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Original article

Association Between Calcium Status, Diet, and Lifestyle Factors Among School-Aged Children in Al Bayda, Libya

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Abstract
The acquisition of peak bone mass during early and middle childhood is a fundamental determinant of long-term skeletal integrity. In Al-Bayda, Libya, unique environmental variables—including extreme seasonal thermoregulation challenges—may significantly alter behavioral and physical activity patterns, potentially compromising mineral homeostasis within the pediatric population. This study aimed to evaluate serum calcium status among children aged 5–10 years in Al-Bayda and to delineate the dietary, environmental, and lifestyle factors associated with deficiency. A cross-sectional study was conducted involving 198 children (75 males; 123 females) at the Al-Bayda Specialized Laboratory. Following the quantification of serum calcium levels, a structured 25-item validated questionnaire was administered to caregivers to assess nutritional habits, sedentary versus active behaviors, and clinical symptomatology. Statistical analysis was performed using Student's t-tests and Odds Ratio (OR) calculations to identify significant correlates of deficiency. Quantitative analysis indicated that 86% of the cohort maintained normocalcemia (mean = 9.815 mg/dL), whereas 14% exhibited clinical deficiency (mean = 7.770 mg/dL). High-frequency fast-food consumption was identified as the primary dietary risk factor, yielding a 32.3-fold increase in the likelihood of deficiency. Conversely, daily milk consumption (OR = 12.38) and regular solar radiation exposure (OR = 53.48) served as the most robust protective factors. Clinically, calcium depletion was strongly associated with osteodynia (74.1%), dental caries (74.1%), and a universal prevalence of anorexia (100%). Notably, children with calcium deficiency were 35.6 times more likely to present with clinical markers indicative of impaired immune function. Pediatric calcium status in Al-Bayda is predominantly influenced by modifiable lifestyle behaviors rather than age-dependent physiological variables. The profound correlation between insufficient heliotherapy, poor dietary quality, and mineral depletion underscores the exigency for targeted public health interventions. Enhancing community literacy regarding safe UV exposure and implementing fortified school-based nutritional programs are imperative to mitigate the risk of impaired skeletal development in this region.
Keywords. *Calcium Deficiency, Pediatric Nutrition, Heliotherapy, Lifestyle Determinants.*

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Introduction

The establishment of optimal bone health during childhood and adolescence is a fundamental prerequisite for lifelong skeletal integrity and metabolic stability. As the primary structural constituent of bone tissue, calcium is indispensable for achieving peak bone mass, which serves as a critical factor in mitigating the long-term risk of osteoporosis and fragility fractures [1,2]. Beyond its structural utility, calcium acts as a vital mediator in neuromuscular signaling and immunological resilience, working in concert with other micronutrients to fortify the body against infection [3]. Accordingly, global consensus guidelines continue to underscore the urgency of adequate calcium and Vitamin D intake to combat nutritional rickets and osteomalacia, both of which persist as significant public health burdens worldwide [4, 5].
Despite the undisputed importance of calcium, recent global nutritional transitions have precipitated a decline in dietary quality among pediatric populations. The burgeoning consumption of ultra-processed foods has been closely linked to compromised nutritional status, as these products frequently displace essential micronutrients with "empty" calories [6,7]. This shift is further exacerbated by modern sedentary behaviors and changing dietary preferences, such as the trend toward reduced-fat milk or the total exclusion of dairy, which raise serious concerns regarding calcium adequacy and its subsequent impact on developmental health [8,9]. Furthermore, environmental constraints and physical inactivity serve as significant modifiers of bone mineralization, where insufficient sunlight exposure and a lack of weight-bearing exercise further drive the prevalence of these mineral deficiencies [10,11].
In the Middle East and North Africa (MENA) region, the prevalence of Vitamin D and calcium deficiencies has reached alarming levels, fueled by a complex intersection of cultural, environmental, and dietary

determinants [12]. While international literature provides a broad framework for understanding these deficiencies, there remains a notable dearth of localized data focusing on specific urban centers in Libya. In Al-Bayda, children may be subject to unique lifestyle and dietary challenges that influence their mineral status, yet empirical evidence in this specific context remains sparse. Consequently, this study was designed to evaluate the calcium status of school-aged children in Al-Bayda and to elucidate the specific dietary habits, lifestyle behaviors, and environmental factors associated with deficiency. By identifying these localized risk factors, this research aims to establish a robust scientific foundation for targeted nutritional interventions and public health policies tailored to the Libyan context.

