

ORIGINAL ARTICLE

Zinc and Growth with Picky Eating in a Jordan Pediatric Clinic: An Observational Study

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Abstract

Background: Picky eating is a common feeding disorder in early childhood, characterized by a refusal to eat familiar foods or try new ones. This disorder can lead to nutritional deficiencies as well as impacting growth and development. The study aimed to determine whether picky eating is associated with reduced serum zinc levels and impaired growth in southern Jordan.

Methods: Data collection was based on history taking and the physical examination of all examined patients at the pediatric clinic of Al-Karak Teaching Hospital. data collected included signs such as hair loss and other indicators of zinc deficiency, weight for age (Z-score), income category of the family, and the presence of underlying diseases. Blood levels of zinc, vitamin D, ferritin and hemoglobin were determined, and the results were analyzed statistically using ANOVA and *t*-tests.

Results: An association was found between low serum zinc levels and low weight for age Z-scores, confirming the relationship between zinc deficiency and underlying general nutritional deficiencies, such as celiac disease and acrodermatitis enteropathica, which were rare (4 out of 118 studied cases); however, these patients had severely low serum zinc levels compared to the nutritional causes. On the other hand, family income category did not consistently correlate with low serum zinc levels.

Conclusion: Picky eating is associated with lower weight for age, hemoglobin levels, and vitamin D levels, thereby suggesting that picky eating can lead to a wide range of nutritional deficiencies beyond just zinc deficiency.

Keywords: Picky eating, nutrition, eating behavior, anemia, zinc deficiency

INTRODUCTION

Zinc, the trace element, is a fundamental component required for cell division, growth, and cognitive development in children [1, 2]. Over 1,000 known transcription factors and 300 enzymes rely upon zinc to function [2]. Zinc deficiency is a serious disorder that can manifest as dermatitis, alopecia, chronic inflammation, taste disorders, impaired healing, loss of appetite, growth retardation, liver disease, and a wide range of neuropsychiatric symptoms [3, 4].

Most of the cases of dietary deficiencies account for zinc deficiency [5]. However, other diseases such as acrodermatitis enteropathica, a monogenetic disorder, can also lead to zinc deficiency [6]. Globally, the prevalence of zinc deficiency is estimated to be around 20.5% [7].

Some studies suggested that over two billion people are affected by zinc deficiency, primarily in developing countries [8–10]. Despite the low prevalence in the USA (1–3%) [11], it is estimated that around 10% of the U. S. population is at risk of developing zinc deficiency due to consuming less than half the recommended dietary zinc requirement [12]. Picky eating (also characterized as selective or fussy eating) is characterized by a strong dislike for certain foods and a strong desire for others. Picky eating can result in reduced energy and nutritional intake, which is potentially harmful to one's health [13, 14]. The definitions and methods for assessing fussy/picky eating are varied and sometimes ambiguous [15]. These differences, along with cultural variations, make studying picky eating challenging.

It is well acknowledged that a nutritionally balanced diet is essential for children's proper growth and development. Children's daily dietary habits should include a diverse diet rich in nutrient-dense foods, such as a wide variety of vegetables and fruits, grains

(preferably whole grains), lean proteins, and low-fat dairy products [16, 17]. Foods rich in saturated fat, processed sugars, and salt should be avoided since they may displace the healthier options [18]. These dietary suggestions help ensure adequate consumption of nutrients essential for children's normal growth and development [19]. Considering that individual items for each food group have different nutritional profiles, the variety of foods consumed is also important. For example, chicken and other meats are high in niacin and zinc, while seafood is rich in omega-3 long-chain polyunsaturated fatty acids, such as eicosapentaenoic acid, such as docosahexaenoic acid [20]. Moreover, meat, chicken, and seafood, contain heme iron, which is more readily absorbed than the non-heme iron found in plant proteins [21]. Although picky eating is often considered as a natural aspect of a child's growth (i.e., from the time substantial foods are offered to early childhood), it can contribute to a restricted consumption of specific food groups, and consequently critical nutrients. In some children, these eating behaviors may result in an inability to achieve essential nutritional and energy needs, potentially leading to significant and diverse health outcomes such as growth impairment, nutritional deficiencies, or other functional impairments [22]. Regardless of the lack of a 'gold-standard' classification or method of identifying picky eaters, studies on the subject have been published by many researchers in recent years. These researchers investigated whether picky eating is consistently associated with quantitative differences in food intake, as reported by the parents or caregivers based on their child's eating behaviors and limited food preferences.

