A study of plasma levels of zinc in children with pica in a public hospital setup

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Abstract

Background: Pica is the craving and purposeful consumption of non-food substances. In children with pica, there is a greater possibility of zinc deficiency.

Objectives: To study the plasma levels of zinc in children having pica and to study the efficacy of pica as a clinical marker of zinc deficiency.

Method: This is a case control study of children attending the outpatient department of a tertiary health centre. A total of 92 children were enrolled in the study, of which 46 children who had the habit of pica were taken as cases and the remaining 46 children without the habit of pica were enrolled as controls. Serum zinc levels of the 92 children were estimated.

Results: Of the 92 children included in the study, 56% of cases and 47% of controls belonged to the age group of 2 to 2.5 years. It was observed that 96% of cases had zinc deficiency whereas 100% of controls had normal zinc levels. The mean zinc level of the cases was 46.73±21.32mcg/dL compared to 148.5±15.4mcg/dL in the controls. Accuracy of pica as a clinical marker of zinc deficiency was 97%.

Conclusions: The mean zinc level of the cases who had pica was significantly lower than the mean zinc level of the controls indicating that pica is a useful clinical marker for zinc deficiency.

(Key words: Zinc, Iron deficiency anaemia, Pica, Geophagy, Wound healing)

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Introduction

Pica is the craving and purposeful consumption of non-edible substances; it includes geophagy (consumption of earth), amylophagia (consumption of raw starch), pagophagia (consumption of ice) and other forms of non-food consumption and is more prominent in younger children[1,2]. Adverse effects of pica range from parasitic infestation[3], anaemia[4], trichobezoar and intestinal obstruction[5], to life-threatening hypokalaemia[6] and lead poisoning[7,8]. Aetiology of pica is still controversial. Specific prevalence rate for children is unknown[9]. It is estimated that pica occurs in 75% of 12-month-old infants and 15% of 2-3-year-old children[10]. Micronutrients are nutrients required by organisms throughout life in small quantities to organize a range of physiological functions[11]. Pica is sometimes found in conjunction with micronutrient deficiencies and the direction of this relationship is not well understood[12]. There are two mechanisms by which pica may cause these deficiencies. Pica material may bind to the mucosal layer of the gut, thereby preventing absorption of micronutrients; this material may also absorb micronutrients in ingested food, preventing them from being metabolized. Conversely, it has been suggested that micronutrient deficiencies cause humans to seek out minerals from non-edible substances[13]. The micro minerals or trace elements include iron, cobalt, chromium, copper, iodine, manganese, selenium, zinc, and molybdenum[2]. Micronutrients also include vitamins which are organic compounds required as nutrients in trace amounts[14].

Zinc acts as an antioxidant to protect the body against free radical damage[15]. It is an essential component of several enzymes e.g., carbonic anhydrase, alcohol dehydrogenase, etc. and is necessary to maintain the normal levels of certain vitamins and hormones[15]. It is required for wound healing[15]. Zinc enhances cell growth and division, besides stabilizing bio membranes and also protects against infections[15]. Zinc deficiency is associated with growth retardation, poor wound healing, anaemia, loss of appetite, loss of taste sensation and neuropsychiatric disorders like depression, dementia etc.[15]. Prevalence of zinc deficiency in children aged 6 to 60 months in India is 43.8%[16,17]. In children having pica there is the possibility of more severe zinc deficiency.

Objectives

- To study the plasma levels of zinc in

children having pica
- To study the usefulness of pica as a clinical marker of zinc deficiency.

Method

This was a one-time observational case-control study conducted over a period of one year in the Department of Paediatrics of a tertiary healthcare centre. Forty-six children who fulfilled the definition of pica as per DSM-5 criteria (age >2 years and duration of ingestion for at least 1 month) were randomly selected as a study group. We also studied zinc levels in a control group (46 children without the habit of pica) coming to the paediatric outpatient department (OPD). Sample size was determined by using statistical tool OpenEpi version 2.2

Inclusion criteria: Children enrolled on an OPD basis having pica according to DSM-5 criteria were included in the study as cases and children enrolled on an OPD basis without pica were included as controls matched for age, sex, socio-economic status and anthropometry with cases of the study group.