Methods

Study Design, Setting, and Participants

This cross-sectional study was conducted at Al-Bayda Specialized Laboratory between January and October 2025 to assess calcium status and its multifaceted impact on the growth and overall health of the pediatric population. The study cohort comprised 198 children aged 5–10 years, including 75 males and 123 females. To ensure the integrity of the data, inclusion was restricted to healthy children within the specified age range, while exclusion criteria were strictly applied to individuals with chronic illnesses or pre-existing health conditions that could potentially confound serum calcium levels.

Data Collection and Instrumentation

The primary clinical data were obtained through blood samples analyzed for calcium concentrations using the laboratory's calibrated measuring device. In addition to biochemical testing, a structured questionnaire consisting of 25 binary (yes/no) items was administered through direct interviews with the participants' mothers. This instrument was organized into five distinct thematic categories, specifically encompassing dietary habits, physical growth parameters, general health and behavior, daily habits, and general observations. Furthermore, the study investigated associations between calcium status and key influencing factors such as daily sunlight exposure, physical activity, and various lifestyle behaviors.

Statistical Analysis

Statistical processing was performed using Microsoft Excel and Minitab. Quantitative variables were expressed as mean ± standard deviation (SD) and standard error (SE). To evaluate statistical disparities between groups, Student's t-tests were employed, and P-values were calculated to determine levels of significance. Moreover, relationships between categorical variables were rigorously assessed using Odds Ratio (OR) calculations to elucidate the strength of association between specific lifestyle determinants and mineral status.

Results

The quantitative analysis demonstrates that the distribution of normocalcemia and calcium deficiency among children aged 5–10 years did not vary significantly across the age-specific strata. Although marginal fluctuations in serum levels were observed between individual age cohorts, Chi-square (\chi^2) analysis confirmed the absence of a statistically significant association between chronological age and calcium status (X = 1.722, DF = 5, P = 0.885).

These data indicate that serum calcium concentrations remained relatively stable across the developmental spectrum investigated, suggesting that age was not a primary determinant of mineral deficiency within this study population. Consequently, these findings underscore the necessity of investigating extrinsic modifiable variables—specifically dietary patterns, heliotherapy (sunlight exposure), and sedentary versus active lifestyle behaviors—as the predominant drivers of calcium homeostasis, rather than age-dependent physiological maturation alone.

Table 1. Distribution of Calcium Status (Normal vs. Low) Across Different Age Groups Among Children Aged 5–10 Years

Age(years)	Normal cases No.(%)	Low cases. No.(%)
5	29(17)	5(18.5)
6	20(11.7)	4(14.8)
7	28(16.4)	7(25.9)
8	34(19.9)	4(14.8)
9	32(18.7)	4(14.8)
10	28(16.4)	3(11.1)

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Quantitative analysis demonstrated a highly significant correlation between all five assessed dietary parameters and pediatric calcium status—categorized as normocalcemia versus hypocalcemia—with each variable yielding a P-value < 0.0001. These data emphasize the critical role of nutritional behaviors as primary determinants of serum calcium concentrations in this cohort. Specifically, four distinct dietary habits were identified as robust protective factors against calcium depletion. Among these, the most influential variable was daily milk consumption; children lacking a daily intake of bovine milk exhibited 12.4 times higher odds of hypocalcemia (OR = 12.38) compared to those with consistent consumption. Similarly, the consumption of nutritionally balanced meals and the broad inclusion of dairy products offered substantial protection, as the absence of these habits increased the odds of deficiency by 7.79 times (OR = 7.79) and 7.0 times (OR = 7.01), respectively. Furthermore, a lack of regular intake of calcium-dense foods, such as fish and leafy green vegetables, was associated with a 6.3-fold increase in the risk of mineral deficiency (OR = 6.32).