However, the relationship between picky

eating and various nutrients levels has not been thoroughly studied. One study suggests that while macronutrients are not significantly deficient, micronutrients may be [13]. Therefore, the objective of the current research is to determine whether picky eating is associated with lower serum zinc levels and impaired growth in the southern region of Jordan.

MATERIALS AND METHODS

This was a prospective observational study conducted at an outpatient pediatric clinic at Al-Karak Teaching Hospital in Jordan. The study protocol was approved by the local ethics committee and informed consent was obtained from the patient's parents before enrollment.

A protocol was developed and implemented to collect data on all pediatric patients examined at the pediatric clinic between January 2015 to January 2017.

Inclusion criteria

We included any patient who had low serum zinc levels between the ages of 2 and

14 years and had one or more of the following: complaints of hair loss (partial or diffuse), changes in hair texture, regression of hair growth, and hair loss or scalp disorders on physical examination, as well as any other sign of zinc deficiency such as dermatitis, chronic inflammation, impaired healing, loss of appetite and growth retardation. The reason for choosing patients over the age of 2 was because picky eating is difficult to determine before this age.

The total number of patients screened for hair abnormalities was 2,400. In total, 326 patients were enrolled in the study, out of whom 163 had a zinc deficiency, 118 met the inclusion criteria and 45 were excluded due to being under 2 years (Figure 1). The initiation for serum zinc level screening was hair loss, skin changes, growth retardation and other signs of zinc deficiency.

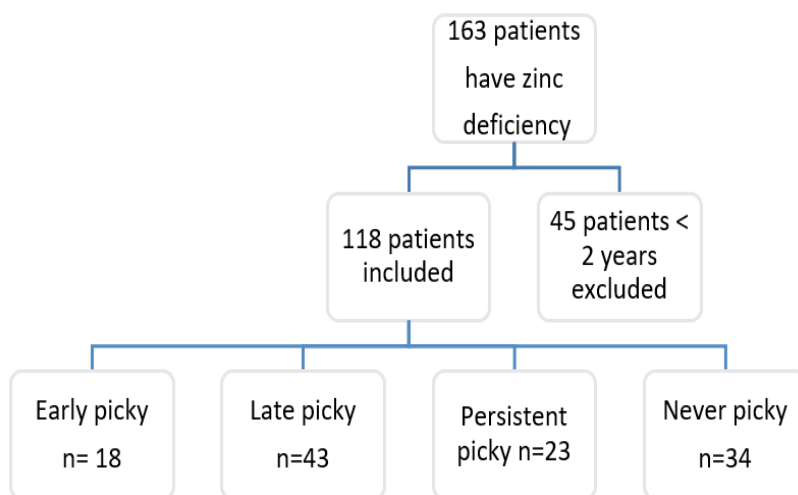


Figure1. Flowchart illustrating the categorization of patients with zinc deficiency. Out of 163 patients identified with zinc deficiency, 45 patients under 2 years of age were excluded from the study. The remaining 118 patients were categorized based on their picky eating behavior into four groups: Early Picky (n=18), Late Picky (n=43), Persistent Picky (n=23), and Never Picky (n=34).

Exclusion criteria

Patients with normal hair, normal serum zinc levels, under the age of 2 or taking multivitamin supplements were excluded from the present study.

