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Effectiveness of Zinc Suplementation on Linear Growth of Stunting Toddlers in Semarang City

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A B S T R A C T

Toddlers with nutritional deficiencies risk experiencing linear growth disorders, resulting in stunting. The provision of zinc supplementation is considered to increase linear growth in children. This study aimed to determine the effectiveness of zinc supplementation on the linear growth of stunting toddlers in the city of Semarang. Health workers and examination enumerators conducted blood sampling, serum zinc levels, and anthropometry. The method used in this research is a quasi-experimental research design with a pretest-posttest study design. Supplementation using zinc sulfate syrup containing elemental zinc at a dose of 10 mg/day (n=24) and 5 mg/day (n=23) for 12 weeks, given once a day. The data obtained before and after supplementation were serum zinc levels, weight, and height. The study was conducted from November 2020 to February 2021. The results showed a significant difference in the increase in serum zinc levels of 33.92±36.07 g/dL (10 mg dose) and 12.91±25.9 g/dL (5 mg dose). Analysis of nutritional status before and after supplementation showed significant differences in HAZ, WAZ, and WHZ z-score in the group with 10 mg zinc supplementation with p values 0.004, 0.000, and 0.000, respectively ($p<0.05$). While in the group with a 5 mg zinc supplementation dose, nutritional status parameters showed significant results in HAZ and WAZ, respectively 0.000 and 0.011 ($p<0.05$), while nutritional status WHZ was not significant at 0.100 ($p> 0.05$). While in the group with a 5 mg zinc supplementation dose, nutritional status parameters showed significant results in HAZ and WAZ, respectively 0.000 and 0.011 ($p<0.05$), while nutritional status WHZ was not significant at 0.100 ($p> 0.05$). The effectiveness of supplementation experienced by the 10 mg supplementation dose was 0.000, while the 5 mg supplementation value was 0.026 ($p<0.05$). This research shows that zinc supplementation can increase serum zinc levels and the nutritional status of children under five. The increase is more effective in the 10 mg supplementation dose group.

Kata kunci:

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A B S T R A K

Balita dengan defisiensi zat gizi dapat berisiko mengalami gangguan pertumbuhan linear sehingga mengakibatkan *stunting.* Pemberian suplementasi *zinc* dinilai dapat meningkatkan pertumbuhan linear pada anak. Tujuan dari penelitian adalah untuk mengetahui efektifitas suplementasi *zinc* terhadap pertumbuhan linear balita stunting di Kota Semarang. Pengambilan sampel darah, pengukuran kadar *zinc serum* dan antropometri dilakukan oleh tenaga kesehatan dan enumerator terlatih. Metode yang digunakan dalam penelitian adalah desain penelitian *quasy experimental* dengan rancangan *pretest posttest study design*. Suplementasi menggunakan sirup *zinc sulfat* yang berisi *zinc elemental* dengan dosis10 mg/hari (n=24) dan dosis 5 mg/hari(n=23) selama 12 minggu, diberikan sehari 1 kali. Data yang diperoleh

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sebelum dan sesudah suplementasi yaitu kadar *zinc serum*, berat badan dan tinggi badan. Penelitian dilaksanakan bulan November 2020-Februari 2021. Hasil penelitian menunjukkan signifikan adanya perbedaan kenaikan kadar *zinc serum* 33,92±36,07 µg/dL (dosis 10 mg) dan 12,91±25,9 µg/dL (dosis 5 mg). Hasil analisis pada status gizi sebelum dan sesudah suplementasi menunjukkan perbedaan signifikan pada TB/U, BB/U dan BB/TB pada kelompok dengan suplementasi *zinc* 10 mg masing-masing 0,004; 0,000 dan 0,000 (p<0,05). Sedangkan pada kelompok dengan dosis suplementasi *zinc* 5 mg, status gizi menunjukkan hasil signifikan pada TB/U dan BB/U, masing-masing 0,000 dan 0,011 (p<0,05) sedangkan status gizi BB/TB tidak signifikan 0,100(p>0,05). Efektifitas suplementasi dialami dosis suplementasi 10 mg dengan nilai 0,000 sedangkan pada suplementasi dosis 5 mg nilai 0,026 (p<0,05). Hal ini menunjukkan bahwa suplementasi *zinc* mampu meningkatkan kadar *zinc serum* dan status gizi balita, peningkatan lebih efektif dialami oleh kelompok dosis suplementasi 10 mg.