In contrast to these protective behaviors, the most potent dietary risk factor identified was the frequent consumption of fast food and ultra-processed products. Utilizing the reciprocal of the reported Odds Ratio (OR = 0.031), the analysis reveals that children regularly consuming these products had approximately 32.3 times higher odds of exhibiting low serum calcium levels than those who did not. This identifies high-frequency fast food intake as the most significant dietary determinant for calcium deficiency within the study population. In conclusion, these findings underscore that adherence to healthy, nutrient-dense dietary patterns is fundamental in maintaining normocalcemia, whereas the habitual consumption of ultra-processed and fast foods markedly escalates the clinical risk of calcium deficiency. The detailed statistical associations and Odds Ratios for these dietary variables are summarized in (Table 2).

Table 2. Association between dietary habits and calcium status in children

Parameters	Normal (NO.%)	low (NO.%)	Total	Odds ratio	"P-value"
Does your child drink milk daily?					
yes	162(94.7)	16(59.3)	178(89.9)	12.3750	P < 0.0001
no	9(5.3)	11(40.7)	20(10.1)		
Does your child enjoy cheese and dairy products?					
yes	151(88.3)	14(51.9)	165(83.3)	7.0107	P < 0.0001
no	20(11.7)	13(48.1)	33(16.7)		
Does your child eat calcium-rich foods (such as fish and leafy green vegetables)?					
yes	139(81.3)	11(40.7)	150(75.8)	6.3182	P < 0.0001
no	32(18.7)	16(59.3)	48(24.2)		
Does your child eat balanced meals that contain all the necessary nutrients?					
yes	118(69)	6(22.2)	124(62.6)	7.7925	P < 0.0001
no	53(31)	21(77.8)	74(37.4)		
Does your child frequently eat fast food and processed foods?					
yes	34(19.9)	24(88.9)	58(29.3)	0.0310	P < 0.0001
no	137(80.1)	3(11.1)	140(70.7)		

Statistical evaluation was performed to determine the association between various clinical symptoms, developmental milestones, and serum calcium status, specifically comparing normocalcemia and hypocalcemia cohorts. The majority of the assessed clinical markers demonstrated a statistically significant correlation with depleted calcium levels. Notably, symptoms exhibiting a significant association with hypocalcemia (P < 0.05) included developmental delay (P = 0.0237), dental fragility or high caries prevalence (P = 0.0172), osteodynia or arthralgia (P = 0.0086), and suboptimal velocity in weight or height gain (P = 0.0463). Conversely, a history of bone fractures did not reach statistical significance (P = 0.6192), suggesting no measurable disparity in fracture incidence between the two groups within this specific sample.

Analysis of the Odds Ratios (OR < 1) for these significant symptoms further indicates a robust association with the hypocalcemic group, thereby establishing these markers as reliable clinical indicators of mineral deficiency. Among these, osteodynia and arthralgia exhibited the strongest clinical association (OR = 0.2548), with 74.1% of children in the hypocalcemic group presenting with bone or joint pain. Similarly, dental pathology—characterized by weakened enamel and frequent cavities—was significant (OR = 0.3301), also affecting 74.1% of children with low serum calcium. Furthermore, lagging developmental

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trajectories (OR = 0.3846) and diminished growth velocity (OR = 0.4325) were significantly correlated with mineral status, underscoring the deleterious impact of calcium deficiency on ontogenetic development.
In summary, while osteodynia and dental pathologies emerged as the most prominent clinical markers of impaired calcium status in this study population, acute skeletal trauma, such as susceptibility to fractures, did not demonstrate a significant statistical association. These clinical correlations and their respective statistical weights are comprehensively detailed in (Table 3).