Picky eating was identified through a verbal interview with the parents and children, using the Avon Longitudinal Study of Parents and Children questionnaire [23].

Patients that showed signs of picky eating at around the ages of 2–3 years were

considered to have early onset picky eating, whereas patients that started at about 4–5.5 years were considered to have late onset picky eating. Patients who started in the early onset picky eating category and continued to have picky eating behavior were persistent picky eaters [13].

History and physical examination allowed the collection of data related to hair loss, weight for age (Z-score) [24], income category of the family [25], and the presence of underlying diseases. Blood tests were conducted to determine serum zinc levels, vitamin D levels, ferritin and hemoglobin levels.

Statistical analysis

ANOVA and *t*-tests were used to identify significant differences between mean serum zinc levels across various categories, and to compare weight-for-age, vitamin D, and Ferritin levels within the picky eating categories. Chi-squared tests were used to test relationships between categorical variables, such as income and picky eating categories. *P* values were considered

significant at <0.05 .

RESULTS

Among the 118 patients included in this study, 45 (38.1%) were male, and 73 (61.9%) were female. The patients' ages ranged from 2 to 14 years, with a mean of 6 years. The mean serum zinc concentration was 52.8 ± 10.5 $\mu\text{g/dL}$. The results show that the "Persistent picky" group has the lowest mean zinc level at 38.7 $\mu\text{g/dL}$, with a relatively high standard deviation, indicating significant variability within this group. This low level is statistically significant ($p < 0.05$) when compared to other groups. Similarly, the "Early picky" and "Late picky" groups also exhibit lower mean zinc levels (47.9 $\mu\text{g/dL}$ and 55.0 $\mu\text{g/dL}$, respectively) compared to the "Never picky" group, which has a mean zinc level of 61.9 $\mu\text{g/dL}$ (Table 1). The "Too young (excluded)" group ($n = 45$), which is not considered picky, shows the highest mean zinc level at 64.0 ± 8.4 $\mu\text{g/dL}$.

Table 1. Zinc Levels Among Different Picky Eating Categories

Picky Eating Categories	N	Mean Zinc level	Std. deviation	Minimal Zinc level	Maximum Zinc level
Early picky	18	47.9*	5.9	27.00	54.40
Late picky	43	55.0*	5.2	45.00	64.16
Persistent picky	23	38.7*	9.5	21.00	54.00
Never picky	34	61.9	5.4	48.00	68.00
Total	118	52.8	10.5	21.00	70.00

* $p < 0.05$

Vitamin D deficiency has also been linked with low serum zinc levels, lending further support to the nutritional cause idea. Moreover, 16.6% of our sample had anemic hemoglobin levels (less than 11 g/dl). The average levels of hemoglobin and vitamin D were 12.5g/dl and 41ng/ml, respectively in non-picky eaters. Hemoglobin and vitamin D

levels were 11 ± 1.2 g/dl and 36.8 ± 16.7 ng/dl, respectively in picky eaters (Table 2). Underlying disorders such as celiac disease, acrodermatitis enteropathica, and cystic fibrosis were rare (4 out of 118 studied cases); however, they did have severely low serum zinc levels 49.7 ± 20.2 $\mu\text{g/dL}$ compared to nutritional causes (Table 3).

Table 2. Picky eating versus hemoglobin/vitamin D

hemoglobin/vitamin D	Picky Eating Categories	N	Mean level	Std. deviation
Hemoglobin	Never picky	34	12.5	1.0
	Picky	84	11*	1.2
Vitamin D	Never picky	34	41	12.0
	Picky	84	36*	16.7

* $p < 0.05$ **Table 3. Zinc versus underlying disease**

underlying disease	N	Mean Zinc level	Std. deviation
No underlying disease	114	52.9	10.0
With underlying disease	4	49.7*	20.2

* $p < 0.05$

Surprisingly, the income category of the patient's family could not consistently predict low serum zinc levels. It was expected that low-income families were more susceptible to zinc deficiency, but our results were inconsistent with this expectation, as higher-income categories also had picky eaters, negating the effect (Tables 4 and 5).