INTRODUCTION

Stunting can cause stunted growth, impaired cognitive function, susceptibility to non-communicable diseases, and decreased productivity. This condition can be a bad predictor of the quality of human resources because it results in the decrease someone's productive abilities in the present and the future (Reinhardt and Fanzo, 2014).

Zinc deficiency is believed to cause childhood stunting (Gera, Shah, and Sachdev, 2019). One of the treatments for stunting toddlers is zinc supplementation which can increase serum zinc levels. It will later be associated with increased body weight and height of the stunted toddler. Serum zinc levels can be used as a success indicator of supplementation and the level of zinc absorption (Brown *et al.*, 2002). The results showed that zinc supplementation significantly increased serum or plasma zinc concentrations by 20.3 mol/dl compared to no zinc (Petry *et al.*, 2016). In addition to the concentration of zinc in the blood, research conducted by Seul Gi Park et al. (2017) in Korea showed that there was an increase in the TB/U z-score and serum zinc in the group of stunted children who received zinc supplementation when compared to the control group (Park *et al.*, 2017).

Furthermore, the results showed that long-term zinc supplementation at a dose of 10 mg/day significantly affected linear growth in children <5 years, whereas doses of 5 and 3 mg/day had no significant effect. This study was conducted for 24 weeks and showed differences in height and weight gain. During the first 12 weeks, it produced a larger average of 1.64 cm and 0.59 kg compared to the second 12 weeks, which had 1.5 cm and 0.55 kg (H. C. Chao, Chang, and Huang, 2018).

The prevalence of stunting under five worldwide is still high at 22.2% in 2018. According to the results of Riskesdas (Basic Health Research) in 2018, in Indonesia, it is 30.8%, the prevalence of stunting under five in Central Java Province is 31.21%, while in Semarang City, it was 29.68% (Indonesian Ministry of Health, 2018). The prevalence rate is still becoming a public health problem because it has exceeded the cut-point rate for stunting in children under five, which WHO has set, specifically 20% (World Health Organization, 2014). Furthermore, based on the weighing operation activities carried out in 2019, it is known that there are quite high cases of stunting in the South Semarang area, namely 766 stunting children under five (DKK Semarang, 2019).

Based on the description above, the authors are interested in researching the effectiveness of zinc supplementation on linear growth in stunted toddlers in the city of Semarang.

METHOD

The design of this research is quasi-experimental with a pretest-posttest study design. This study involved 47 children aged 6-59 months diagnosed with stunting in 8 Semarang Regional Health Centers. In this study, treatment/supplementation of zinc sulfate was carried out in the form of syrup. The sample was randomly divided into two groups, namely group 1 (n=24), which received 10 mg elemental zinc supplementation and group 2 (n=23) received 5 mg elemental zinc supplementation daily for 12 weeks (Park *et al.*, 2017; H. C. Chao, Chang, and Huang, 2018). Mothers of stunting toddlers gave supplements once a day for 12 weeks under the supervision of researchers and assisted by enumerators. Children are classified as obedient if they take supplements 60 times in 12 weeks and are not compliant if they take supplements < 60 times in 12 weeks (Central Java Provincial Health Office, 2017). The subjects of this study were generally compliant in taking supplements, namely 97.9%, while the research subjects who were not compliant in taking supplements were 2.1%. Non-compliance occurred in the early weeks of the intervention because there were side effects, namely nausea, vomiting, and under-educated mothers of toddlers. Researchers overcame this condition by providing education and further explanation regarding zinc supplementation in mothers of children under five to improve compliance. Some exclusion criteria were set as follows: children with congenital abnormalities or physical disabilities; and children who have midget congenital abnormality.