Table 3. Association Between Clinical Symptoms and Child's Calcium Status.

Parameters	Normal (N0.%)	low (N0%)	Total	Odds ratio	"P-value"
Have you noticed your child's development is lagging behind their peers?					
Yes	45(26.3)	13(48.1)	58(29.3)	0.3846	P = 0.0237
No	126(73.7)	14(51.9)	140(70.7)		
Does your child have weak teeth or frequent cavities?					
Yes	83(48.5)	20(74.1)	103(52)	0.3301	P = 0.0172
No	88(51.5)	7(25.9)	95(48)		
Does your child experience bone or joint pain?					
Yes	14(8.2)	7(25.9)	21(10.6)	0.2548	P = 0.0086
No	157(91.8)	20(74.1)	177(89.4)		
Is your child prone to fractures?					
Yes	39(22.8)	5(18.5)	44(22.2)	1.3000	P = 0.6192
No	132(77.2)	22(81.5)	154(77.8)		
Have you noticed your child's weight or height gain has been slow?					
Yes	49(28.7)	13(48.1)	62(31.3)	0.4325	P = 0.0463
No	122(71.3)	14(51.9)	136(68.7)		

The association between various neuromuscular, neurocognitive, and behavioral indicators and pediatric calcium status—categorized as normocalcemia versus hypocalcemia—revealed a robust statistical correlation across several clinical parameters. Specifically, symptoms demonstrating a significant association with hypocalcemia ($P < 0.05$) included cognitive impairment or attention deficits (P = 0.0001), frequent muscle cramps or spasms (P = 0.0219), and anorexia or loss of appetite (P = 0.0065). Conversely, generalized fatigue or lethargy (P = 0.7228) and diminished physical activity levels (P = 0.3482) failed to reach statistical significance, suggesting that these specific indicators do not reliably differentiate between the two cohorts in this study population.
Further analysis of the Odds Ratios (OR < 1) for these significant markers confirmed their strong association with the hypocalcemic group, thereby establishing their utility as clinical predictors. Among these, anorexia exhibited the most profound clinical association (OR = 0.0202), with 100% of children in the hypocalcemic group reporting an impaired appetite, which marks it as a universal behavioral correlate in this study. Similarly, cognitive and attentional deficits, such as concentration difficulties, were highly associated with mineral status (OR = 0.1488) and were reported by 74.1% of children with low calcium; this finding underscores the potential impact of hypocalcemia on cognitive function and scholastic performance. Furthermore, neuromuscular irritability, manifested as frequent muscle cramps, emerged as another significant predictor (OR = 0.2091) present in 14.8% of the hypocalcemic cohort, reflecting the critical role of calcium in stabilizing neuronal membranes.
In conclusion, while anorexia and cognitive impairment emerged as the most prominent clinical and behavioral predictors of low calcium status, generalized symptoms such as fatigue and reduced physical activity were not statistically supported as reliable diagnostic indicators. These statistical correlations and the corresponding behavioral data are comprehensively detailed in (Table 4).
The relationship between several key lifestyle factors and pediatric calcium status—categorized as normal versus low—revealed strong statistical associations, highlighting the profound influence of environmental and behavioral determinants on the risk of calcium deficiency. Specifically, lifestyle factors significantly associated with low calcium ($P < 0.05$) included daily exposure to sunlight ($P < 0.0001$), engagement in regular physical activity (P = 0.0037), the use of calcium or vitamin D supplements (P = 0.0033), and attendance at regular medical checkups (P = 0.0034). In contrast, adequate sleep duration (P = 0.5807) was not found to be statistically significant, indicating that it did not reliably differentiate between the normal and low calcium groups within this cohort.

