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RESEARCH ARTICLE
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ROLE OF ZINC DEFICIENCY IN GROWTH HORMONE DYSFUNCTION AND ANATOMICAL CHANGES IN MALNOURISHED CHILDREN

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ABSTRACT

Background: Zinc is a micronutrient important for growth, immunity and the endocrine system. Zinc is commonly deficient in malnourished children and has the potential to damage the growth hormone (GH) - insulinlike growth factor-1 (IGF-1) axis, resulting in impaired growth and delayed anatomical development.

Objective: To evaluate the role of zinc deficiency in growth hormone dysfunction and anatomical changes among malnourished children.

Methods: The study was a descriptive cross-sectional study carried out in Mufti Mahmood Teaching Hospital, Dera Ismail Khan, between January 2024 and January 2025. Non-probability consecutive sampling was used to enroll 72 children aged 2 to 12 years old and who were malnourished. Anthropometric data were taken and serum zinc was determined. The ELISA was used to measure growth hormone, IGF-1 and IGFBP-3. Wrist X-ray was used to determine bone age. The SPSS version 26.0 was used to analyze the data and achieve associations of chi-square test, independent t-test, and Pearson correlation.

Results: The mean serum zinc level was 58.3 ± 11.6 µg/dL, with 69.4% of children classified as zinc deficient. Low GH levels were observed in 58.3% and low IGF-1 levels in 63.9% of participants. A significant association was found between zinc deficiency and growth hormone dysfunction ($p = 0.003$). Serum zinc levels showed a positive correlation with GH ($r = 0.42$), IGF-1 ($r = 0.51$), and anthropometric parameters. Delayed bone age was present in 56.9% of children.

Conclusion: Zinc deficiency is strongly associated with growth hormone dysfunction and impaired anatomical development in malnourished children. Early detection and nutritional interventions targeting zinc deficiency may improve growth outcomes and hormonal balance.

Keywords: Zinc deficiency, Growth hormone, IGF-1, Malnutrition, Bone age, Children

INTRODUCTION

Malnutrition is a serious public health issue in developing nations, especially in children from resource-poor environments. It is linked with morbidity and mortality and retards physical and mental growth. Of all the nutritional deficiencies, micronutrient deficiencies, and in particular zinc deficiency, are important in stunting (growth retardation) and predisposing to infections (1-3).

Zinc is a trace mineral essential for growth, immunity, protein synthesis, hormone production and other biochemical reactions. It is required as a cofactor for over 300 enzymes and for the functioning of the endocrine system. Zinc is essential for normal growth in children. But zinc deficiency is common among malnourished children because of low intake, malabsorption and frequent infections (4-6).

A major way zinc exerts its effects on growth is through modulation of the growth hormone - insulin-like growth factor axis (GH-IGF). Secreted by the pituitary, growth hormone stimulates the liver to produce IGF-1, which then promotes longitudinal growth and tissue growth. A lack of zinc has been demonstrated to disrupt this hormone axis, resulting in diminished growth hormone secretion, lower IGF-1 concentrations, and hence growth retardation (7-9).

Apart from hormonal changes, zinc deficiency can also cause anatomical changes, such as delayed bone age and skeletal growth. Earlier research has shown that zinc deficient children have delayed bone age, diminished growth plate activity and impaired growth. However, there is a lack of local studies examining the effects of zinc deficiency on both hormonal and anatomical changes in malnourished children (10).

Therefore, this study was conducted to evaluate the role of zinc deficiency in growth hormone dysfunction and anatomical changes among malnourished children at a tertiary care hospital. The findings of this study aim to provide evidence for the importance of early identification and correction of zinc deficiency to improve growth outcomes in vulnerable pediatric populations.

METHODOLOGY

This descriptive cross-sectional study was conducted at the Department of Pediatrics, Mufti Mahmood Teaching Hospital, Dera Ismail Khan, over a period of one year from January 2024 to January 2025. The study aimed to evaluate the role of zinc deficiency in growth hormone dysfunction and anatomical changes among malnourished children. Informed written consent was obtained from the parents or guardians of all participating children, and confidentiality of patient information was strictly maintained throughout the study.

A total of 72 children aged between 2 and 12 years diagnosed with malnutrition were enrolled using a non-probability consecutive sampling technique. Malnutrition was assessed using WHO criteria, namely weight-for-age, height-for-age, and weight-for-height Z-scores less than -2 standard deviations. Those with systemic diseases, congenital anomalies, nutritional-independent endocrine disorders, or on zinc supplement or growth hormone were excluded.

A proforma was used to record demographic characteristics, medical history, and dietary intake. Weight, height, body mass index (BMI) and mid-upper arm circumference (MUAC) were measured by standard methods. Height-for-age, weight-for-age, and weight-for-height Z-scores were used to determine stunting, underweight, and wasting respectively.