Exclusion criteria: Children who were very sick, with developmental delay, with chronic illness or with moderate /severe malnutrition (according to IAP classification) were excluded from the study.

The detailed proforma was filled after taking a detailed history regarding the habit of pica as to what type of non-food items patient was eating, age of onset of ingestion of non-food items, frequency of ingestion of non-food items, any similar history in the past, family history, siblings having the similar history of pica, along with a thorough clinical examination to rule out any significant problems fitting into the exclusion criteria. Detailed anthropometry was done in all cases and controls enrolled in the study according to inclusion criteria. Age of study population was taken as per the date of birth mentioned by their parents.

Blood (3 mL) was collected from a peripheral vein into trace element-free, heparinized plastic vials using disposable plastic hub bed needles. Plasma zinc levels were determined with the help of thermos-scientific I.C.E. 3000 series aa spectrometer. The reference range of zinc according to this method is 80-120µg/dL. In our study all subjects with zinc levels <80µg/dL were taken as zinc deficient and further sub-classified as mildly (60-80µg/dL), moderately (31-59µg/dL), and severely (<30µg/dL) deficient.

Ethical issues: The study was approved by the Institutional Ethics Committee of Surat Municipal Institute of Medical Education and Research, Surat, Gujarat, India in 2016. Prior written informed consent was taken from the parents of the children involved in the study.

Statistical analysis: Descriptive statistics were used to summarize data by measuring mean, standard deviation, and proportions. Inferential statistics was done by using independent t-test. $p<0.05$ was considered significant. All measurements were done using Open Epi version 2.2 and Microsoft Excel.

Results

Table 1 shows the age distribution of cases with pica and controls. It was found that the cases and controls are well matched for age. ($p> 0.05$)

Table 1: ***Age distribution of cases and controls***

Age group (years)	Cases (n=46)	Controls (n=46)	p-value
2 to 2.5 - n (%)	26 (56.5)	22 (47.8)	0.105
2.5 to 3.5 - n (%)	15 (32.6)	11 (23.9)	
>3.5 - n (%)	05 (10.9)	13 (28.3)	
Mean age ± SD (months)	29.87 ± 9.06	32.21 ± 11.83	0.289

Figure 1 shows 45% males and 54% females among cases and 63% males and 36% females among controls. It was found that the cases and controls are well matched for gender with a p value of 0.09.

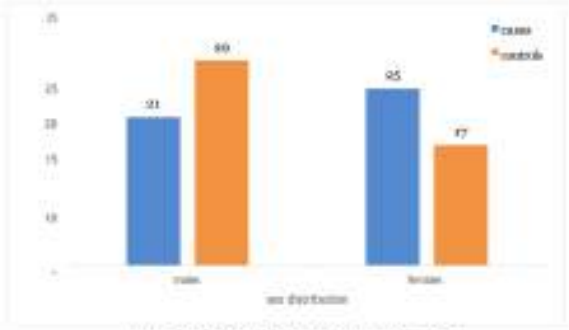

Figure 1: *Gender distribution of cases and controls*

Table 2 shows the comparison of the nutritional status of the study population and the mean zinc levels. Figure 2 shows the types of non-food substances ingested by the cases. Those children who had the habit of pica were more likely to consume multiple types of non-food substances. As many as 39% consumed soil, chalk, and wall paint. There were no cases who ate only pencil as a non-food substance.

Table 2: ***Comparison of the nutritional status of the study population and mean zinc levels***

Nutritional status of study population	Mean zinc levels ± standard deviation	
	Cases (n=46)	Controls (n=46)
Grade 1 PEM	44.86 ± 13.05 µg/dL (n=14)	144.58 ± 11.89 µg/dL (n=12)
Normal	46.72 ± 21.55µg/dL (n=32)	148.5 ±15.56µg/dL (n=34)
Weight for age (%)	82.87 ± 8.85	83.39 ± 7.09
p-value	0.766	0.432

