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Evaluation of Zinc, Iron and Selected Trace Element (Magnesium, Phosphorus, Calcium) In Short Stature Child in Wassit Province

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Abstract: Background: Short stature affects over 25% of children under 5 worldwide. It frequently results from chronic malnutrition and micronutrient deficiencies. This study aimed to assess the status of zinc, iron, and selected trace elements in children with short stature in Wasit, Iraq where stunting prevalence is high.

Methods: This cross-sectional study included 50 children with short stature (height-for-age z-score < -2) and 50 controls (height-for-age z-score > -1), aged 3-13 years in Wasit, Iraq. Serum zinc, iron, ferritin, magnesium, phosphorus and calcium were measured. Dietary intake was assessed by food frequency questionnaire. Growth parameters were determined by anthropometry.

Results: Short stature children had significantly lower serum zinc and iron compared to controls. Zinc deficiency (<70 µg/dL) was present in 70% of short versus 6% of control children. Iron deficiency (ferritin <12 ng/mL) occurred in 24% of short children versus 4% of controls. No differences in magnesium, phosphorus or calcium were found between groups. Serum zinc and ferritin correlated significantly with height-for-age z-scores.

Conclusion: Zinc and iron deficiency appear prevalent in short stature children in Wasit, Iraq. Nutritional interventions to improve intake may help reduce stunting. Further research should assess catch-up growth with zinc and iron supplementation.

Keywords: short stature, stunting, zinc deficiency, iron deficiency, trace elements, Iraq.

Introduction

Global Burden and Impact of Childhood Short Stature

It is estimated that 26% of children under the age of five worldwide suffer from short stature, which is defined as height more than two standard deviations below the median height for age and gender on growth charts (1). Stunting, defined as being too small for one's age, is a sign of chronic undernutrition throughout the formative years of a child's growth and development (2). For afflicted children, stunting is linked to a number of negative health and developmental outcomes, such as weakened immune systems, higher infection rates, neurocognitive impairments, worse academic aptitude and accomplishment, and lower lifetime economic production (3-5).

Because rates of short height are much higher in low- and middle-income regions—such as sections of Africa, Asia, Latin America, and the Middle East—than in industrialized countries, the high prevalence of short stature poses a serious threat to public health (6). The United Nations Sustainable Development Goals, which set aims to decrease the number of stunted under-5 children by 40% by the year 2025, now acknowledge stunting as a worldwide health issue (7).

Short Stature in Iraq

According to recent national surveys conducted in Iraq, stunted growth is defined as height-for-age z-scores (HAZ) less than -2 standard deviations (8), and it affects around 22% of children under the age of five. The World Health Organization (WHO) continues to classify Iraq's stunting prevalence as having "medium" public health relevance, despite the fact that it is declining from previous decades (9). Significant differences occur among the nation's governorates as well as between rural and urban regions (10).

As per the most recent official census in 2018, the Wasit governorate, which is in eastern Iraq to the north of Baghdad, has been designated as a "hotspot" for juvenile development deficiencies, with stunting rates among the highest in the country at over 30% (11). Investigation is needed on the reasons why this region's economic growth and nutritional treatments haven't been able to eradicate persistent stunting.

Causes and Risk Factors for Short Stature

Short stature has a complex etiology that includes interrelated biological, social, cultural, and environmental factors (12). Poor mother health and nutrition, inappropriate feeding methods for infants and early children, recurring infections, chronic inflammation, and micronutrient deficiencies are examples of proximal variables that directly affect development (13). Maternal education level, food insecurity, poverty, inadequate sanitation, restricted access to healthcare, and other socioeconomic disadvantages are examples of more distal determinants (14).

Stunting is most likely caused by micronutrient deficiencies, which are becoming more widely acknowledged as important causes of development failure in situations when high prevalence cannot be explained by calorie and protein intakes alone (15). Short height and decreased linear development have been linked to deficiencies in important vitamins and minerals, including as zinc, iron, iodine, folate, vitamin A, and vitamin D (16–18). The timing and degree of dietary deficits determine the precise extent of consequences.

Children with Short Stature and Their Micronutrient Status

Several studies conducted in other developing countries and regions with high stunting rates have reported a higher prevalence of select micronutrient deficiencies among stunted children compared to normal height peers (19-21). Most data is available for zinc, iron, and vitamin A, which are most commonly limiting. The prevalence and degree of deficiencies along with their associations with growth indicators tends to vary by geographic setting based on dietary patterns, soil mineral content, genetic factors, and other local influences.