The phlebotomist took Children's blood serum zinc levels through the child's vein as much as 3 ml. Furthermore, it was measured using the Atomic Absorption Spectrophotometry (AAS) method in g/dL units. Blood sampling and measurement of serum zinc levels were carried out by trained health personnel. Serum zinc levels were analyzed at the GAKY laboratory, Semarang. Serum zinc concentrations were grouped into 3 categories, namely >150 g/dL, 70–150 g/dL, and <70 g/dL (Suryaatmadja, 2004). This measurement was carried out twice, namely before and after zinc supplementation.

Anthropometric data observed were linear growth based on *height-for-age (HAZ) and weight-for-age (WAZ), weight-for-height (WHZ) z-score,* measured by age and sex with 2005 WHO standard using the Z-score method and calculated using the WHO Anthro 2005 software. The method of measuring height was using a stadiometer and body length with an accuracy of 0.1 cm. The HAZ category includes short (stunted) if the Z score measurement results are -3 SD to < -2 SD and very short (severely stunted) if the Z score is < -3 SD (Regulation of the Minister of Health of the Republic of Indonesia of 28 of 2020, 2020). In addition, researchers also observed body weight measurements using a digital weighing scale with an accuracy of 0.1 kg. The measurement results are categorized into: severely underweight with the Z score < -3 SD; underweight with the Z score -3 SD < -2 SD; and normal weight with the Z score -2 SD to +1 SD. This research has been approved by the Committee for Clinical Research Ethics, Faculty of Medicine, Sultan Agung University.

RESULTS

Characteristics of Respondents

Age grouping is divided into three, namely: 6-11 months (2.1%); 12-23 months (46.8%); and 24-59 months (51.06%). Out of the total subjects, 24 toddlers are male and 23 toddlers are female Male sex dominates in the group with 10 mg Zinc (75%), while girls dominate in the group with 5 mg Zinc (73.9%).There were 8.5% of children with a birth weight < 2500 grams and 91.5% with a birth length < 48 cm. The characteristics of the research subjects are presented in Table 1.

Table 1. Characteristics of Research Subjects

Variable	Score		Zinc Group 10 mg	Zinc Group 5 mg	Total
	Group*Zinc*10 mg(n:24)	Zinc group 5 mg (n:23)	n(%)	n(%)	n(%)
Age	24.9 ± 8.2	24(12-58)*			
6-11 months			1 (4,2)	0 (0)	1(2.1)
12-23 months			11 (45.8)	11 (47.8)	22 (46.8)
24-59 months			12 (50)	12 (52.2)	24 (51.06)
Gender					
Man			18 (75)	6 (26.2)	24 (51.06)
Woman			6 (25)	17 (73.9)	23 (48.9)
Birth Body Length	48.5(25-51)**	49 (45-51)**			
< 48 cm			8 (33.3)	6 (26.1)	14 (29.8)
48 cm			16 (66.7)	17 (73.9)	33 (70.2)
Birth Weight	3060.1 ± 383.3*	2975.87 ± 334.3*			
< 2500 grams			2 (8.3)	2 (8,7)	4 (8.5)
2500 grams			22 (91.7)	21 (91.3)	43 (91.5)
Height (before supplementation)	77.9 ± 6.2*	75.9 (65.8-98.6)**	24 (100)	23 (100)	47 (100)
Height (after supplementation)	81.2 ± 6.06*	79.4 (69.6-99.9)**	24 (100)	23 (100)	47 (100)
Body Weight (before supplementation)	9.02 ± 1.5*	8.4 (6.3-14.6)**	24 (100)	23 (100)	47 (100)
Weight (after supplementation)	10.02 ± 1.5*	9.3 (6.73 – 15.5)**	24 (100)	23 (100)	47 (100)
History of illness in the last three months (before supplementation)					
There is			7 (29.2)	7 (30.4)	14 (29.8)
There aren't any			17 (70.8)	16 (69.6)	33 (70.2)
History of illness in the last three months (during supplementation)					
There is			5 (20.8)	6 (26.1)	11 (23.4)
There aren't any			19 (79.2)	17 (72.9)	36 (76.6)
Consumption of Drugs/Supplements for three months (before supplementation)					
There is			13 (54.2)	13 (56.5)	26 (55.3)
There aren't any			11 (87.5)	10 (43.5)	21 (44.7)
Consumption of Drugs/Supplements (during supplementation)					
There is			6 (25,0)	7 (30.4)	13 (27.7)
There aren't any			18 (75.0)	16 (69.6)	34 (72.3)

