

## Zinc Absorption of Preschool Children

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### 학령전 아동의 아연흡수에 관한 연구

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#### Abstract

This study was performed to estimate the zinc absorption, excretion, and balance of preschool children in Pohang and to evaluate the relationship zinc absorption and related variables. To determine the zinc absorption and excretion, duplicate food samples, pooled feces and urine samples were collected for 3 consecutive days in 21 preschool children. The mean fecal and urine excretions were 7.03mg/day and 0.16mg/day for the boys and 5.87mg/day and 0.15mg/day for the girls. Analyzed daily mean zinc intake was 10.45mg/day for the boys and 7.80mg/day for the girls. The mean apparent absorption rate and balance were 29.7% and 3.25mg for the boys and 23.3%, 1.78mg for the girls. Although the mean apparent absorption rate and balance of boys tended to be higher, there was no significant difference between boys and girls.

In this study, subjects showed the positive balance except one. Fecal zinc loss reflected dietary zinc ( $p < 0.01$ ), but urinary zinc loss was unaffected by zinc intake. There was a positive relationship between zinc apparent absorption and zinc balance ( $p < 0.01$ ). These results show that the zinc absorption and balance were favorable.

Key words : zinc absorption, zinc balance, preschool children.

#### Introduction

Zinc requirements are generally based on the amount needed to support balance or to replace endogenous losses.<sup>1)</sup> Zinc absorption is influenced by the types of food ingested. According to previous study, about 10 to 35% of dietary zinc is absorbed from foods. The higher figure is more likely when animal protein sources are consumed, the body's zinc needs are elevated.<sup>2)</sup> The total zinc content of a meal was an important factor influencing the amount of zinc absorbed.<sup>3)</sup> Also several dietary factors have contributed to the negative zinc balances measured when the high - fiber, low-protein diet was

consumed. From other studies it was concluded that protein improves the absorption of zinc from the diet.<sup>4-5)</sup>

Korean's diet appear to be high cereal grains and low in sources of readily available zinc. Correspondingly, the low animal protein and high fiber diet may have decreased the zinc absorption.

Zinc is involved in the growth process. Zinc has been identified in numerous enzymes. It is a component of biomembranes, is thought to be necessary for RNA, DNA, and ribosome stabilization, is involved in the binding of a number of transcription factors, stabilizes hormone - receptor complexes.<sup>1)</sup> Severe zinc deficiency is now a rare condition. Mild zinc deficiency, however,

may be relatively common. The symptoms marginal zinc deficiency were poor appetite, poor growth, hypogeusia.<sup>6)</sup> Thus, adequate zinc intake is necessary to support many bodily functions and growth of preschooler.

Data from Western children study indicated<sup>7)</sup> that zinc intakes of from 7 to 8mg per day appears to provide the necessary intake, assuring zinc availability between 20 and 30% during the growing period. If the diet is largely plant sources, the zinc intake should be in the range of 8 to 9mg per day to provide sufficient zinc to meet the needs of the growing child. In contrast, little information is available concerning the zinc nutriture of Korean children. Data on zinc absorption and balance of Korean children is limited. Thus the purpose of this study was to investigate and provide information on the zinc absorption and balance in Korean preschool children.

## Materials and Methods

### 1. Feces, and Urine Collection

To assess zinc absorption on usual diet, subjects completed three consecutive days diet collection and three consecutive days pooled feces and urine collection on same days. For food, urine, and feces collection and record, subject's mothers were instructed how to measure, to record, and to collect with the aid of a scale and mass cylinder. All food was weighed during preparation and it was eaten quantitatively by the subjects. Twenty one preschool children aged 3 to 6 with no health problems participated in this study. Characteristics of the subjects are given in Table 1.

### 2. Analysis of Zinc Excretion, Absorption, and Balance

Zinc was determined in food and feces by inductively

coupled argon plasma spectroscopy (Jobin Yvon 38+, Jobin Yvon Inc., France) after wet digestion of aliquots of freeze-dried blended material with nitric and perchloric acids. Urinary zinc was determined directly by ICAP. The amount of nutrient intake except zinc was determined by weighed food records using food table.<sup>8)</sup> Apparent zinc absorption and zinc balance were calculated by using intake, urinary loss, and fecal loss data from the three day collection periods. Analysis data of zinc intake and calculated nutrient intakes were presented in previous report.<sup>9)</sup>

Crude balance was calculated as intake - feces - urine.

Apparent absorption was calculated as (intake - feces) / intake  $\times$  100

### 3. Statistical Analysis

Statistical analysis was performed with a Statistical Analysis System. Results were expressed as mean value and standard deviation and percentages. Statistical differences between two groups were compared by Student's t-test at  $p < 0.05$ . Pearson product moment correlation coefficient test was used to determine the relationship between zinc intake, excretion, balance and absorption.