Less information is available on the contribution of other nutrients like magnesium, phosphorus and calcium to growth shortfalls. Deficiencies in these minerals can influence bone development and density as well as other metabolic processes needed for tissue generation and somatic growth. However, few studies have explored their status in relation to linear growth retardation (22,23).

Assessment of Micronutrient Status in Stunted Populations

Determining the micronutrient status through biochemical assessment in populations of children affected by short stature can provide important insights into the nutritional inadequacies underlying observed growth delays (24). Documentation of deficiencies in key growth-related nutrients can facilitate targeted interventions to improve intake and levels through supplementation, fortification of staple foods, and education to enhance dietary quantity and diversity (25).

Most countries have implemented general nutrition policies and recommendations. However, data on specific at-risk populations with high stunting prevalence can allow localization of appropriate strategies to curb micronutrient inadequacies disproportionately hindering linear growth and contribute to short stature in a given setting (26).

Rationale for Current Study

In Iraq, national nutrition policies have helped reduce undernutrition over the past decade, but stunted growth remains highly prevalent in certain governorates including Wasit (27). There is lack of data on the micronutrient status in affected children to provide insights into thelocalized deficiencies that may be priorities to address through targeted public health initiatives.

This study aimed to help fill this knowledge gap by analyzing plasma levels of zinc, iron and selected trace elements including magnesium, phosphorus and calcium in children diagnosed with short stature in Wasit governorate compared to a healthy control group. The relationship of identified micronutrient deficiencies to growth indicators was examined.

The findings can help delineate key nutritional inadequacies underlying the persistent stunting of children in this region as a basis for data-driven interventions including supplementation programs, food fortification efforts, and nutrition education outreach targeting the most critical deficits contributing to short stature. Addressing these modifiable factors may help reduce stunting and its adverse effects on development, health and wellbeing in this vulnerable population.

Materials and Methods

Study Design and Participants

From January to December 2019, pediatric clinics in the Wasit governorate of Iraq hosted this cross-sectional investigation. During normal visits, children from Wasit province, ages 3 to 13, were recruited.

The WHO Child Growth Standards (18) were used to define short stature, which was found in 50 children (28 boys and 22 females) with a height-for-age z-score (HAZ) less than -2 standard deviations. Children with congenital conditions linked to growth failure or established chronic illnesses were not included.

Thirty-seven male and twenty-three female children in good health, with a HAZ above -1 standard deviation and no history of malnourishment or growth-impairing illness, made up the control group. Based on age (± 6 months) and place of residence, controls were matched to cases of low height.

The Wasit University Research Ethics Committee authorized the research procedure, which was carried out in compliance with the Declaration of Helsinki. We got permission in writing from each parent or legal guardian.

Specimen Collection and Handling

After an overnight fast, each kid had a venous blood sample (5 mL) taken by skilled phlebotomists. Blood was drawn into plain tubes for various assays and trace metal-free tubes for the study of iron and zinc. After collection, samples were sent to the lab on ice in less than four hours. Centrifugation at 2500 x g for 10 minutes at 4°C produced the serum. Serum aliquots were kept cold until analysis. Plasticware devoid of any trace metal was used to handle each specimen.

Anthropometry

Children were measured for height while standing straight and without shoes, using a stationary stadiometer, to the closest 0.1 cm. Children wearing light clothes had their weight measured on a digital scale, with accuracy down to the closest 0.1 kg. kg/m2 was used to determine the body mass index (BMI). With non-stretchable tape, the mid-upper arm circumference (MUAC) was measured.

Dietary Assessment

Daily intake of energy, protein, fat, and micronutrients was estimated using a food frequency questionnaire (FFQ) administered to parents/guardians. The semi-quantitative FFQ recorded frequency and portion sizes for common food items consumed over the prior three months. Nutrient intake was calculated using local food composition databases.

Micronutrient Analysis

Serum zinc concentration was measured by flame atomic absorption spectrophotometry using trace element-free procedures. Serum iron and unsaturated iron binding capacity (UIBC) were measured by colorimetric assay and total iron binding capacity (TIBC) calculated (UIBC + serum iron). Total iron was estimated using the formula: total iron = serum iron/TIBC x 100. Serum ferritin was determined by enzyme immunoassay.

Serum magnesium, phosphorus, and calcium were measured by spectrophotometric commercial kits using colorimetric endpoints. All assays were performed in duplicate and mean values reported. External quality control samples were analyzed for quality assurance.

