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Zinc Intake Affects Toddler Stunting: A Cross-Sectional Study on Toddlers Aged 3 Years

Asupan Zinc Berpengaruh pada Stunting Balita : Studi Belah Lintang pada Balita Usia 3 Tahun

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ABSTRACT

Background: Stunting toddlers in Indonesia was still a concern of the government. The Indonesian Ministry of Health noted that the 2020 stunting rate was 27.7% to 24.4% in 2021, while the government's target in 2024 was 14%.
Objectives: The purpose of the study was to prove the relationship between Zinc intake and the average height growth of toddlers, in addition to proving the relationship between Zinc intake and stunting.
Methods: A cross-sectional study was conducted on 54 toddlers with a history of births at Sultan Agung Hospital and Bangetayu Health Center in August-November 2017. The average body length growth was the rate of body length increase per month for the first three years of life (cm/month). Data on Zinc intake (mg/day) were obtained from food recall with a food model and analysis of Zinc content in food using the Nutrisurvey application. Test the hypothesis statistically using Spearman, Chi-square, and Fisher's Exact.
Results: Zinc intake was not correlated with mean height growth (p=0.231 r=0.166). Stunting was significantly associated with Zinc intake <3 mg/day, p=0.001. There was a relationship between nutritional status WAZ-score and stunting at three years, p = 0.001. There was a negative correlation between birth length and average height growth.
Conclusions: Zinc intake was not associated with the rate of growth in body length in the first three years. Daily Zinc intake was associated with stunting in toddlers.

INTRODUCTION

Indonesian Basic health research (Riskesdas) 2018 stated that the stunting rate reached 30.8% but decreased compared to 2013 (37.2%)[1]. In contrast, the 2021 stunting rate was 24.4%, a decline from 27.7% in 2020[2]. The government targeted reducing the stunting rate from 24.4% (2021) to 14% in 2024[3].

Anthropometric calculations use the Z-score from the World Health Organization. Stunting is a condition where toddlers do not reach a height appropriate for their growing age due to stunted linear growth, which is indicated by height/age (H/A) <-2 SD[4]. A study in Korea proved that zinc supplementation for six months given to infants aged six months to six years was more effective for underweight children than the stunting group[5]. A study in Surabaya on toddlers proved that the stunting group received lower energy, protein, and zinc intake than the control group[6]. Research in China showed the relationship between hair zinc levels and adaptive developmental quotient (ADQ) for toddlers aged 3-4 years, but zinc is unrelated to anthropometric Z-scores or intelligence quotient (IQ.) calculations[7].

This study is part of the researcher's cohort study in health, a term, and normal birth weight infants. Significant evidence shows that babies weighing <2,800 g have lower cord zinc levels than controls[8]. Based on the results of previous studies that were still contradictory, as an example of our study population, we proved that umbilical cord zinc was associated with a tendency for birth weight <2,800 g. In a study in China, zinc levels in children under five did not correlate with nutritional status according to WHO Z-scores. An experimental study in Korea did not prove the correlation between zinc supplementation and stunting toddlers' height increase but on malnourished toddlers' weight gain[5,7,8]. The question is whether zinc plays a role in increasing body height (BH) under five or just body weight (BW), meeting the daily requirement of 3 mg/day according to the 2019 Indonesian Ministry of Health's Nutrition Adequacy Rate (RDA) and RDA (Recommended Dietary Allowance), whether it is related to stunting in our cohort study

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subjects. Based on these thoughts, examining the relationship between daily zinc intake and the increase in BH in the first three years of life or the incidence of stunting is necessary. Height gain should be calculated in the last year due to limited BH data for toddlers aged 1-2 years, so birth length data is used.

Wessel revealed the estimated prevalence of inadequate micro-nutrient zinc intake in Indonesia was >25%. These data are based on the composite nutritional composition database, the physiological requirements of IZINCG, and the Miller equation for estimating individual zinc absorption[9].

According to the 2013 first 1,000 days of life movement planning program guidelines, providing the micro-nutrient zinc to toddlers is only intended as an anti-diarrhea supplement. To our best knowledge, no program provides routine zinc supplements for newborns and toddlers[10]. This study aimed to prove the correlation between zinc intake and the average height growth of toddlers in the first three years of life, the relationship between zinc intake and stunting, and determine the relationship between stunting and distinguishing factors including gender, socioeconomic, mother's education, nutritional status, weight/age, weight/weight according to the WHO Z-score, and a history of solids (complementary food for breast milk).