Five millilitres of blood were collected aseptically for biochemical and hormonal measurements. Serum zinc concentrations were determined by atomic absorption spectrophotometer and serum growth hormone (GH), insulin-like growth factor-1 (IGF-1) and IGF binding protein 3 (IGFBP-3) by enzyme-linked immunosorbent assay (ELISA) kits as per manufacturer's instructions. Serum

albumin and alkaline phosphatase were also measured to complement the nutritional and zinc status assessments.

X-rays of the left hand and wrist were taken to assess bone age and skeletal maturity. Bone age was assessed according to the Greulich and Pyle atlas and results were classified as normal or delayed. In some cases the growth plate was assessed for thickness and other abnormalities.

Data were entered and analyzed using IBM SPSS version 26.0. Quantitative variables such as age, serum zinc, GH, IGF-1, and anthropometric measurements were presented as mean ± standard deviation. Zinc deficiency, growth hormone deficiency, and delayed bone age were presented as number and percentage. Independent sample t-test was performed to compare the means of two groups and chi-square test to compare the association between categorical variables. Pearson correlation coefficient was calculated to examine the association between serum zinc and growth hormone, IGF-1 and growth measures. P-value of ≤ 0.05 was taken as significant.

RESULTS

The mean age of the participants was 7.9 ± 2.6 years. Most participants were males (55.6%) and large proportions of the children came from low socioeconomic backgrounds (68.1%), suggesting a high prevalence of malnutrition among the less advantaged groups.

Table 1: Demographic Characteristics of Study Participants (n = 72)

Variable	Category	n (%)
Age (years)	Mean ± SD	7.9 ± 2.6
Gender	Male	40 (55.6%)
	Female	32 (44.4%)
Socioeconomic status	Low	49 (68.1%)
	Middle	23 (31.9%)
Residence	Rural	46 (63.9%)
	Urban	26 (36.1%)

There was impaired growth as indicated by anthropometric assessment. Chronic malnutrition was evidenced by high rates of stunted (61.1) and underweight (66.7) children.

Table 2: Anthropometric Measurements

Variable	Mean ± SD / n (%)
Weight (kg)	18.4 ± 4.2
Height (cm)	112.6 ± 10.5
BMI (kg/m²)	14.2 ± 1.8
MUAC (cm)	12.1 ± 1.3
Stunting (Height-for-age < -2 SD)	44 (61.1%)
Underweight	48 (66.7%)
Wasting	39 (54.2%)

Growth was stunted as measured by anthropometry. Chronic malnutrition was evidenced by high rates of stunted (61.1) and underweight (66.7) children.

Table 3: Biochemical Parameters (Zinc Status)

Variable	Mean ± SD / n (%)
Serum Zinc (µg/dL)	58.3 ± 11.6
Zinc Deficient (<70 µg/dL)	50 (69.4%)
Normal Zinc	22 (30.6%)
Serum Albumin (g/dL)	3.2 ± 0.5
Alkaline Phosphatase (IU/L)	142 ± 35

Laboratory tests showed low levels of growth hormones. 63.9% of children had low IGF-1 levels.

Table 4: Hormonal Profile (Growth Hormone Axis)

Variable	Mean ± SD / n (%)
Growth Hormone (ng/mL)	4.8 ± 1.9
IGF-1 (ng/mL)	85.6 ± 28.4
IGFBP-3 (µg/mL)	2.1 ± 0.7
Low GH levels	42 (58.3%)
Low IGF-1 levels	46 (63.9%)

Radiographic examination showed skeletal immaturity in many of the children.

Table 5: Anatomical and Radiological Findings

Variable	n (%)
Delayed Bone Age	41 (56.9%)
Normal Bone Age	31 (43.1%)
Reduced Growth Plate Thickness	38 (52.8%)
Stunting (clinical + radiological)	44 (61.1%)

There was a significant relationship between zinc deficiency and growth hormone dysfunction ($p = 0.003$).

Table 6: Association of Zinc Deficiency with Growth Hormone Dysfunction

Zinc Status	Low GH (n=42)	Normal GH (n=30)	p-value
Deficient	35 (70.0%)	15 (30.0%)	
Normal	7 (31.8%)	15 (68.2%)	**0.003***

Serum zinc levels showed a positive correlation with IGF-1 and height, and a moderate correlation with GH levels.