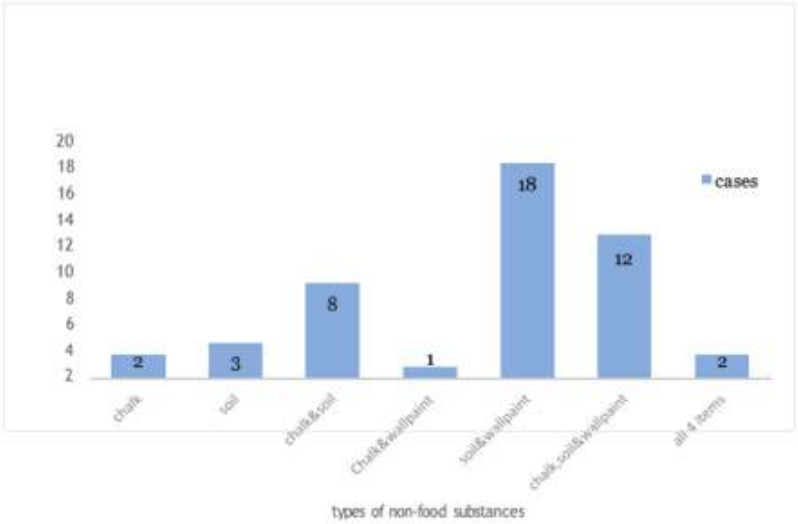

Figure 2: ***Types of non-food substances ingested by cases***

Table 3 shows the incidence of anaemia among the cases with pica and controls in the study. Proportion of cases with anaemia was significantly higher compared to controls (p=0.00005). Mean haemoglobin level was significantly lower in cases compared to controls (p=<0.001).

Table 4 shows the comparison of plasma zinc levels in cases and controls.

Table 3: ***Incidence of anaemia among the cases and controls in the study***

Classification of anaemia	Cases (n=46)	Controls (n=46)	p-value
Severe anaemia – n (%)	03 (06.5)	02 (04.3)	0.00005
Moderate anaemia – n (%)	28 (60.9)	18 (39.1)	
Mild anaemia – n (%)	13 (28.3)	08 (17.4)	
Normal – n (%)	02 (04.3)	18 (39.1)	
Mean haemoglobin level (g/dL) – Mean ±SD	9.03 ± 1.31	10.19 ± 1.82	<0.001

Table 4: Comparison of ***plasma zinc levels in cases and controls***

Zinc levels	Cases (n=46) n (%)	Controls (n=46) n (%)	p-value
<80µg/dL	44 (96.0)	0 (0)	<0.0001
≥80µg/dL	02 (94.0)	46 (100.9)	

Table 5 is a comparison of mean zinc levels among cases and controls. There was a significant association between pica and zinc levels (p<0.001). None of the controls had zinc deficiency, whereas out of the 46 cases enrolled in the study, 44 had zinc deficiency.

Table 5: ***Comparison of mean zinc levels among cases and controls***

Mean zinc levels	Cases (n=46)	Controls (n=46)	p-value
	46.73 ± 21.32 µg/dL	148.5 ± 15.4µg/dL	<0.001

Table 6 shows the frequency of ingestion of non-food substances. Table 7 shows the correlation of the duration of ingestion of non-food items with the mean zinc levels. The duration of ingestion of non-food substances did not affect the mean zinc levels (p>0.05

Table 6: ***Frequency of ingestion of non-food substances***

Frequency of ingestion	Cases (n=46) n (%)
2-4 times/day	30 (65)
>4-6 times/day	15 (32)
>6 times/day	01 (02)

Table 7 shows the correlation of the duration of ingestion of non-food items with the mean zinc levels. The duration of ingestion of non-food substances did not affect the mean zinc levels (p>0.05).

Table 7: ***Correlation of the duration of ingestion of non-food items with mean zinc levels***

Duration of ingestion	Cases n (%)	Mean zinc levels Mean ± SD	p-value
< 3 months	36 (78)	55.70 ± 27.27 mcg/dl	
≥3months	10 (21)	41.94 ± 16.37 mcg/dl	0.137

Table 8 shows the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy of pica. Sensitivity of pica as a clinical marker to identify zinc deficiency is 100% which means that presence of pica could identify 100% cases of zinc deficiency. Specificity of pica as a clinical marker to identify zinc deficiency is 95.8% which means that absence of pica could exclude 95.8% cases without zinc deficiency among total normal cases. PPV of pica as a clinical marker is 95.7% which means that a case having positive history of pica will have 95% chances of zinc deficiency. NPV of pica as a clinical marker is 100% which means that a case with absence of pica will be without zinc deficiency on all occasions. Accuracy of pica as a clinical marker is 97%, which indicates that in 97% cases pica will accurately identify zinc deficiency.