## Results and Discussion

### 1. Characteristics of the Subjects

The average age of total subjects was  $4.7 \pm 0.8$ . The mean age boys and girls was  $4.6 \pm 0.7$  and  $4.8 \pm 0.9$ , respectively. Their mean body weight and height were slightly lower than those of Korean standards for age,<sup>8)</sup> but similar to the results of other preschool children.<sup>11)</sup> The mean Kaup index boys and girls was  $16.3 \pm 1.8$  and  $15.3 \pm 1.8$ , respectively. The subjects had Kaup index level in the normal range. The preschool years are the

**Table 1. Characteristics of subjects**

Variables	Boys	Girls	All subjects
Age (yr)	$4.6 \pm 0.7^{1)}$	$4.8 \pm 0.9^{N.S.3)}$	$4.7 \pm 0.8$
Weight (kg)	$18.3 \pm 2.8$	$16.5 \pm 2.3$	$17.2 \pm 2.6$
Height (cm)	$106.1 \pm 9.6$	$104.2 \pm 9.4$	$105.0 \pm 9.5$
Kaup index <sup>2)</sup>	$16.3 \pm 1.8$	$15.3 \pm 1.8$	$15.7 \pm 1.9$

<sup>1)</sup> Values represent mean  $\pm$  standard deviation.

<sup>2)</sup> Kaup index : [weight(g)/height(cm<sup>3</sup>)]  $\times$  10, criteria for obesity  $\geq 20$ .

<sup>3)</sup> N.S. : All measurements were not significantly different between boys and girls by Student's t - test.

**Table 2. Dietary intake of the subjects**

Variables	Boys	Girls	All subjects
Energy (kcal)	1404.9 $\pm$ 285.6 <sup>1)</sup>	1253.2 $\pm$ 314.4	1311.0 $\pm$ 312.6
Protein (g)	41.7 $\pm$ 10.5	39.9 $\pm$ 12.6	40.6 $\pm$ 11.9
Animal protein(g)	17.6 $\pm$ 7.4	17.9 $\pm$ 8.5	17.8 $\pm$ 7.9
Fiber(g)	3.58 $\pm$ 1.22	2.27 $\pm$ 0.6	2.77 $\pm$ 1.09
Ca (mg)	587.9 $\pm$ 244.1	512.2 $\pm$ 219.1	541.0 $\pm$ 231.9
P (mg)	696.7 $\pm$ 154.2	693.8 $\pm$ 229.	694.9 $\pm$ 204.4

<sup>1)</sup> Mean  $\pm$  SD.

best time for a child to start a healthful pattern of living and eating, focusing on nutritious foods.<sup>10)</sup> Mean daily energy intake levels were 1,404.9kcal for boys and 1,253.2kcal for girls, which were slightly lower than the Korean RDA. Although the mean energy intakes for girls tended to be lower, there was no significant difference between boys and girls, because of the large variation of the girls values. Mean daily protein intake levels were 40.6g/day. The proportion of animal protein of the subjects was about 43.8%, which was higher than the recommended range.

## 2. Zinc Excretion, Apparent Zinc Absorption, and Zinc Balance

Mean daily zinc excretion, apparent absorption, and balance are shown in Table 3 and correlation between zinc absorption and related variables are presented in Table 4.

The mean urine zinc excretion level was 0.16 $\pm$ 0.04mg/day, unaffected by dietary zinc. But fecal excretions (6.31 $\pm$ 3.21mg/day) increased as intakes increased ( $p < 0.01$ ). In this study, fecal zinc reflected dietary zinc, on

the other hand, urinary zinc remained relatively stable. This result is similar to previous reports that excretion of zinc occurs primarily through the feces and lesser amounts are excreted in the urine.<sup>12)</sup> Particularly, zinc deficiency is likely in children with poor dietary intakes and chronic diarrhoea with loss of zinc from the body through failure to reabsorb secreted zinc.<sup>13)</sup> Zinc is considered to be relatively nontoxic, particularly if taken orally. But zinc intakes over 100mg/day also result in diarrhea, nausea, vomiting, and depressed immune system function. The Korean RDA for zinc is 8mg in preschool children. Studies in young children suggest that diets should provide a minimum of 7mg of zinc daily for growing children.<sup>7)</sup> If the diet is largely plant sources and the absorption of zinc would likely be less than 30% of intake, the zinc intake should range of 8 to 9mg/day to provide sufficient zinc to meet the needs of the growing period. In this study the average zinc intake of boys and girls was 10.45 $\pm$ 5.01mg and 7.80 $\pm$ 3.86mg, respectively. Although the mean zinc intake of boys tended to be higher, there was no significant difference between boys and girls. The mean daily zinc intake was 8.81mg

**Table 3. Zinc excretion, apparent absorption, and balance**

Variables	Boys	Girls	All subjects
Zinc excretion			
Fecal zinc (mg/day)	7.03 $\pm$ 2.93	5.87 $\pm$ 3.29 <sup>N.S.3)</sup>	6.31 $\pm$ 3.21
Urine zinc (mg/day)	0.16 $\pm$ 0.03	0.15 $\pm$ 0.04	0.16 $\pm$ 0.04
Zinc intake (mg/day)	10.45 $\pm$ 5.01	7.80 $\pm$ 3.86	8.81 $\pm$ 4.52
Zinc balance (mg/day) <sup>1)</sup>	3.25 $\pm$ 2.39	1.78 $\pm$ 1.38	2.34 $\pm$ 1.96
Apparent absorption (%) <sup>2)</sup>	29.70 $\pm$ 13.27	23.33 $\pm$ 13.85	25.75 $\pm$ 13.98

<sup>1)</sup> Intake - feces - urine.<sup>2)</sup> [(intake - feces) / intake]  $\times$  100.<sup>3)</sup> N.S. : All measurements were not significantly different between boys and girls by Student's t - test.