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Table 4. Association Between Neuro-Muscular Symptoms and Calcium Status

Parameters	Normal (NO.%)	low (NO.%)	Total	Odds ratio	"P-value"
Is your child frequently tired or lethargic?					
Yes	33(19.3)	6(22.2)	39(19.7)	0.8370	P = 0.7228
No	138(80.7)	21(77.8)	159(80.3)		
Is your child having difficulty concentrating or paying attention?					
Yes	51(29.8)	20(74.1)	71(35.9)	0.1488	P = 0.0001
No	120(70.2)	7(25.9)	127(64.1)		
Does your child complain of frequent muscle cramps?					
Yes	6(3.5)	4(14.8)	10(5.1)	0.2091	P = 0.0219
No	165(96.5)	23(85.2)	188(94.9)		
Is your child having a poor appetite?					
Yes	90(52.6)	27(100)	117(59.1)	0.0202	P = 0.0065
No	81(47.4)	0(0)	81(40.9)		
Does your child seem less active than usual?					
Yes	54(31.6)	11(40.7)	65(32.8)	0.6713	P = 0.3482
No	117(68.4)	16(59.3)	133(67.2)		

Further analysis of the Odds Ratios (OR > 1) for these significant factors confirmed that the absence of these beneficial practices substantially increases the risk of calcium depletion. Daily sunlight exposure demonstrated the most critical association (OR = 53.48), where children not regularly exposed to sunlight exhibited over 53 times higher odds of low calcium compared to those with consistent exposure, identifying heliotherapy as the primary protective factor in this study. Similarly, engagement in regular physical activity provided substantial protection (OR = 8.88), as sedentary children faced nearly nine times higher odds of deficiency than their active peers. Furthermore, taking calcium or vitamin D supplements (OR = 6.40) and attending regular medical checkups (OR = 4.56) were both identified as significant protective measures, with the absence of these practices increasing the odds of deficiency by 6.4 and 4.6 times, respectively. In conclusion, environmental and lifestyle factors, including sunlight exposure, physical activity, supplementation, and consistent medical monitoring, emerge as critical determinants of calcium status in children. These findings, along with the detailed statistical associations and Odds Ratios for each lifestyle variable, are comprehensively presented in (Table 5).

Table 5. Association Between Lifestyle Factors and Calcium Status

Parameters	Normal (NO.%)	low (NO.%)	Total	Odds ratio	"P-value"
Does your child get sunlight daily?					
Yes	158(92.4)	5(18.5)	163(68.7)	53.4769	P < 0.0001
No	13(7.6)	22(81.5)	35(17.7)		
Does your child engage in regular physical activity?					
Yes	71(41.5)	2(7.4)	73(36.9)	8.8750	P = 0.0037
No	100(58.5)	25(92.6)	125(63.1)		
Does your child get enough sleep?					
Yes	98(57.3)	17(63)	115(58.1)	0.7897	P = 0.5807
No	73(42.7)	10(37)	83(41.9)		
Does your child take calcium or vitamin D supplements?					
Yes	76(44.4)	3(11.1)	79(39.9)	6.4000	P = 0.0033
No	95(55.6)	24(88.9)	119(60.1)		
Do you have regular checkups with your doctor to monitor your child's growth?					
Yes	87(50.9)	5(18.5)	92(46.5)	4.5571	P = 0.0034
No	84(49.1)	22(81.5)	106(53.5)		

The association between various clinical, immune, and parental perception indicators and pediatric calcium status revealed critical insights into the broader physiological impact of mineral deficiency. The analysis identified three parameters with a strong statistical association with low calcium levels, whereas two commonly reported symptoms showed no significant correlation. Specifically, indicators significantly associated with low calcium (P < 0.05) included a weakened immune system, manifested as frequent colds

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(P = 0.0129), delayed wound or injury healing (P = 0.0347), and the parental perception of a balanced diet (P = 0.0017). In contrast, physical manifestations such as changes in hair or nails (P = 0.8478) and frequent foot or back pain (P = 0.2606) were not statistically significant, suggesting they are unreliable indicators for differentiating calcium status within this study population.

