيوم (K^{+})، والكلوريد (Cl^{-})، والكالسيوم (Ca^{2+})، والمغنيسيوم (Mg^{2+}). تم قياس مستويات الكهارل باستخدام تحليل الأقطاب الانتقائية للأيونات

*Corresponding author.
E-mail addresses: husam.alamamy@gmail.com.
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(ISE) وطرق قياس الطيف الضوئي. أظهرت النتائج أن مستويات الصوديوم (Na^+) والبوتاسيوم (K^+) والكلوريد (Cl^-) كانت ضمن المعدلات الطبيعية في الغالب. في المقابل، كانت اضطرابات المغنيسيوم (Mg^{2+}) والكالسيوم (Ca^{2+}) أكثر شيوعًا. وكان نقص المغنيسيوم أكثر اضطرابات الكهارل شيوعًا (41.9%)، يليه نقص الكالسيوم (17.9%). لوحظ ازدياد في قابلية الإصابة لدى الفئات العمرية الأصغر (أقل من 15 عامًا) والأكبر (55 عامًا فأكثر)، دون وجود فروق ذات دلالة إحصائية بين الجنسين ($p > 0.05$).. يمثل نقص المغنيسيوم (Mg^{2+}) مشكلة صحية مهمة وغير معروفة بشكل كافٍ لدى هذه الفئة السكانية، مع ما يترتب على ذلك من آثار محتملة على توازن الكهارل والصحة العامة. تسلط هذه النتائج الضوء على أهمية المراقبة الروتينية لمستويات المغنيسيوم والكالسيوم وتؤكد على الحاجة إلى مزيد من البحث في العوامل الغذائية والبيئية الكامنة.

1. Introduction

Electrolytes, including sodium (Na^+), potassium (K^+), chloride (Cl^-), calcium (Ca^{2+}), and magnesium (Mg^{2+}), play a critical role in maintaining essential physiological processes such as cellular function, blood pressure regulation, and muscle contraction, as well as cardiovascular and renal activity [1]. Electrolyte imbalances, whether due to excess or deficiency, may lead to serious health complications, including cardiac arrhythmia, seizures, nerve damage, and coma [2].

Magnesium (Mg^{2+}) acts as a cofactor in more than 300 enzymatic reactions, particularly in regulating the Na^+/K^+-ATPase pump, which maintains proper intracellular ion distribution [3]. Its levels also influence calcium and potassium balance, and deficiencies are associated with poor health outcomes, including an increased risk of cardiovascular disease and complications in diabetic patients [4].

Patients with chronic diseases such as diabetes, especially those undergoing treatments that elevate sodium and potassium levels, are at increased risk of complications, including cardiovascular and neurological disorders [5]. Studies in Libya also indicate significant differences in electrolyte concentrations between healthy and diseased individuals, influenced by environmental and physiological factors [6].

Many developing regions lack sufficient data on electrolyte imbalance despite environmental and dietary influences that may affect electrolyte homeostasis [7]. Electrolyte imbalance represents an important risk factor in chronic diabetes and should be included in comprehensive evaluations of glycemic status, as blood glucose levels reflect body water balance and total glucose load, indicating the harmful effects of metabolic imbalance [8].

Regarding potassium, its levels are tightly regulated, and abnormalities can lead to alterations in cardiac rhythm and neuromuscular function. Elevated levels may result in serious cardiac complications, including cardiac arrest [9]. It also plays a vital role in regulating metabolism and acid–base balance, particularly in metabolic acidosis [10].

Potassium imbalance is associated with neuromuscular symptoms such as spasms and tingling and is linked to an increased fracture risk in diabetic patients with nephropathy. Additionally, magnesium imbalance is common among patients with type 2 diabetes due to its association with cardiovascular disease and neuropathy [11], while excessive levels, although rare, may impair neurological function and affect blood pressure in chronic conditions [12].

Electrolyte balance is influenced by several interconnected environmental, health, and nutritional factors, making its understanding essential for preventing and managing imbalances. Environmental conditions, particularly climate, play a significant role. In desert regions such as Ajdabiya, high temperatures increase fluid and salt loss through sweating, leading to disturbances in sodium, potassium, calcium, and magnesium levels [13].