Table 4. Correlation between zinc absorption and related variables

Variables	Zinc absorption			Zinc intake		
	Boys	Girls	All subjects	Boys	Girls	All subjects
Zinc intake	0.4693	0.2069	0.3593	1.0000	1.0000	1.0000
Urinary zinc	-0.0186	0.0727	0.0661	-0.4880	0.5364	0.1907
Fecal zinc	0.1952	-0.1171	0.2999	0.9513**	0.9373**	0.9253**
Balance	0.7418*	0.8587**	0.7758**	0.9265**	0.5532*	0.7839**

\*  $p < 0.05$ , \*\* $p < 0.01$ .

(110.1% RDA), which was slightly higher than the amount Korean RDA. Data on zinc intake and excretion of Korean preschool children is limited. Compared with previous studies, the subjects zinc intake level was higher than that of Kim et al.,<sup>14)</sup> Lee et al.,<sup>15)</sup> and Park et al.<sup>16)</sup> and lower than that of Kim et al.<sup>20)</sup>. Mean daily zinc intake level was reported as 6.1mg,<sup>15)</sup> 6.7mg,<sup>14)</sup> and 7.47mg,<sup>16)</sup> in Korean adults, 11.35mg in Korean college women.<sup>17)</sup> The subjects zinc intake level in this study was similar to other researches. Holden et al.<sup>18)</sup> reported a mean daily zinc intake of 8.6mg when the diets of 22 Americans of different ages were analyzed. Average intake of zinc by young Western woman<sup>19)</sup> was calculated to be 9.9mg/day.

Zinc absorption appears to be response to zinc status, dietary factors; protein and fiber. From previous study,<sup>4)</sup> it was concluded that protein improves the absorption of zinc from the diet. The mechanism of zinc absorption across the gastrointestinal mucosa is incompletely characterized. In the body, zinc is bound to albumin or to amino acids for transport to the liver. About two-thirds of the zinc found in the peripheral circulation is bound loosely to albumin, approximately another third is firmly complexed with  $\alpha 2$  - macroglobulin, and a small portion is bound to amino acids. Zinc that is bound to albumin and amino acids is readily taken up by tissues.<sup>12)</sup>

In the present study, calculation of apparent absorption revealed a mean of 25.8%. As regards zinc balance, the mean of all subjects was 2.34mg/day. Subjects were in positive balance except one. Little information is available concerning the zinc absorption and balance preschool children. Compared with previous results, above results were similar to the reports of Price et al.<sup>20)</sup> and Engel et al.<sup>21)</sup>. Price et al.<sup>20)</sup> reported that the subjects retained 2mg of zinc in a diet providing approximately 7 mg of zinc.

Engel et al.<sup>21)</sup> reported retentions of approximately 30% of intake, 7mg/day, by preadolescent girls. The total zinc content of a diet was an important factor influencing the amount zinc absorbed. In this study, zinc absorption was significantly related to zinc balance ( $p < 0.01$ ), but there was no significant difference zinc absorption and total zinc intake, related dietary factors which are protein, fiber, phosphorus. Balance was significantly correlated with zinc intake ( $p < 0.01$ ).

As a result of this study, it seems that the subjects diet consider to proper in zinc balance and absorption. But research on zinc of Korean children is limited, so further studies are needed to determine zinc nutriture, also nutrition education is needed in order to proper intake of zinc of preschool children.

## 요 약

학령전 아동의 zinc absorption, excretion, balance에 대하여 연구한 결과는 다음과 같다.

Zinc absorption은 남자아동의 경우 29.7%, 여자아동의 경우 23.3%, 평균 25.8%로 나타났다. 대상자의 zinc absorption은 zinc intake와는 상관성이 나타나지 않았으며, zinc balance와 유의적 상관( $p < 0.01$ )을 보였다. Zinc balance는 남자아동의 경우 평균 3.25mg/day, 여자아동의 경우 1.78mg/day, 평균 2.34mg/day로 1명의 대상자를 제외하고 모두 positive balance를 보였다.

Fecal zinc loss는 평균 6.31mg/day, urinary zinc loss는 평균 0.16mg/day였다. zinc intake는 fecal zinc loss 및 zinc balance에 유의적 영향을 미치는 것으로 나타났다( $p < 0.01$ ), urinary zinc는 intake의 영향을 받지 않았다.

우리나라 학령전 아동의 zinc absorption 및 balance는 양호한 것으로 나타났다. 그러나 이 방법의 연구 자료가 많지 않아, 성장기 아동을 대상으로 한 zinc nutri-

tion에 대한 구체적이고 지속적인 연구가 필요하다.

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