*mean±SD
**median (min-max)

For all toddlers in this study, 91.5% of toddlers were born with normal birth weight and 70.2% of toddlers were born with a body length of more than 48 cm. It can be said that stunting in toddlers who participated in this study was primarily due to external factors, including poor nutritional intake. This result is in line with research in Semarang by Nashikhah (2012), which reported that birth weight is not a risk factor for stunting. (Nasikhah and Margawati, 2012) Babies with LBW will grow and develop slower because they have experienced intrauterine growth retardation since they were in the womb and will continue until the next age. As a result, they also often fail to follow the growth rate that should be achieved after birth.

Before zinc supplementation, in subjects in the 10 mg supplementation group, seven children had diarrhea, one child had Acute Respiratory Infection (ARI), and one child had Dengue Hemorrhagic Fever. During zinc supplementation, five toddlers had diarrhea. Meanwhile, five toddlers had diarrhea in the group with 5 mg zinc supplementation, one toddler had ARI, and one toddler had pulmonary tuberculosis with 1.5 months of treatment before supplementation. During the zinc supplementation, four toddlers experienced diarrhea and two toddlers suffered from ARI. The characteristics of the subject's family in this study are following table 2 below:

Table 2. Family Characteristics of Research Subjects

Variable	Distribution	Zinc group 10 mg (n:24)	Zinc group 5 mg (n:23)	Total
		n(%)	n(%)	n(%)
Father's Education	Elementary School	3 (12.5)	3 (13.0)	6 (12.7)
	Junior High School	4 (16.7)	3 (13.0)	7 (14.9)
	Senior High School	13 (54.2)	15 (65.2)	28 (59.6)
	Diploma/Bachelor	4 (16.7)	2 (8,7)	6 (12.7)
Mother's Education	Elementary School	2 (8.3)	1 (4,3)	3(6,4)
	Junior High School	6 (25)	2 (8,7)	8 (17.02)
	Senior High School	9 (37.5)	15 (65.2)	24 (51.06)
	Diploma/Bachelor	7 (29.2)	5 (21.7)	9 (19.2)
Father's occupation	Government Employees	2 (8.3)	0 (0)	2 (4,3)
	Private sector employee	14 (58.3)	9 (39.1)	23 (48.9)
	Self-employed	5 (20.8)	9 (39.1)	14 (29.8)
	Laborer	2 (8.3)	4 (17.4)	6 (12.7)
	Doesn't work	1 (4,2)	1 (4,3)	2 (4,3)
Mother's Job	Government Employees	2 (8.3)	0 (0)	2 (4,3)
	Private sector employee	0 (0)	4 (17.4)	4 (8.5)
	Self-employed	4 (16.7)	1 (4,3)	5 (10.6)
	Laborer	2 (8.3)	0 (0)	2 (4,3)
	Doesn't work	12 (50)	18 (78.3)	30 (63.8)
Family Income	Low (< UMP)	8 (33.33)	12 (52.2)	20 (42.5)
	Enough (≥ UMP)	16 (66.66)	11 (47.8)	27 (57.5)

The characteristics of family income in this study are divided into two categories: less than the provincial minimum wage (UMP) or low and more than the UMP or sufficient. The family income of the research subjects is generally sufficient, 57.5% (Table 2). However, this shows that almost half of the respondent's parents (42.5%) have low incomes (Nshimyiryo *et al.*, 2019).

Differences of *Serum Zinc Level* Before and After Zinc Supplementation

Zinc supplementation in children under five could significantly increase serum zinc level both in the group given zinc syrup with an elemental dose of 10 mg and an elemental dose of 5 mg ($p<0.05$), according to Table 3.