METHODS

A cross-sectional study design was used in this study. This research was part of the cohort of Priyantini S et al. in 2017, which examined the role of zinc on allergies, the health status of 80 babies born at RSI Sultan Agung and Bangetayu Health Center in Semarang City, babies born at full-term, average birth weight, and healthy infants. Currently, the toddler age range is around 38-41 months. The sampling method for all cohort subjects was taken[11]. The baby was already three years old, but 27 of them moved their domicile or refused to participate in further research, and the remaining 54 toddlers whose parents agreed. Exclusion criteria in this study were respondents moving domicile, being hospitalized due to severe illness, and families not agreeing to participate. Daily zinc intake data was calculated using a questionnaire for *food recall* equipped with the props-*diet model* and anthropometric measurements of height and body weight under five. The research time was in January 2021.

Calculate daily zinc intake, including energy, protein, and carbohydrates, with a 24-hour and 3x24-hour food recall, was conde during the study. A food recall was done through direct interviews asking children what food was consumed in a day. The food recall also involves conducting interviews, including the type and amount of volume (size of spoons, bowls, glasses) of food, and validating the weight of the food by showing the food model demonstrator to the mother/caregiver, then asking the food eaten sequentially backward, last night or yesterday afternoon and yesterday afternoon. Before the 24-hour food recall interviews two days earlier, a questionnaire was distributed as a table to record the type and amount of food the child ate for two consecutive days. The third day is the 24-hour direct food recall interview. Calculating the amount of zinc intake based on the results of a 3x24-hour food recall was calculated using the Nutrisurvey application. The average zinc mg/day was obtained. The zinc requirement for toddlers aged 1-3 years, according to the 2019 Indonesian Ministry of Health Nutritional Adequacy (AKG) and Recommended Dietary Allowances (RDA), is 3 mg/day. Zinc intake was considered sufficient, 3 mg/day[12,13].

The child's height was measured with a microtoise (0.1 cm accuracy), which was permanently attached to a sturdy wooden ruler so that it was easy to carry and stable when measuring. Height was measured by standing straight, looking forward barefoot, against the wall. Body weight was measured with a digital scale, and the child stood quietly on the scale. The accuracy of the measurement results is one decimal place after the decimal point (0.1 g).

The average growth in height is in height in the first three years of life. The assessment method was from the difference between birth length and height at around three years of age (age range 38-41 months), then calculating the growth of height/month to cm/month. Researchers did not get data on body length aged 1-2 years because >50% of children under five had problems with the completeness of the previous data on the healthy card (KMS) (the data was missing, or the height was not recorded in KMS). According to the WHO Z-Score calculation, the stunting category is PB/U <-2 SD^2. The category of good nutritional status (weight/age or height/age), if the z-score was ≥- 2SD, including over-nutrition, was included in this category. The category of under-nutrition status if it is in the range <-2 SD, including malnutrition in this criterion, as the subject was not found malnutrition. Data on the history of complementary foods aged 0-2 years were taken from previous cohort data considered good according to the scoring system (≥9) and assessed from the quality, quantity, and consistency of weaning food. The minimum socioeconomic level is according to the average minimum wage (UMR), and the minimum education level is in high school.

This research was conducted after obtaining ethical clearance from the Medical/Health and Bioethical Research Committee of the FK UNISSULA Semarang with number 300/IX/2020/Bioethics Commission. All respondents were given informed consent by their parents. A research team carried out this with the assistance of the KIA Health Surveillance Midwife (Gasurkes) from the Bangetayu and Genuk Health Centers. Analysis used Spearman's correlation test, chi-square test, or Fisher's test with SPSS 21 application.

RESULTS AND DISCUSSION

The characteristics of the respondents consisted of age, gender, mother's education, socioeconomic, history of complementary foods, and nutritional status. A description of the characteristics of the respondents is shown in Table 1.

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Table 1. Distribution of subjects based on age, sex, socioeconomic, education, nutritional status, and complementary feeding

Characteristics	N	%
Age (n=54)		
38 months	11	20.3
39 months	25	46.2
40 months	14	25.9
41 months	4	7.4
Gender		
Male	29	53.7
Female	25	46.3
Mother's Education		
Elementary school	2	3.7
Junior high school	14	25.9
High school	28	51.8
Higher education	10	18.5
Socioeconomic		
Enough	43	79.7
Not enough	11	20.3
Complementary feeding history		
Well	24	44.4
Not enough	30	55.6
Nutritional status		
WAZ (BB/U)		
Well	49	90.7
Not enough	5	9.3
HAZ (PB/U)		
Non-stunting	46	85.1
Stunting	8	14.9
WHZ (BB/PB)		
Well	50	92.6
Not enough	4	7.4

In Table 1, the percentage of respondents with good complementary feeding was 44.4%, and 55.6% had poor complementary feeding. Toddlers with BB/U who were classified as good reached 90.7%. This finding means that most respondents have enough weight according to their age. Based on HAZ status (TB/U), 46 (85.1%) were non-stunting, which implicated that the number of normal toddlers was higher than stunted toddlers (14.9%). As many as 92.3% of toddlers have a proportional weight according to height (WHZ> -2 SD Z-score).