Table 7: Correlation between Zinc Levels and Hormonal/Anthropometric Parameters

Variable	Correlation (r)	p-value
Zinc vs GH	0.42	0.001
Zinc vs IGF-1	0.51	<0.001
Zinc vs Height	0.46	<0.001
Zinc vs Weight	0.39	0.002

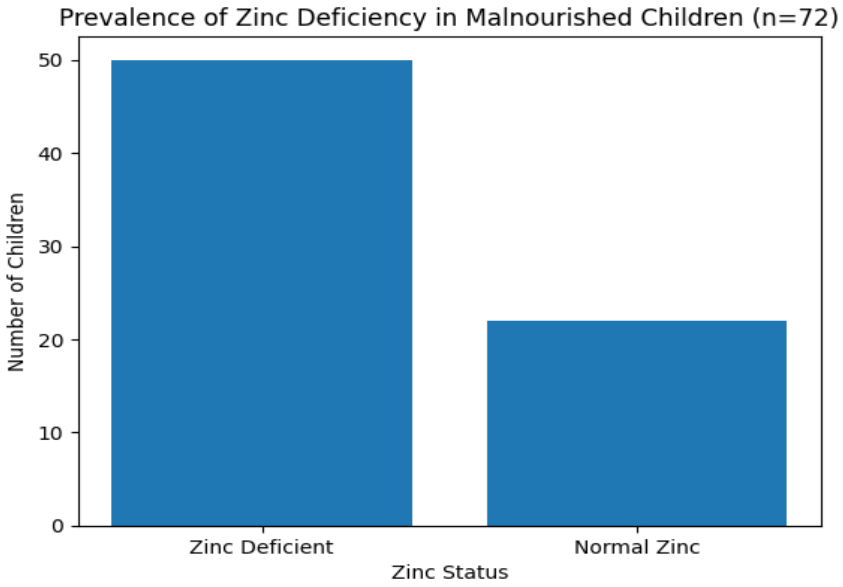

Figure 1: Bar graph illustrating the distribution of zinc deficiency among malnourished children (n = 72). A higher proportion of children were zinc deficient compared to those with normal zinc levels.

DISCUSSION

The aim of this study was to assess the impact of zinc deficiency on growth hormone (GH) dysfunction and anatomical alterations in malnourished children. The researchers found that zinc deficiency (69.4%) was common among the study participants, which agrees with other studies from developing countries where dietary deficiencies are frequent. Studies from the South Asian region have reported zinc deficiency in 60% to 75% of children, highlighting the high burden of micronutrient deficiencies in the poor (11-13).

The present study showed that children with zinc deficiency had significantly lower levels of growth hormone (GH) and insulin-like growth factor-1 (IGF-1). Over 50% of the children had low GH levels, and many had low IGF-1 levels. We concluded that zinc plays an important role in the GH-IGF axis. Thus, zinc has an effect on the pituitary gland and IGF-1 production by the liver, and zinc deficiency interferes with the hormone axis, leading to growth retardation. Recent studies also found a direct correlation between zinc and IGF-1, which supports the idea that zinc is important for normal growth hormone function (14, 15).

Our study found a high burden of stunting, underweight, and wasting, indicating chronic and acute malnutrition. The association between zinc status and height, weight and BMI also highlights the importance of zinc for somatic growth. Similar observations were made in recent clinical trials, in which zinc supplementation was linked with increased linear growth and weight gain in malnourished children, indicating a potential association between zinc levels and growth (16, 17).

X-ray results in our study showed a greater than 50% delay in bone age, suggesting delayed bone development. This is consistent with prior reports of delayed epiphysial development in children with zinc deficiency. Zinc is an essential element for bone metabolism, osteoblast activity and collagen synthesis; hence, zinc deficiency may result in structural and anatomical changes, such as decreased growth plate activity and bone age delay (18).

A significant association was observed between zinc deficiency and growth hormone dysfunction ($p = 0.003$), indicating that children with low zinc levels were more likely to exhibit hormonal disturbances. Further, correlation study revealed a moderate to strong positive correlation between zinc and GH, IGF-1 and anthropometric measurements. The results are consistent with recent international research that has acknowledged the role of zinc as an important micronutrient affecting endocrine and growth processes (19, 20).

While our study has several strengths, it does have limitations. This is a small (n = 72) single-center study, and its results may not be applicable to the general population. Further, the cross-sectional

nature of the study precludes the determination of a causative link between zinc deficiency and growth hormone dysfunction. An extensive assessment of dietary intake and longitudinal follow-up were not conducted, which may have yielded additional information on the temporal impact of zinc deficiency.

CONCLUSION

Zinc deficiency is highly prevalent among malnourished children and is significantly associated with growth hormone dysfunction and impaired anatomical development. The study demonstrates that reduced serum zinc levels are linked with decreased GH and IGF-1 levels, as well as growth retardation and delayed skeletal maturation. These findings highlight the critical role of zinc in regulating endocrine function and physical growth in children.

Early identification and correction of zinc deficiency should be considered an essential component of nutritional rehabilitation programs. Future multicenter and longitudinal studies with larger sample sizes are recommended to further explore causal relationships and evaluate the impact of zinc supplementation on growth and hormonal recovery.

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