Table 3. Differences in serum zinc before and After Zinc Supplementation

Group	N	Initial serum zinc level	Final Serum Zinc Level	Zinc Serum	*P value*
Zinc Supplementation 10 mg	24	94.04±15.4*	128.50 (83.0 – 222.0)**	33.92±36.07	**0.000a**
Zinc Supplementation 5 mg	23	102.09±30.17*	115.0±19.2*	12.91±25.9	**0.026b**
P value		0.259c	0.183d	**0.027d**	

[a]Wilcoxon test
[b]Paired Sample T-test
[c]Test Independent-Samples T-test
[d]Mann-Whitney test
*Mean ± SDd
**Median (Min-Max)

Measurement of serum zinc levels before supplementation between the two groups showed no significant difference in initial serum zinc levels between the two groups (p=0.259). Likewise, with the final serum zinc level, the difference test showed no significant difference in serum zinc level after supplementation between the two groups (p=0.183).

The different tests of initial and final serum zinc levels in the group with an elemental dose of 10 mg had a p-value of 0.00. This result shows a significant difference in the serum zinc levels of children under five before and after the supplementation. Based on the difference in serum zinc levels, there was an average increase of 33.92±36.07 g/dl. Different tests in the group with 5 mg elemental zinc supplementation also showed a significant difference between serum zinc levels before and after supplementation with a p-value of 0.026. Based on the difference in serum zinc levels, there was an average increase of 12.91±25.9 g/dl.

The mean difference in improvement in the group with zinc supplementation at a dose of 10; mg (33.92±36.07 g/dl) was higher than the group with 5 mg zinc supplementation (12.91±25.9). Based on different test, there was a significant difference in the mean difference in the increase in serum zinc levels between the groups with zinc supplementation at a dose of 10 mg and a dose of 5 mg (p = 0.027). In that meta-analysis, long-term zinc supplementation at a dose of 10 mg/day significantly affected linear growth in children <5 years, whereas doses of 5 and 3 mg/day had no significant effect (H. C. Chao, Chang and Huang, 2018).

Differences in Anthropometry Before and After Zinc Supplementation

a. Height

Zinc supplementation for 12 weeks at a 10 mg/day dose significantly impacted on linear growth. This study showed a significant increase in height after supplementation in the group with 10 mg and 5 mg elemental zinc doses. However, the two groups had no significant difference in height increase before and after supplementation (Table 4).

The height difference test before zinc supplementation between the groups with 10 mg and 5 mg zinc supplements showed no significant difference between the two groups (p=0.469). Likewise, the height difference test after zinc supplementation also showed no significant difference in height after supplementation between the groups with 10 mg and 5 mg zinc supplementation (p=0.397). Therefore, the height difference test based on the difference in height before and after zinc supplementation shows that there was an average height increase of3.3±1.3 cm.

Table 4. Differences in Height Before and After Zinc Supplementation

Group	n	Height Before Supplementation	Height After Supplementation	∆ Height	*P value*
*Zinc*10 mg	24	77.9±6.2*	81.2±6.06*	3.3±1.3*	**0.000a**
*Zinc*5 mg	23	75.9 (65.8 – 98.6)**	80.4±7.4*	3.07±1.04*	**0.000b**
P value		0.469c	0.397d	0.609d	

[a]Paired Sample T-test
[b]Wilcoxon test
*Mean ± SD
[c]Mann-Whitney test
[d]Test Independent Sample T-test
**Median (Min-Max)

Different tests in the group with supplementation *zinc* with an elemental dose of 5 mg also showed a significant difference in height gain before and after supplementation with a p-value of 0.00. The difference in height before and after zinc supplementation showed an average increase of 3.07±1.04 cm.

The mean difference in height gain in the group with zinc supplementation at a dose of 10 mg (3.3±1.3 cm) was higher than the group with 5 mg zinc supplementation (3.07±1.04 cm). However, there was no significant difference of height gain between the groups with zinc supplementation at a dose of 10 mg and 5 mg (p = 0.609).

The increase in height is possible because the function of zinc affects the growth process. Several studies have shown that zinc deficiency affects growth hormone and low insulin levels, such as Growth Factor 1 (1 GF-1), Growth Hormone (GH) Receptors, and GH Binding Protein RNA are often associated with zinc deficiency. In addition, linear growth hormone's low regulation system can inhibit linear growth hormone can inhibit linear growth and sometimes even weight gain (Adriana and Wirjatmadi, 2014).