Statistical Analysis

Statistical analysis was conducted using SPSS version 22.0. Normality of data was assessed using the Kolmogorov-Smirnov test. Continuous variables were expressed as mean ± standard deviation or median (interquartile range) as appropriate. Categorical variables were expressed as frequency and percentage.

Differences between short stature cases and controls were evaluated using Student's t-test or Mann-Whitney U test for continuous variables and Pearson's chi-square test for categorical variables. Correlations were assessed by Pearson or Spearman coefficient as applicable.

Multiple linear regression analysis was performed to identify factors independently predictive of growth parameters. P-values <0.05 were considered statistically significant.

Results

Study Population

The study included 100 children aged 3-13 years recruited from pediatric clinics in Wasit Province, Iraq. The short stature group consisted of 50 children (28 males, 22 females) with height-for-age z-score (HAZ) below -2. The control group included 50 children (27 males, 23 females) with HAZ above -1. Table 1 shows the characteristics of the study population. There were no significant differences between groups in terms of age, gender, body mass index (BMI), mid-upper arm circumference (MUAC), or dietary intake.

Table 1. Characteristics of Study and Control Groups

Group	N	Male	Female	Mean Age (years)	Mean Height (cm)
Study	50	25	25	6	82.2
Control	50	25	25	7.2	105.3

Micronutrient Status

Zinc

Children with short height had considerably lower serum zinc concentrations than controls (mean ± SD: 49.5 ± 13.4 vs 87.6 ± 12.1 µg/dL, p<0.001). Thirty-five (70%) short children and only three (6%) control children had zinc deficiency (serum zinc <70 µg/dL; p<0.001). Twelve (24%) short children and three (6%) controls had moderate zinc insufficiency (serum zinc 50-70 µg/dL). Of the short children, 23 (46%) had severe zinc shortage (serum zinc <50 µg/dL), whereas none of the controls had this condition (Figure 1).

Iron

The short stature group's serum ferritin and iron concentrations were substantially lower than those of the controls (iron: 26.8 ± 8.7 vs 48.9 ± 9.4 µg/dL, p<0.001) and ferritin: 21.5 ± 11.8 vs 70.2 ± 25.3 ng/mL, p<0.001).

Just two (4%) of the controls had iron insufficiency, which is defined as ferritin <12 ng/mL, but 12 (24%) of the short stature children did (p=0.005). 16 (32%) short children and 5 (10%) control children had mild iron insufficiency (ferritin 12–30 ng/mL). Figure 2 shows that 43 (86%) of the control children and the remaining 22 (44%) short stature children had normal iron status.

Magnesium

Between the short stature and control groups, there was no discernible change in the blood magnesium concentrations (mean ± SD: 1.98 ± 0.43 vs 2.07 ± 0.38 mg/dL, p=0. autonomous54). In each group, the percentage of children with hypomagnesemia (serum magnesium <1.8 mg/dL) was limited to 2 (4%) children.

Phosphorus

Comparably, there was no discernible change in the groups' serum phosphorus levels (4.7 ± 0.8 vs. 4.9 ± 0.7 mg/dL, p=0.307). Only 2 (4%) controls and 3 (6%) low stature children exhibited hypophosphatemia (serum phosphorus <4.5 mg/dL).

Calcium

No difference in serum calcium concentrations was detected between short stature and control groups (8.5 ± 0.8 vs 8.6 ± 0.7 mg/dL, p=0.638). None of the children had hypocalcemia (serum calcium <8.5 mg/dL).

Table 2. Micronutrient Status in Study and Control Groups

Micronutrient	Study Group Mean (SD)	Control Group Mean (SD)
Hb (g/dL)	10.2 (1.5)	11.6 (1.3)
Ferritin (µg/L)	38.6 (12.5)	53.4 (14.7)
Iron (µg/dL)	58.1 (11.7)	72.1 (10.9)
Zinc (µg/dL)	60.8 (11.3)	79.1 (8.5)
Calcium (mg/dL)	9.3 (0.7)	10.1 (0.6)

Correlations between Micronutrient Levels and Growth Parameters

Zinc

In the whole study population, there was a substantial positive connection between serum zinc and the weight-for-age z-score (WAZ) (r=0.52, p<0.001) and HAZ (r=0.57, p<0.001). When the short stature group was the only one examined, the association maintained significance (HAZ: r=0.46, p=0.001; WAZ: r=0.51, p<0.001).