Furthermore, low levels of serum zinc are associated with low weight-for-age Z-scores, confirming that underlying general nutritional deficiencies are related to zinc deficiency [26]. Picky eating has been associated with reduced weight-for-age Z-scores (mean of Z score = $-1 \pm .9$) (Table 6).

Table 4. Zinc versus income categories

Descriptive analysis of Zinc versus income categories							
Income category	N	Mean Zinc level	Std. Deviation	95% Confidence interval for mean		Minimum Zinc level	Maximum Zinc level
				Lower Bound	Upper Bound		
Low	5	51.9	10.2	39.3	64.6	43.0	64.1
Lower-middle	66	52.5	10.8	49.8	55.2	21.0	70.0
Upper-middle	45	53.2	10.3	50.1	56.3	25.7	68.0
High	2	54.0	1.4	41.2	66.7	53.0	55.0

* $p < 0.05$ **Table 5. Picky eating versus income categories**

Income category		Low income	Lower-Middle income	Upper Middle income	High income	Total
Picky eater category	Never Picky	0	21	13	0	34
	Picky	5	45	32	2	84

Table 6. Picky eating category versus weight and age

Picky eater category	N	Z- score for Weight	Std. deviation of Z- score
Never picky	34	-0.5	0.7
Picky	84	-1.0	0.9

* $p < 0.05$

DISCUSSION

The results show that children in the persistent picky eating category may be at a greater risk for zinc deficiency, with

significantly lower mean zinc levels compared to other groups. The significant differences in zinc levels across these categories underscore

the potential nutritional risks associated with picky eating behaviors.

Vitamin D deficiency and hemoglobin have also been linked with low serum zinc levels, lending further support to the nutritional cause idea.

Underlying disorders such as celiac disease, acrodermatitis enteropathica, and cystic fibrosis, although rare, were associated with markedly lower zinc levels compared to nutritional causes.

Surprisingly, the income category of the patient's family could not consistently predict low serum zinc levels. It was expected that low-income families were more susceptible to zinc deficiency, but our results were inconsistent with this expectation, as higher-income categories also had picky eaters, negating the effect. This indicates that there was no correlation between picky eating and the family's income category. Furthermore, a previous study has shown that low-income families are more susceptible to picky eating [27]. A larger sample size may be needed to more accurately determine the relationship between income, picky eating, and zinc deficiency.

Low levels of serum zinc are associated with low weight-for-age Z-scores, confirming that underlying general nutritional deficiencies are related to zinc deficiency [26]. Picky eating has been linked to low weight-for-age, suggesting a potential link to calorie deficiency [13], although this could be attributed to other nutritional deficiencies. Further studies are needed to investigate whether picky eaters are at higher risk of being calorie deficient.

In the present study, most of the patients were female because the parents noticed hair and skin complaints in their daughters more readily than in their sons [29]. Our study cannot explain the overall occurrence of picky eating in Jordan due to the nature of the

inclusion criteria. However, the prevalence of zinc-deficient picky eater patients is higher than reported in other studies [16, 28]. This indicates that picky eating is a significant cause of dietary zinc deficiency, in agreement with the results of our study and previous research [30].

In the present study, the ALSPAC questionnaire was applied to guide the definition of picky eating; other studies have used a 6-item FF scale from the CEBQ [29] and Children's Eating Behavior Questionnaire [17, 22] and the Child Feeding Questionnaire as well as the study-specific question(s) [30, 31]. ALSPAC is a population-based randomized trial that has comprehensively studied diet and gathered survey data from parents on feeding their children, leading to the recognition of picky eaters. The ALSPAC dataset thus presents a unique platform to investigate the persistent occurrence of picky eating and its impact on nutrients and food groups, as well as the impact of probable dietary changes on health-related consequences, which has been missing in earlier research [32]. In a previous study, the results offer an initial step to identifying persistent picky eaters that may enable intervention at an early age [33].