The results of this study follow the results of a study by Seul Gi Park et al. (2017) in Korea, where there was an increase in the HAZ z-score and serum zinc in the group of stunted children <5 years. In contrast, the control group, who was only given nutritional counseling, showed a decrease in serum zinc levels (Park *et al.*, 2017).

Table 5. Differences in Body Weight Before and After Zinc Supplementation

Group	N	Weight Before Supplementation	Weight After Supplementation	∆ Weight	*P value*
*Zinc*10 mg	24	9.02±1.5*	10.02±1.5*	0.99±0.37*	**0.000[a]**
*Zinc*5 mg	23	8.4 (6.3-14.6)**	9.3 (6.73-15.5)**	0.69±0.39*	**0.000[b]**
P value		0.282[c]	0.99[c]	**0.009[d]**	

[a]Paired Sample T-Test
[b]Wilcoxon test
*mean± SD
[c]Mann-Whitney test
[d]Test*Independent Sample T-Test*
**Median (Min-Max)

b. Weight

Differences in body weight before and after zinc supplementation are presented in Table 5. Different tests on body weight before zinc supplementation between groups with 10 mg and 5 mg zinc supplements showed no significant difference between the two groups (p=0.282). Likewise, the weight difference test after zinc supplementation also showed no significant difference in body weight after supplementation between the groups with 10 mg and 5 mg zinc supplementation (p=99).

This study showed a significant increase in body weight after the supplement was given in the group that received supplements with 10 mg and 5 mg elemental doses (p <0.05). In addition, different tests on body weight before and after zinc supplementation in the group with a 10 mg elemental dose showed a significant difference in the height gain of children under five before and after supplementation (p=0.00). Based on the difference in body weight before and after zinc supplementation, there was an average weight gain of0.99±0.37 kg.

The weight difference test in the group with 5 mg elemental zinc supplementation also showed a significant difference in body weight gain before and after supplementation with a p-value of 0.00. In addition, the difference in height before and after zinc supplementation showed an average increase of 0.69±0.39 kg. There was a significant difference of weight gain between groups with 10 mg and 5 mg zinc supplementation (p=0.09). The increase was higher in the group with 10 mg elemental zinc supplementation (0.99±0.37 kg) compared to the 5 mg elemental group (0.69±0.39 kg). This weight gain is in accordance with the results of Jin Min Cho's research in

2018, where zinc supplementation can positively impact body weight in stunting children (Cho, Kim, and Yang, 2019).

Differences in Nutritional Status Before and After Zinc Supplementation

The increase in nutritional status based on the Z-score for HAZ and WAZ was experienced more by toddlers who were given zinc supplements with an elemental dose of 10 mg. These results are in line with the results of the meta-analysis of Nissensohn et al. (2016), where infants with a zinc intake of 10 mg/day had a nutritional status of WAZ and WHZ 4% higher than infants with a zinc intake of 5 mg/day (Nissensohn *et al.*, 2016).

Zinc supplementation in this study showed the ability to increase differences in nutritional status in the group that has been given zinc syrup with an elemental dose of 10 mg or an elemental dose of 5 mg (Table 6).

Table 6. Differences in Nutritional Status Before and After Zinc Supplementation

Nutritional Status Indicator	10 mg			5 mg		
	Beginning	End	*P*	Beginning	End	*P*
TB/U	-2.18 (-3.61 – (-2.01) **	-1.98 (-3.31 – (-0.79) **	0.004a	-2.56 (-4.29 – (-2.01) **	-2.14 (-4.31 – (-1.64) **	0.000 a
BB/U	-2.2 ± 0.16*	-1.71±0.74*	0.000b	-2.5±0.17*	-2.24±0.78*	0.011b
BB/TB	-1.34 ± 0.92*	-0.90±0.86*	0.000b	-1.57±0.95*	-1.36±0.85*	0.100b

*mean± SD
**Median (Min-Max)
[a]Wilcoxon
[b]Paired T-test

The results of the analysis on nutritional status before and after supplementation showed that there were significant differences in nutritional status based on height and weight for age, weight for height, before and after zinc supplementation in the group with zinc supplementation with an elemental dose of 10 mg ($p < 0.05$). Meanwhile, in the group with 5 mg zinc supplementation, all nutritional status parameters showed significant results ($p<0.05$) except for nutritional status based on weight for height ($p>0.05$).