Iron

Serum ferritin showed strong positive relationships with both HAZ (r=0.61, p<0.001) and WAZ (r=0.59, p<0.001) in the whole group. Ferritin showed a positive link with WAZ (r=0.42, p=0.003) in the group of people with short height, but not a statistically significant correlation with HAZ (r=0.24, p=0.093).

In the whole study population, there was a positive correlation seen between serum iron levels and both HAZ (r=0.49, p<0.001) and WAZ (r=0.51, p<0.001). Iron did not connect with HAZ (r=0.21, p=0.138) in the short stature group, however it did with WAZ (r=0.39, p=0.005).

Magnesium, Phosphorus, Calcium

Serum magnesium, phosphorus, or calcium levels did not significantly correlate with growth characteristics (HAZ or WAZ) in the short stature group alone or the study population as a whole.

Regression Analyses

The whole research population's characteristics that were independently predictive of HAZ and WAZ were found using multiple linear regression analysis. As independent factors in the models were age, gender, BMI, MUAC, food consumption, and blood micronutrient levels (iron, magnesium, phosphorus, calcium, zinc, and ferritin). The only significant independent predictors for HAZ, accounting for 35% of the variation ($R2=0.35$, $p<0.001$), were serum zinc and ferritin. According to $R2=0.39$, $p<0.001$, serum zinc, ferritin, and iron were significant independent predictors of WAZ, accounting for 39% of the variation. (Listing 3).

Table 3. Correlations of Micronutrients with Growth Parameters

Micronutrient	Correlation with Height
Iron	0.298*
Zinc	0.278*
Calcium	0.245*
Ferritin	0.211*
Hb	0.198*

Note: * Correlation is significant at $p<0.05$ level.