CONCLUSION

Picky eating is related to zinc deficiency, and its presence possibly puts children at high risk of various nutritional deficiencies. We could not establish a connection between income and picky eating, or between income and zinc deficiency; therefore, a larger sample size is needed to observe such an association. Zinc deficiency has the potential to significantly impact the health and growth of millions of young children. The challenge of determining the extent and severity of zinc deficiency complicates the assessment of its impact, but deficiency risks are expected to be higher in

vulnerable groups such as children due to their picky eating behavior. Parents should be made aware of the possible negative health effects of picky eating and encouraged to help their children eat a balanced diet to minimize the risk of zinc deficiency. Overall, effective prevention interventions must address both the increased zinc requirements and the underlying context that perpetuates a vicious cycle of zinc insufficiency and other negative consequences.

Ethical approval: The study has been approved by the Scientific and Ethics Committees of the Faculty of Medicine, Mutah University, Jordan (reference 582022).

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Authors' Contributions: Amjad Tarawneh participated in writing the proposal of the study and designing its protocol, conducting the data analysis, interpretation of the findings and manuscript writing. Haitham Al-Dhmour, Rami M. Almajali, Fadi Sawaqed, Aseel Al-Dmour and Samir S Mahgoub participated in editing, revising and preparing the manuscript for submission. All authors have read and agreed to the published version of the manuscript.

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الزنك والنمو في الأطفال الأردنيين الذين يعانون من الانتقائية الشديدة في الأكل

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المخلص

الخلفية والاهداف: الانتقائية الشديدة في الأكل هي اضطراب شائع في مرحلة الطفولة المبكرة، وتتميز برفض تناول الطعام المألوف أو تجربة أنواع جديدة من الطعام. وتعد اضطرابا متعدد العوامل، وبعض العوامل المساهمة فيها هي النقص الغذائي. هدفت هذه الدراسة إلى تحديد ما إذا كانت الانتقائية الشديدة في الأكل لها علاقة بانخفاض مستويات الزنك في مصل الدم والنمو في جنوب الأردن.

المنهجية: تم جمع البيانات بناءً على الاستقصاء التاريخي والفحص السريري لجميع المرضى المفحوصين في عيادة الأطفال في مستشفى الكرك التعليمي. شملت البيانات المجموعة تساقط الشعر وعلامات أخرى لنقص الزنك، ونقص الوزن، وفئة دخل الأسرة، ووجود أمراض أخرى يمكن أن تسبب نقص في الزنك. كذلك تم تحديد مستويات فيتامين د و مخزون الحديد و خضاب الدم، ثم تم تحليل النتائج إحصائياً باستخدام اختبار التحليل التبايني واختبار التحليل t.

النتائج: أظهرت النتائج وجود علاقة بين انخفاض مستويات الزنك في مصل الدم ومستويات منخفضة لمؤشر الوزن للعمر، مما يؤكد العلاقة بين نقص الزنك ونقص الغذاء العام الأساسي مثل داء السيلياك (الداء البطني، المسمى أيضاً بالذرب البطني) ومرض التهاب جلد الاطراف المعائي الذي كان نادراً (4) من بين 118 حالة شملتها الدراسة، ولكنها كانت تعاني من مستويات زنك منخفضة جداً بالمقارنة مع الأسباب الغذائية. من ناحية أخرى، لم تكن فئة دخل عائلة المريض مؤشراً موثقاً لانخفاض مستويات الزنك في الدم.

الاستنتاجات: الانتقائية الشديدة في الأكل مرتبطة بانخفاض مؤشر الوزن للعمر، ومستويات خضاب الدم، ومستويات فيتامين د. وهذا يشير إلى أن الانتقائية الشديدة في الأكل يمكن أن تسبب مجموعة واسعة من العيوب الغذائية بالإضافة إلى نقص الزنك.

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