Table 8: ***Sensitivity, specificity, positive predictive value, negative predictive value and accuracy of pica***

Statistics	Value	95% confidence interval
Sensitivity	100%	92%-100%
Specificity	95.8%	85%-99.5%
Positive predictive value	95.7%	85%-98.8%
Negative predictive value	100%	
Accuracy	97.8%	92.4%-99.7%

Discussion

Prevalence of pica in our study among children was 0.4%. In our study 56.5% were 2-2.5 years old, 32.6% were 2.5-3.5 years old and 11.9% were more than 3.5 years old compared to study by Bhatia R, *et al*[19], where 69% were aged 2-5 years and 30% were aged 6-10 years. In our study 54% were female in contrast to male predominance in studies by Singhi S, *et al*[20] (67%) and Bhatia R, *et al*[19] (58%). In our study mean haemoglobin level was 9.03±1.31g/dL whereas in a study by Singhi S, *et al*[20], it was 8.5±1.3g/dL and in a study by Sharma J, *et al*[21], it was 8.2±1.2g/dL. So, it was observed that the baseline mean haemoglobin levels of cases of pica were lower.

In our study duration of ingestion of non-edible substances was 3 months in 78% of cases similar to 74% in study by Singhi S, *et al*[20]. In our study 32% had a frequency of ingestion of 4-6 times/day compared to 67% in study by Singhi S, *et al*[20].

In present study the mean zinc level of cases was 46.73±21.32µg/dL. Almost 96% of cases had zinc deficiency while none of the controls had zinc deficiency. In study by Singhi S, *et al*[20], mean zinc level was 60.0±4.4µg/dL which was 45% less than control group. In the meta-analysis by Miao D, *et al*[13] the plasma zinc was significantly lower in the pica group than in the non-pica group and pica

behaviour was associated with lower plasma zinc (34µg/dL) compared to controls without pica.

It was observed that the mean zinc levels in the study group with frequency of ingestion less than 3 times a day, 3-5 times a day and >5times were 67.63±22.45µg/dL, 46.72±21.56µg/dL and 46.63±22.96µg/dL respectively compared to 59.8±6.2µg/dL, 59.3±7.1µg/dL and 58.8±4.7µg/dL respectively in study by Singhi S, *et al*[20]. This suggests that the frequency and duration of ingestion of non-food substances do not seem to affect zinc levels significantly. In our study 95% of study group had anaemia compared to study by Miao D, *et al*[13], where pica behaviour was associated with 2.4 times increased risk of anaemia. In our study zinc deficiency was present in 96% cases. Sensitivity was 100%, specificity 96%, PPV 96% and NPV 100%. Overall accuracy was 98% which suggests that pica as a clinical marker of zinc deficiency is likely to be sensitive as well as specific.

Thus, although it cannot be determined if pica is causally related to micronutrient deficiencies, it does suggest that pica is a clear marker of risk for these deficiencies, all of which have serious health consequences. Studies with larger sample size would help in further confirmation of the observation. It may be useful to supplement zinc in all cases of pica even if serum zinc levels are not done and clinical signs of zinc deficiency are not obvious considering the vital role of this micronutrient in growing age of the children when they are prone to higher incidence of infection and thus need any additional immune protective coverage.

Conclusions

In this study there was a definite association of zinc deficiency in children with the habit of pica, as the mean zinc level was significantly lower in those children which suggests that pica may be a useful clinical marker for zinc deficiency.

References

1. Barltrop D. The prevalence of pica. *American Journal of Diseases of Children* 1966; **112**(2): 116-23. https://doi.org/10.1001/archpedi.1966.02090110060004 PMid: 5221971

2. Geissler PW, Mwaniki DL, Thiong'o F, Friis H. Geophagy among school children in western Kenya. *Tropical Medicine and International Health* 1997; **2**(7): 624-30. https://doi.org/10.1046/j.13653156.1997.d01-345.x PMid: 9270730

3. Glickman TL, Chaudry IV, Constantino J, Clark FB, Cypess RH, Winslow L. Pica patterns, toxocariasis and elevated blood lead levels in children. *American Journal of Tropical Medicine and Hygiene* 1981; **30**: 77-80. https://doi.org/10.4269/ajtmh.1981.30.77 PMid: 7212174