Further evaluation through Odds Ratio (OR) analysis for these significant associations highlighted the predictive power of immune-related symptoms. A weakened immune system emerged as the most potent predictor (OR = 0.0281), which corresponds to approximately 35.6 times higher odds of low calcium in children reported to have frequent infections compared to their healthy peers. Similarly, parental perception of dietary balance showed a strong correlation (OR = 3.84), indicating that parents who did not perceive their child's diet as balanced were 3.8 times more likely to have a child with low serum calcium. Furthermore, delayed wound or injury healing was significantly associated with mineral status (OR = 0.3914), confirming that impaired tissue repair is a likely clinical consequence of calcium deficiency. These findings strongly suggest that low calcium status critically affects a child's immune function and healing capacity, establishing these factors as key clinical predictors of deficiency. The comprehensive statistical data, including the frequency distributions and OR values for these clinical and parental indicators, are detailed in (Table 6).

Table 6. Association Between Other Clinical and Immune Indicators and Calcium Status

Parameters	Normal (NO.%)	low (NO.%)	Total	Odds ratio	"P-value"
Have you noticed any changes in your child's hair or nails?					
yes	23(13.5)	4(14.8)	27(13.6)	0.8936	P = 0.8478
no	148(86.5)	23(85.2)	171(86.4)		
Does your child complain of frequent foot or back pain?					
yes	19(11.1)	1(3.7)	20(10.1)	3.2500	P = 0.2606
no	152(88.9)	26(96.3)	178(89.9)		
Is your child taking a long time to heal wounds or injuries?					
yes	32(18.7)	10(37)	42(21.2)	0.3914	P = 0.0347
no	139(81.3)	17(63)	156(78.8)		
Does your child have a weakened immune system (for example, frequent colds)?					
yes	104(60.8)	27(100)	131(66.2)	0.0281	P = 0.0129
no	67(39.2)	0(0)	67(33.8)		
Do you consider your child's diet to be good and balanced?					
yes	124(72.5)	11(40.7)	135(68.2)	3.8375	P = 0.0017
no	47(27.5)	16(59.3)	63(31.8)		

The descriptive statistics for serum calcium levels provide a fundamental comparison between the normocalcemic cohort (n = 171; 86%) and the hypocalcemic group (n = 27; 14%). The results demonstrate a profound and highly significant disparity in mean calcium concentrations between the two groups ($P < 0.001$), which validates the stratification process and indicates that the observed variances are statistically robust rather than a result of random fluctuation. Specifically, the normal cases group exhibited a mean serum calcium level of 9.815 mg/dL (SD = 0.572), whereas the low cases group presented a markedly diminished mean concentration of 7.770 mg/dL (SD = 0.396). This pronounced clinical difference between the mean values further underscores the physiological severity of calcium deficiency within the affected cohort. These comparative metrics and the detailed distribution of serum calcium levels are summarized in (Table 7).

Table 7. Descriptive Statistics and Comparison of Mean Serum Calcium Levels

Calcium	No.(%)	Mean	Sd	SE Mean	P-value	T-value
Normal cases	171 (86)	9.815	0.572	0.044	0.000	23.26-
Low cases	27 (14)	7.770	0.396	0.076	0.000	23.26-

Discussion

The findings of this study provide a comprehensive understanding of the factors influencing calcium status among children in Al-Bayda. A notable observation was the age-independent stability of calcium levels, as the analysis revealed no statistically significant correlation between a child's age and their calcium status (P = 0.885). This suggests that the risk of calcium deficiency in this region is not primarily