DISCUSSION

The results of this study indicate that zinc supplementation was able to increase the serum zinc levels of children under five in the group with a dose of 10 mg ($p = 0.000$) and 5 mg (0.026). The mean difference in serum increases between before and after supplementation is 33.92 μg/dL in the group with a dose of 10 mg and 12.9 µg/dL in the 5 mg dose group. In line with Jin Min Cho's study in South Korea (2019), this study showed that 5 mg elemental oral zinc supplementation for 6 months in premature children could improve serum zinc status. This study also significantly increased serum zinc levels with zinc supplementation and a placebo (Cho, Kim and Yang, 2019). The cross-sectional study by Berawi et al. (2019) regarding the zinc levels of stunted children in Lampung showed a significant difference between the average zinc levels of stunted and non-stunted infants. The mean zinc level in stunted infants is lower than zinc levels in non-stunted infants (Berawi *et al.*, 2019). In 2017, research in Egypt also showed that serum zinc levels in stunted children decreased significantly compared to normal children (Abd El-Maksoud *et al.*, 2017). In addition to increasing serum zinc levels, zinc supplementation can positively increase body weight and linear growth in stunted children (Cho, Kim, and Yang, 2019). In conclusion, zinc supplementation can be an alternative solution to prevent and overcome stunting problems. Research conducted by Seul Gi-Park1 et al. (2017) on 114 children aged between 4 months to 6 years showed that zinc supplementation has a beneficial effect on the growth of infants and children with growth disorders (Park *et al.*, 2017).

In addition to serum zinc levels, this study showed a significant increase in height and weight in both groups after zinc supplementation. This increase impacts improving the nutritional status of children under five. Rerksuppaphol's research on zinc supplementation in school-aged children in Thailand showed that supplementation for 6 months could increase a child's height (Rerksuppaphol and Rerksuppaphol, 2017). The results of Kusudrayat and Prananingrum's research also showed similar results where zinc supplementation could increase height and Z-score of height according to age in stunted toddlers (Pertiwi, Kusudaryati, and Prananingrum, 2016).

Zinc is closely related to bone metabolism, making it a mineral that plays a positive role in growth (Salgueiro *et al.*, 2002). In addition, the role of zinc mineral as linear growth among others, is a component of metalloenzymes, conformational polymerases, and various functions as free ions in membrane stability (Prasad, 1977). Zinc is known to interact with hormones that play a role in linear bone growth, such as somatomedin-c, osteocalcin, testosterone, thyroid hormone, and insulin (Salgueiro *et al.*, 2002). Several studies have shown that low levels of Insulin-like Growth Factor 1 (1 GF-1), Growth Hormone (GH) Receptors, and GH Binding Protein RNA are often associated with zinc deficiency. The low regulation system of linear growth hormone can inhibit linear growth and sometimes stop linear growth in body weight (Adriana and Wirjatmadi, 2014).T The results of this study follow the results of a study by Seul Gi Park et al. in Korea, where there was an increase in the TB/U z-score and serum zinc in the stunting group of children <5 years. While the control group, who was only given nutritional counseling, showed a decrease in serum zinc levels. (Park *et al.*, 2017)

In addition to height, weight gain after zinc supplementation in addition to height. This result followed the research of Mozaffari-Khosravi et al. (2008) who gave zinc supplements to children aged 2-5 years in Iran. The results showed that after 12 months of zinc supplementation, there was significant weight gain in the supplemented group compared to the placebo group, especially in the second six-month period (Mozaffari-Khosravi *et al.*, 2008). These results is influenced by the effect of zinc supplementation that can increase the appetite of children with low serum zinc levels (H. Chao, Chang, and Huang, 2018). With the increasing appetite, children's food intake will increase and they could gain more weight.

CONCLUSION

Zinc supplementation for 12 weeks increased serum zinc levels and the nutritional status of children under five. The increase was more effective in the group with a 10 mg supplement dose.

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Conflict of interest

This research does not include any conflict of interest.

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