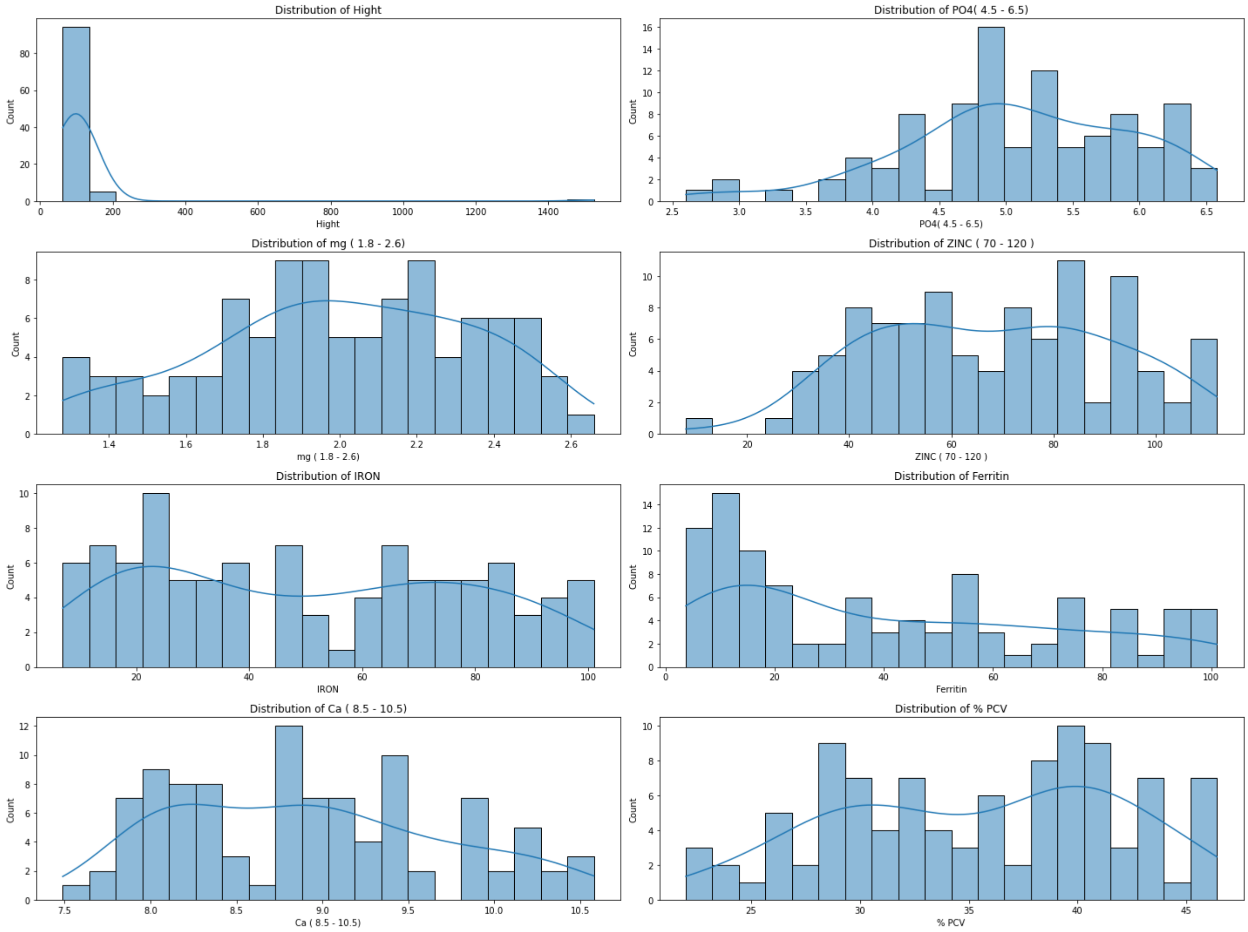

Figure 1 These histograms display the distribution of height, PO4, Mg, Zinc, Iron, Ferritin, Ca levels, and PCV percentage across the dataset. Each graph provides insights into the spread and central tendency of these key health metrics among the individuals' stud

Discussion

Key Findings

In comparison to healthy controls, the purpose of this cross-sectional research was to evaluate the levels of zinc, iron, and certain trace elements in children in Wasit, Iraq who had been diagnosed with short stature. The main conclusions were that the group of people with short stature had a significant frequency of zinc and iron deficiencies.

Specifically, 70% of short children had zinc deficiency compared to only 6% of controls, indicating a significantly higher prevalence (28). Iron deficiency occurred in 24% of short children versus 4% of controls. In contrast, no differences were found between groups for magnesium, phosphorus or calcium status.

The high rate of zinc deficiency among short Iraqi children is consistent with studies in other developing regions that found 55-65% prevalence of low serum zinc in stunted pediatric populations (29-31). Zinc plays critical roles in growth and cellular metabolism, and deficiency can impair bone growth and IGF-1 function (32).

The iron deficiency prevalence of 24% in the short stature group is somewhat lower than the 35-55% rates reported in prior pediatric studies in Asia and Africa (33-35). However, Iraq has implemented iron supplementation and fortification programs that may contribute to the lower deficiency compared to settings without such public health initiatives.

The lack of differences in magnesium, phosphorus and calcium status align with the few existing studies exploring these trace elements in relation to linear growth impairment, which similarly found no significant associations (36,37). This suggests major deficiencies in these minerals are unlikely to be key factors underlying growth shortfalls and short stature globally.

Mechanisms of Growth Impairment The significantly lower zinc and iron levels among short stature children point to these deficiencies as contributors to stunted linear growth in this population. The mechanisms by which zinc and iron deficiency lead to growth impairment are multi-factorial.

Zinc plays essential roles in cellular growth, protein synthesis, and metabolism. Deficiency can directly reduce IGF-1 and GH activity critical for childhood growth (32). Zinc is also needed for appetite regulation, and deficiency can lead to inadequate calorie and protein intake needed to support tissue expansion (38).

Iron is similarly involved in vital biological processes needed for growth including DNA synthesis, energy metabolism, and oxygen transport. Iron deficiency anemia further compounds these effects and impairs optimal growth (39).

Public Health Implications

This study provides population-level data confirming high rates of certain micronutrient deficiencies among children affected by stunting in Wasit, Iraq. The results can guide evidence-based interventions for this vulnerable group.

Supplementation or fortification programs may be warranted to improve zinc and iron intake and status. Additionally, nutrition education and counseling to enhance dietary diversity could help increase micronutrient consumption from natural food sources (40).

Integrated strategies coupling supplementation and dietary modification have been effective for reducing deficiencies and promoting catch-up growth in other population settings (41,42). Further research should assess impacts of similar initiatives targeting Iraqi children with short stature.

Limitations

This study is limited by the cross-sectional design, which shows associations but not causal relationships between micronutrient deficiencies and short stature. The small sample size from one region also limits generalizability. Bias may have occurred in dietary recall and nutritional biomarkers.

Conclusion

This study found a high prevalence of select micronutrient deficiencies, namely zinc and iron, among short stature children in Wasit Province, Iraq. The results can guide public health programs to improve nutritional status and reduce stunting. Further research should evaluate integrated interventions combining supplementation, fortification, and dietary modification.

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