Chronic diseases such as diabetes, kidney disorders, and endocrine dysfunctions significantly affect electrolyte balance. Kidney damage in diabetic patients impairs electrolyte reabsorption, causing loss or accumulation of ions such as potassium and magnesium [14]. Moreover, medications such as diuretics can increase electrolyte loss, making regular monitoring essential during treatment [15].

Ionic balance is closely linked to dietary intake, as imbalances in sodium, potassium, and magnesium may cause functional disorders, particularly among vulnerable groups such as the elderly and patients. Socioeconomic factors also affect access to electrolyte rich diets [16]. Due to these environmental, dietary, and demographic influences, this study aimed to assess serum magnesium and calcium levels among individuals undergoing laboratory testing in Ajdabiya.

Despite the recognized importance of magnesium and calcium in maintaining electrolyte homeostasis, data on their prevalence and imbalance remain limited in eastern Libya, particularly in Ajdabiya. Understanding the distribution of these essential electrolytes is crucial for early detection and prevention of associated metabolic and clinical complications.

Therefore, this study aimed to evaluate serum magnesium and calcium levels and to determine the prevalence of their abnormalities among individuals undergoing laboratory testing in Ajdabiya, Libya.

2. Materials and Methods

2.1. Study Design and Setting

This study was designed as a retrospective cross-sectional study conducted at Al-Masarra Medical Analysis Laboratory in Ajdabiya, Libya, from January 2024 to December 2025. The study aimed to evaluate serum electrolyte levels, with a particular focus on magnesium (Mg^{2+}) and calcium (Ca^{2+}), among individuals undergoing routine biochemical investigations.

2.1.1. Study Population

The comparison between 2024 and 2025 was based on aggregated laboratory data. The samples analyzed in each year were not necessarily obtained from the same individuals, and therefore, the comparison reflects population-level trends rather than longitudinal changes. A total of 100 individuals were included in this study. Participants were categorized into five age groups for analytical purposes.(0–12 years), (13–25 years), (26–45 years), (46–60 years), and (>60 years).The study population included both males and females who attended the laboratory for routine

Inclusion and Exclusion Criteria

Inclusion Criteria

- Individuals who attended the laboratory between 2024 and 2025
- Individuals with laboratory requests for serum electrolyte analysis
- Properly collected and processed blood samples suitable for biochemical testing

Exclusion Criteria

- Hemolyzed blood samples
- Insufficient sample volume
- Improperly stored or contaminated specimens
- Samples with incomplete laboratory data

2.1.2. Sample Collection and Processing

Venous blood samples were collected using standard aseptic techniques into serum separation tubes. The samples were allowed to clot at room temperature and were subsequently centrifuged at 3000 rpm for 10 minutes to separate serum from cellular components. The obtained serum was used immediately for biochemical analysis to ensure accuracy and minimize pre-analytical errors.

2.2. Biochemical Analysis

Serum electrolyte concentrations were measured using standardized laboratory techniques:

- Sodium (Na^+), potassium (K^+), and chloride (Cl^-) levels were determined using an ion-selective electrode (ISE) analyzer.

- Calcium (Ca^{2+}) and magnesium (Mg^{2+}) concentrations were measured using automated spectrophotometric methods, including the MAGLUMI 800 system and the MISPA AGAPPE analyzer.

All measurements were performed according to the manufacturers' instructions to ensure analytical accuracy and reproducibility.

2.3. Quality Control

Quality control procedures were implemented throughout the study. All instruments were calibrated regularly using standard reference solutions. Internal quality control samples were analyzed daily to verify the accuracy and precision of the measurements. Proper sample handling and equipment maintenance were strictly followed to minimize analytical errors.

2.4. Statistical Analysis

Data was coded and analyzed using IBM SPSS Statistics version 26. Descriptive statistics were used to summarize the data, with continuous variables expressed as mean ± standard deviation (SD), and categorical variables presented as frequencies and percentages. Inferential statistical analysis was conducted .Inferential statistical analysis was conducted. An independent samples t-test was used to compare electrolyte levels between males and females .One-way analysis of variance (ANOVA) was used to assess differences across age groups A p-value of less than 0.05 was considered statistically significant. The results were presented in tables and figures where appropriate to facilitate interpretation and comparison.