Table 2. The Descriptive of zinc intake and growth in toddlers' height

Characteristics	Mean±SB	CI 95%
Zinc intake (mg/day)	3.71±1.39	3.33-4.09
Growth Height(cm/month)	1.15±0.10	1.13-1.18

The average zinc intake consumed by toddlers aged 3 ranged from 3.71 ± 1.39 mg, and the average height growth was 1.15 ± 0.10 (Table 2). Statistical analysis for hypothesis testing used a two-way test with a significance limit of p<0.05. The strength of the correlation was expressed with the correlation test in R. Analysis of the relationship between zinc intake and the average body length growth of children aged three years old was determined by Spearman's non-parametric correlation test because the transformation of the research data was not successful in normalizing the distribution of the data.

Table 3. Correlation of zinc intake with average height growth

Characteristics		Average body length growth (cm/month)
Zinc intake (mg/day)	*r*	0.166
	*p**	0.231
	n	54

*Spearman correlation

Table 3 presents the results of Spearman's non-parametric correlation test with a very weak correlation coefficient r = 0.166, p>0.05, which means that zinc intake did not correlate with the average height growth in the first three years of life. Table 4 shows the relationship between the average birth length and monthly growth in body length in the first three years of

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life, carried out through a non-parametric correlation test.

Table 4. Correlation of body length at birth with the average growth in body length

Characteristics		Average body length growth (cm/month)
Body Length at Birth (cm)	*r**	-0.416
	p.s	0.002
	n	54

*Spearman correlation

Table 4 shows a significant negative correlation between birth length and average height growth. The strength of the correlation was moderate, with a value of r= -0.416 and p= 0.002, meaning that babies born with lower birth lengths have the potential for higher body length gain. The relationship between the characteristics of toddlers and stunting (PB/A < -2 SD) was determined by the Chi-Square test or the alternative.

Table 5. Factors related to stunting

Characteristics	H/A Nutritional Status		p-value
	Non-stunting	*stunting*	
Gender			
Male	23	6	0.262*
Female	23	2	
Socioeconomic			
Enough	38	5	0.192**
Not enough	8	3	
Mother's Education			
Enough	33	5	0.597**
Not enough	13	3	
Weight/age Nutritional status			
Well	45	4	0.001*
Not enough	1	4	
Weight/height Nutritional Status			
Well	44	6	0.100*
Not enough	2	2	
Complementary feeding history			
Well	16	1	0.441*
Not enough	30	7	
Intake of zinc/per day			
Enough	33	1	0.001**
Not enough	13	7	

*Fisher's test **Chi square test

In Table 5, zinc intake < 3 mg/day was associated with stunting, and the results also proved a significant relationship between weight/age and stunting. Table 5 illustrates that there was no relationship between the characteristics consisting of gender, socioeconomic, education level of the mother, weight/height, and history of complementary feeding with stunting.

The percentage of stunted toddlers in this study was 14.9%, and the nutritional status of weight/body length was underweight (7%). Stunting is a condition where toddlers do not reach a height appropriate for their age due to stunted linear growth, as indicated by a body length/age Z-score less than -2 SD[14]. Stunting is still a health problem in Indonesia that must be resolved globally. Indonesia's target for reducing stunting rates in the RPJMN 2020-2024 is to reduce stunting rates by up to 14%, and WHO targets reducing the global prevalence of stunting to <20%[3,15].

The average zinc intake of toddlers aged three years was generally 3.71 ± 1.39 mg. This finding has exceeded the daily zinc intake limit set by the 2019 Indonesian Ministry of Health Nutritional Adequacy (AKG) and the RDA, which is 3 mg/dl per day[12,13]. This study's analysis of the relationship between average height growth and zinc intake showed no significant correlation. Similar results were shown by the research of Febrianty et al., where consuming milk, calcium, and zinc had no relationship with height[16]. A systematic review of 25 trials has not proven the effect of zinc supplementation on HAZ (Height for age z-score) [17]. Another systematic review mentions zinc supplementation in pregnant women and children 6-23 months. Zinc supplementation in pregnant women did not affect birth body weight and birth length. Zinc administration in infancy affected the child's WAZ but not the HAZ, although it did improve the child's zinc status[18].

Our study proved a significant relationship between insufficient zinc intake (< 3 mg/day) and stunting. In line with a study in Thailand, zinc supplementation for six months in elementary school children proved that the growth in body length was higher than that of the control group and in HAZ status[19]. The results of studies that were still contradictory about

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the role of zinc on body length growth might be caused by several factors such as zinc status early in life, age, zinc intake from the daily diet, racial differences, and the immune status of the population related to zinc metabolism-homeostasis which is very dynamic at cellular levels[20].