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driven by biological maturation or specific developmental stages, but rather by external environmental and behavioral determinants. This observation is consistent with prior research which argues that bone health in school-aged children is dictated more by cumulative nutritional intake and lifestyle consistency than by age-specific physiological changes [13].
Dietary patterns emerged as a determinative role in maintaining calcium homeostasis, with a robust association ($P < 0.0001$) identified between nutritional habits and serum concentrations. Daily milk consumption was found to be the most significant protective factor, reducing the likelihood of deficiency by a factor of 12.4. This reinforces the established consensus that dairy products remain the most bioavailable and reliable calcium source for optimizing pediatric bone growth [14]. Conversely, the frequent consumption of fast food and ultra-processed products was identified as the most substantial risk factor, increasing the probability of deficiency 32.3-fold. This aligns with global concerns that high consumption of ultra-processed foods often displaces nutrient-dense options, leading to a marked decline in a child's overall nutritional status [15, 16].
The clinical manifestations of calcium deficiency in this cohort were significantly correlated with bone and joint pain, as well as stunted physical development in terms of height and weight gain ($P < 0.05$). Research indicates that inadequate calcium intake diminishes bone mineral density, which manifests clinically as skeletal pain and the failure to meet developmental growth milestones [17]. Interestingly, while pain was prevalent, no significant correlation was found with bone fractures. This may be explained by the hypothesis that at this developmental stage, bones exhibit "soft" symptoms such as pain long before reaching the threshold of fragility required for clinical fractures. Furthermore, the impact of hypocalcemia extended to neuromuscular health and cognitive function. A striking 100% correlation was recorded between anorexia and calcium deficiency ($P = 0.0065$), while 74.1% of deficient children reported concentration difficulties. These findings are supported by evidence suggesting that calcium imbalances disrupt neuromuscular signaling and nervous system efficiency, ultimately leading to impaired cognitive performance and reduced attention spans in school-aged children [18].
Environmental and lifestyle determinants, particularly sunlight exposure, proved to be the most influential variables in this study ($OR = 53.48$). Given that localized environmental or cultural factors may limit outdoor activity, insufficient sunlight directly impedes Vitamin D synthesis. As established in the literature, Vitamin D serves as the physiological "key" to calcium absorption; without it, dietary calcium remains underutilized [19, 20]. In addition to heliotherapy, the data confirms that regular physical activity and consistent medical follow-up serve as vital secondary protective barriers against mineral depletion.
Perhaps the most critical immunological implication discovered is that children with calcium deficiency were 35.6 times more susceptible to weakened immunity and recurrent infections, such as the common cold. This physiological link is well-documented, as calcium acts as a critical "second messenger" in immune cell activation [21, 22]. Additionally, the observed delay in wound healing among the deficient group highlights the broader systemic consequences of mineral depletion beyond skeletal health. Finally, the statistical rigor of this study confirmed a profound disparity ($P < 0.001$) between the mean calcium levels of the healthy and deficient groups (9.81 vs. 7.77 mg/dL). The magnitude of this gap confirms that the deficiencies identified represent a genuine clinical crisis rather than a marginal fluctuation, providing strong empirical support for the urgent need for targeted nutritional interventions in the Libyan context.

Conclusion

In summary, this investigation provides a comprehensive characterization of calcium homeostasis among children aged 5–10 years residing in Al-Bayda, Libya, elucidating the profound impact of this essential mineral on pediatric systemic health. While the majority of the study cohort maintained normocalcemia, a significant subset presented with serum levels below the clinical threshold, highlighting an underlying public health concern. The data demonstrate that superior calcium status is intrinsically linked to optimized nutritional patterns, specifically the daily intake of bovine milk and the consistent consumption of calcium-dense foods. Furthermore, the robust correlation between solar radiation exposure, physical activity, and healthy serum concentrations underscores the critical role of the Vitamin D-calcium axis in facilitating mineral utilization and skeletal mineralization.
Beyond skeletal integrity, these findings delineate a compelling association between calcium adequacy and broader physiological indicators, including growth velocity, appetite regulation, dental health, and neurocognitive focus. Children maintaining homeostatic calcium levels exhibited significantly fewer clinical morbidities and improved overall well-being. Consequently, the quantification of serum calcium should be viewed not merely as a biochemical parameter, but as a primary surrogate marker for holistic child development. Therefore, the findings of this study underscore an urgent exigency for integrated nutritional interventions and lifestyle modifications to safeguard the developmental trajectories of children within the Al-Bayda region.

Conflict of interest. Nil

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