3. Results

3.1. Demographic Distribution:

Table 1: Age and gender distribution of study participants

Age (years)	Male (n)	Female (n)	Percentage (%)
0 – 12	8	7	15%
13 – 25	9	9	18%
26 – 45	14	13	27%
46 – 60	12	10	22%
> 60	9	9	18%
Total	52	48	100%

The study included 100 participants, with 52 males (52%) and 48 females (48%), indicating a relatively balanced representation between both sexes. The age distribution is presented in (Table 1). The largest proportion of participants belonged to the 26–45 years age group (27%), followed by the 46–60 years group (22%). Participants aged 13–25 years and those above 60 years each represented 18% of the total sample, while the 0–12 years group accounted for 15%.

3.2. Electrolyte Concentrations:

Table 2: Serum electrolyte levels and their distribution among study participants in Ajdabiya, Libya

Electrolyte	Mean ± SD	Range	Normal	Low	High
Na^+ (mmol/L)	138.75 ± 5.66	100–145	97.3%	2.7%	0%
K^+ (mmol/L)	4.35 ± 0.50	2.86–5.50	97.3%	2.7%	0%
Cl^- (mmol/L)	100.15 ± 3.72	68–111	96.5%	2.7%	0.9%
Ca^+ (mg/dL)	8.94 ± 0.77	7.00–10.40	82.1%	17.9%	0%
Mg^+ (mg/dL)	1.73 ± 1.35	1.04–2.50	58.1%	41.9%	0%

The electrolyte measurements were summarized using descriptive statistics, as shown in (Table 2) and (Fig.1).Sodium (Na^+): mean 138.75 ± 5.66 mmol/L (range: 100–145); 97.3% within normal range, 2.7% hyponatremia. Potassium (K^+): mean 4.35 ± 0.50 mmol/L (2.86–5.50); 97.3% normal, 2.7% below threshold. Chloride (Cl^-): mean 100.15 ± 3.72 mmol/L (68–111); 96.5% normal, 2.7% low, 0.9% high. Calcium (Ca^{2+}): mean 8.94 ± 0.77 mg/dL (7.00–10.40); 82.1% normal, 17.9% hypocalcemia. Magnesium (Mg^{2+}): mean 1.73 ± 1.35 mg/dL (1.04–2.50); 58.1% normal, 41.9% hypomagnesemia, making it the most frequent abnormality.

The distribution of normal and abnormal electrolyte levels among the study participants. Hypomagnesemia was the most prevalent abnormality (41.9%), followed by hypocalcemia (17.9%), whereas sodium, potassium, and chloride levels were predominantly within normal ranges (Fig. 1).

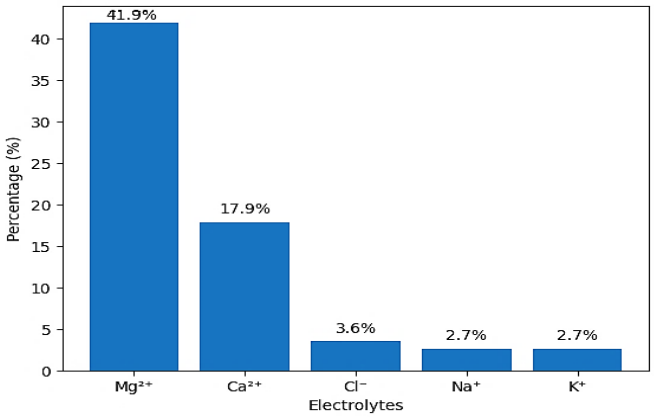

Fig.1: Prevalence of electrolyte abnormalities among study participants

Table 3: Comparison of electrolyte levels between genders

Electrolyte	Male Mean±SD	Female Mean±SD	t-test	p-value
Na^+ (mmol/L)	138.9 ± 5.4	138.5 ± 5.9	0.45	0.65
K^+ (mmol/L)	4.36 ± 0.52	4.34 ± 0.48	0.25	0.80
Cl^- (mmol/L)	100.2 ± 3.7	100.1 ± 3.8	0.12	0.90
Ca^+ (mg/dL)	8.95 ± 0.78	8.93 ± 0.76	0.14	0.89
Mg^+ (mg/dL)	1.75 ± 1.36	1.70 ± 1.34	0.21	0.83

The comparison of electrolyte concentrations between males and females in (Table 3). No statistically significant differences were observed for any electrolyte ($p > 0.05$), indicating that gender did not have a significant impact on electrolyte levels in this population. Regarding inter-annual fluctuations, irregularities in Na^+ decreased markedly in 2025, while K^+ and Cl^- remained relatively stable with only minor variations.