Growth factors can cause stunting during pregnancy. The period after birth and the influence of fetal growth factors include malnutrition in pregnant women, anemia, and fetal growth retardation. Condition factors after birth, including repeated or severe infections, dietary intake lacking in nutrients, or parental behavior in providing weaning food, can affect toddlers' growth. Research at the Jatinangor Health Center shows that mothers' behavior in providing weaning food was related to stunting[21]. Similar to the study in Kendal on infants aged 6-12 months, it showed results where proper complementary feeding was associated with an expected growth curve (Normal Growth)[22].

This study provided exciting findings that there was a negative correlation between the average birth length and the average height growth during the first three years of life. The question was whether there was homeostasis of hormones, micro-nutrients, and trace elements (zinc and iron) that regulate the skeletal growth system to protect against growth abnormalities. As stated in the literature, epigenetic mechanisms such as the role of Rbm24 as an RNA-binding protein are thought to play a role in a dynamic mechanism for maintaining tissue homeostasis during early development[23]. This condition might explain why in our study, babies with lower body lengths tended to grow taller in body length, and this was a kind of body homeostasis to maintain normal growth[20]. The role of zinc assists in synthesizing DNA and RNA in the body, contributes to creating immunity, and functions as a covariate for more than 200 body enzymes. It can be understood that the zinc factor is complex because it is related to many enzymatic processes at the cellular level.

Height growth is not only influenced by zinc micro-nutrients, and many other nutrients play a role in height growth. Other influential nutrients include protein, calcium, phosphorus, vitamin D, and growth hormone Protein, as a building macro-nutrient for all cells in the body, plays an essential role in the growth process of toddlers. Calcium is the most abundant mineral in the body and the most significant component of bone. Calcium regulates the tasks of hormones and growth factors such as insulin-like growth factor-1[16]. Moreover, vitamin D helps the process of absorption of calcium in the process of bone formation[24]. Besides nutrition, growth is also influenced by genetic and environmental factors such as sanitary hygiene. A study in Bangladesh showed that sanitary hygiene could reduce potential stunting factors[25]. The results of Dewey's research stated that a lack of nutrition caused child stunting before and during pregnancy and poor sanitation hygiene[26].

Body length/age was not related to gender. This finding aligns with previous studies where gender did not correlate with the weight or height of toddlers[27]. The mother's education was unrelated to body length/age <2SD. Rumende's research on toddlers supported this finding: the mother's education was unrelated to body length/age and weight/height z-score[28]. However, it was inversely proportional to other studies where the mother's education significantly correlates with the child's nutritional level[29]. Differences in results can occur because mothers live in big cities and have good access to information through social media and the internet. All mothers have android phones and are active in the WA PKK RT-RW group. The socioeconomic level did not show a relationship with stunting in this study. Previous research on children aged 24-59 months have proven that family income has no relationship with weight/age, body length/age, and weight/age z-score[28].

The history of complementary foods for toddlers in the study also did not show a relationship with stunting. The research results by Hanum et al. stated that short stature does not correlate with solids[30]. In contrast, a study conducted in Kendal on infants aged 6-12 months showed results where complementary feeding affected weight growth. Complementary foods are critical in increasing body weight in the first 12 months[22]. The difference in the results of this study could be due to several factors that could become confounders, such as frequency of infection, exclusive breastfeeding, and hormonal factors. Another study stated a significant effect of moderate-to-severe diarrhea at 0-6 months on severe linear growth disorders (growth faltering in height)[31].

The number of samples in the study decreased because the respondents moved their domiciles and refused to participate in the research due to the Covid-19 pandemic. The weakness of the study was that it did not pay attention to other factors such as intake of protein, fat, calcium, and vitamin D. Another weakness of the study was that more than 50% of KMS toddlers lost or had KMS but did not record body length so they could not calculate the difference in average body length growth 1-2 years final. The mother's understanding influenced constraints in filling in food recall data, lack of discipline in recording the 2x24-hour food menu, and uncooperative children when measuring anthropometry, which could affect the validity of the data. Our anticipatory step was to repeat the 24-hour food recall to get closer to more objective results, including re-confirmation to the mother to ensure that the notes previously made by the mother were correct by showing the existing food model. Another way was to re-measure the toddler's height by a home visit on another day when the toddler was calm.

A deeper study of zinc intake at the molecular level is needed by measuring zinc from blood and hair samples concerning linear growth in the past year because zinc works in the long term. It is less precise when assessing zinc intake for a moment. Zinc regulates long-term immunity that affects general health status, including immune cells, which directly affect hormone release. Its role is not limited to anthropometric growth[32].

CONCLUSIONS

This study did not prove the correlation of zinc intake with the average height gain in the first three years of life but proved the relationship between daily zinc intake and toddler stunting. More profound research

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related to hormones, zinc, calcium, and vitamin D metabolism was needed at the biomolecular level.

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