4. Crosby WH. Pica: a compulsion caused by iron deficiency. *British Journal of Haematology* 1976; **34**(2): 341-2. https://doi.org/10.1111/j.13652141.1976.tb00204.x PMid: 974044

5. Phillips MR, Zaheer S, Drugas GT. Gastric trichobezoar: case report and literature review. *Mayo Clinic Proceedings* 1998; **73**(7): 653-6. https://doi.org/10.1016/S00256196(11)64889-1 PMid: 9663194

6. Gonzalez JJ, Owens W, Ungaro PC, Werk EE Jr, Wentz PW. Clay ingestion: a rare cause of hypokalaemia. *Annals of Internal Medicine* 1982; **97**(1): 65-6. https://doi.org/10.7326/0003-4819-97-1-65 PMid: 7092010

7. Menge H, Lang A, Cuntze H. Pica in Germany--amylophagia as the aetiology of iron deficiency anaemia. *Z Gastroenterol.* 1998; **36**(8): 635-40. (Article in German). .

8. Jacobziner H. Lead poisoning in childhood: epidemiology, manifestation, and prevention. *Clinical Pediatrics* 1966; **5**: 277-86. https://doi.org/10.1177/000992286600500507

9. Hartmann AS, Becker AE, Hamptom C, Bryant-Waugh R. Pica and rumination disorder in DSM-5. *Psychiatric Annals* 2012; **42**(11): 426–30. https://doi.org/10.3928/00485713201211005-09

10. Chatoor I. Feeding and eating disorders of infancy and early childhood. In: Sadock BJ, Sadock VA, Ruiz P, editors. Kaplan, and Sadock's Comprehensive Textbook of Psychiatry (9th ed.). Lippincott, Williams & Wilkins. 2009. p. 3607.

11. Canadian UNICEF Committee, Global Child Survival and Health, 2006, p. 67.

12. Young SL, Sherman PW, Lucks JB, Pelto GH. Why on earth? Evaluating hypotheses about the physiological functions of human geophagy. *Quarterly Review of Biology* 2011; **86**(2): 97-120. https://doi.org/10.1086/659884 PMid: 21800636

13. Miao D, Young SL, Golden CD. A meta-analysis of pica and micronutrient status. *American Journal of Human Biology* 2015; **27**(1): 84-93. https://doi.org/10.1002/ajhb.22598 PMid: 25156147 PMCid: PMC4270917

14. "Vitamins and minerals". US Department of Agriculture, National Agricultural Library. 2016. Retrieved 18 April 2016.

15. Satyanarayana, textbook of biochemistry, Mineral metabolism (18); Zinc 410-411

16. Kapil U, Jain K. Magnitude of zinc deficiency under 5-year children in India, *Indian Journal of Pediatrics* 2011; **78**(9): 1069-72. https://doi.org/10.1007/s12098-011-0379-z PMid: 21318393

17. Akthar S. Zinc status in South Asian populations—An update. *Journal of Health, Population and Nutrition* 2013; **31**(2): 139–49. https://doi.org/10.3329/jhpn.v31i2.16378

18. Shakur MS, Bano N, Malek MA, Kundu SK, Ahmed AU. Effect of zinc supplementation on appetite, growth and body composition in children suffering from non-specific etiology of feeding refusal with failure to thrive. *Orion Medical Journal* 2009; **32**(1): 612-5.

19. Bhatia R, Bhatia G. Pattern, beliefs associated with pica in children aged 1-10 years - A study of 119 cases. Indian *Journal of Basic and Applied Medical Research* 2015; **5**(1). 338-41. https://doi.org/10.4103/2229516X.149253 PMid: 25664274 PMCid: PMC4318107

20. Singhi S, Ravishanker R, Singhi P, Nath R. Low plasma zinc and iron in pica. Indian *Journal of Pediatrics* 2003; **70**: 139-43. https://doi.org/10.1007/BF02723740 PMid: 12661808

21. Sharma J, Dhar K, Chopra Vs, Agrawal A, Jhingran S, Gaur P. A study to assess the therapeutic response of iron and zinc in children with Pica. *International Journal of Pharmaceutical Sciences Review and Research* 2019; **28**(1): 233-6.