Reveals a temporal variation in electrolyte abnormalities between 2024 and 2025, with a decreasing trend in hypomagnesemia and a concurrent increase in hypocalcemia. Despite the reduction (Fig. 2), magnesium deficiency remains the most prevalent abnormality in both years, reinforcing its dominant role in electrolyte imbalance. The opposite trends observed for magnesium (Mg^{2+}) and calcium (Ca^{2+}) may reflect physiological interdependence, were alterations in magnesium (Mg^{2+}) status influence calcium (Ca^{2+}) regulation.

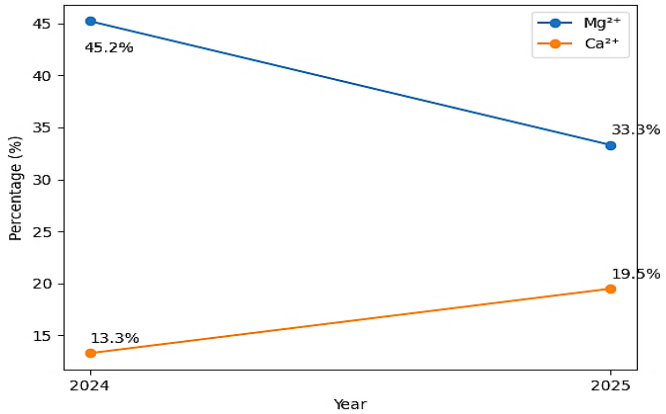

Fig.2: comparison of magnesium (Mg^{2+}) and calcium (Ca^{2+}) abnormalities showing decreasing Mg^{2+} and increasing Ca^{2+} trends

Table 4: Comparison of electrolyte levels across age groups

Age group (years)	Na^+ Mean ± SD	K^+ Mean ± SD	Cl^- Mean ± SD	Ca^{2+} Mean ± SD	Mg^{2+} Mean ± SD	ANOVA p-value
***1.* 0–12**	2. 138.0 ± 5.1	3. 4.30 ± 0.45	4. 99.8 ± 3.5	5. 8.80 ± 0.70	6. 1.60 ± 0.40	7. 0.32
***8.* 13–25**	9. 138.7 ± 5.3	10. 4.32 ± 0.48	11. 100.0 ± 3.6	12. 8.90 ± 0.72	13. 1.72 ± 0.35	14.
***15.* 26–45**	16. 138.9 ± 5.6	17. 4.37 ± 0.51	18. 100.2 ± 3.7	19. 8.95 ± 0.78	20. 1.80 ± 0.38	21.
***22.* 46–60**	23. 138.6 ± 5.5	24. 4.35 ± 0.52	25. 100.1 ± 3.8	26. 8.93 ± 0.76	27. 1.70 ± 0.42	28.
***29.* > 60**	30. 138.4 ± 5.7	31. 4.34 ± 0.49	32. 100.1 ± 3.8	33. 8.92 ± 0.77	34. 1.65 ± 0.39	35.

The comparison of electrolytes among different age categories using one-way ANOVA is presented in (Table 4). No significant differences were observed for any electrolyte ($p > 0.05$), although slight variations were noted in Mg^+ and Ca^+ levels across age groups.

4. Discussion

4.1. Hypomagnesemia (Low Mg):

The results of this study revealed that hypomagnesemia was the most prevalent disorder among participants, highlighting Mg^{+} deficiency as a critical metabolic condition due to its essential roles in cell membrane stability, nerve signal transmission, and cardiovascular function [17,18,19,20].

The prevalence observed in this study was higher than many previous reports, which indicate rates of 10–30% among hospitalized patients and up to 65% in critically ill individuals [21,22]. This discrepancy may reflect differences in population characteristics, environmental conditions, and dietary habits specific to Ajdabiya. The study revealed that hypomagnesemia was the most prevalent electrolyte abnormality (41.9%).This high prevalence suggests that magnesium deficiency is not an isolated clinical finding but rather a population-level disturbance, likely driven by chronic and systemic factors. This indicates a potentially underrecognized public health issue, requiring routine monitoring and preventive strategies. Possible contributing factors include inadequate dietary intake of magnesium (Mg^{2+}) rich foods, low magnesium (Mg^{2+}) content in drinking water, and increased loss due to environmental conditions such as high temperatures and sweating. Additionally, subclinical magnesium deficiency may remain undetected due to the absence of early symptoms. Due to the lack of specific early-stage symptoms, Mg^{+} deficiency often goes clinically undiagnosed [23], emphasizing the importance of serum measurements for early detection and management [24,25]. Future studies should investigate the combined effects of dietary habits, water composition, environmental factors, and health status on magnesium (Mg^{2+}) levels in this population.

4.2. Hypocalcemia (Low Ca):

Hypocalcemia was the second most common abnormality (17.9%).This finding suggests a moderate but clinically relevant deficiency, potentially influenced by nutritional factors and its physiological interaction with magnesium (Mg^{2+}) . The coexistence of hypocalcemia with hypomagnesemia supports the concept of interdependent electrolyte imbalance, rather than isolated deficiencies. Insufficient dietary intake of calcium (Ca^{2+}) has been linked to higher prevalence rates [26], suggesting that nutritional factors may contribute to the findings in this study. The increasing occurrence of hypocalcemia in 2025 indicates a worsening trend, which may be influenced by nutritional deficiencies, chronic diseases, or interactions with magnesium (Mg^{2+}) levels. Previous research also associates high calcium (Ca^{2+}) levels with reduced magnesium (Mg^{2+}) [27], hypoparathyroidism, parathyroid hormone resistance, and increased mortality following trauma [28,29,30].

4.3. Age and Gender Impact:

Higher susceptibility was observed in younger (<15 years) and older ($\geq$ 55 years) age groups. This pattern reflects physiological vulnerability at age extremes, where nutritional requirements and absorption efficiency differ. These groups should be considered high-risk populations for targeted screening and intervention., which matches global figures linking at-risk populations to electrolyte disruption [31,32].

5. Conclusion

This study demonstrates that hypomagnesemia is the most prevalent electrolyte abnormality in the Ajdabiya population, followed by hypocalcemia, while other electrolytes remain largely stable. The clinical importance of these findings is highlighted due to the crucial roles of magnesium (Mg^{2+}) and calcium (Ca^{2+}) in maintaining neurological, cardiac, and renal function, as well as their association with increased mortality in the absence of early intervention. The lack of significant differences between genders suggests that environmental and behavioral factors may have a greater influence than biological factors on prevalence rates. Age remains an important determinant, with the risk of imbalance increasing at both ends of the age spectrum (younger and older individuals). These results indicate that magnesium deficiency is an underrecognized public health issue in this region, likely influenced by environmental and dietary factors rather than acute clinical conditions alone. The findings support the implementation of national nutritional monitoring programs and regular electrolyte screening, as well as the adoption of comprehensive nutritional and health strategies to reduce the burden of these disorders and improve overall health outcomes.

6. Recommendations

1. Routine screening of serum magnesium (Mg^{2+}) and calcium (Ca^{2+}) levels should be implemented, particularly among high-risk groups such as children and elderly individuals.
2. Public health initiatives should focus on improving dietary intake of rich foods, including leafy vegetables, whole grains, and legumes.
3. Further investigations are needed to assess the mineral composition of drinking water in Ajdabiya and its potential role in electrolyte imbalance.
4. Healthcare professionals should increase awareness of hypomagnesemia as a commonly overlooked condition due to its high prevalence and nonspecific clinical presentation.
5. Future large-scale and longitudinal studies are recommended to better understand the underlying causes and long-term health implications of electrolyte imbalances in this population.

7. Acknowledgement

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