Jurnal Kesehatan Ibu dan Anak
Vol.13, No.1, July 2019, pp. 19~27
doi : 10.29238/kia.v13i1.386

The effects of zinc and vitamin c supplementation on changes in height for age anthropometry index on stunting aged 24-59 months

Yuliasti Eka Purnamaningrum[1], Margono[2], Vajee Petphong[3]
[1]Department of Midwifery, Poltekkes Kemenkes Yogyakarta, Indonesia, yuliasti.eka.purnamaningrum@gmail.com
[2]Department of Midwifery, Poltekkes Kemenkes Yogyakarta, Indonesia, margonobgunadi@gmail.com
[3]Faculty of Tropical Medicine, Department of Microbiology and Immunology, Mahidol University, Thailand, petphong@hotmail.com

ARTICLE INFO

Article history:

Received: Sept, 17th 2019
Revised : Dec, 31th 2019
Accepted: Jan, 1st 2020

Keyword:

Height for age index
Stunting
Toddlers
Vitamin C
Zinc

ABSTRACT

Stunting is a physical growth disorder characterized by a decrease in the speed of growth and the impact of nutritional imbalances. Children affected by stunting up to the age of 5 years will be difficult to repair, so it will continue into adulthood and can increase the risk of offspring with low birth weight babies (LBW). Adequacy of zinc and vitamin C for growth is an important factor for children to grow well. This study aims to determine the effect of zinc and vitamin C on changes in the height of age anthropometric index. Methods: (1) A randomized pre-post test with a control group study design with a total of 70 children aged 24-59 months in the work area of Sentolo II Public Health Center (PHC) and Pengasih II PHC. (2) The provision of zinc and vitamin C as much as 5 mg for 12 weeks in the experimental group and placebo syrup in the control group. Data analysis used chi-square, independent t-test, Mann Whitney, and Spearman. The results showed that zinc and vitamin C supplementation had a significant effect on changes in the height for age anthropometry index (p = 0.001 95% CI 0.13-0.45) with a mean difference of 0.29 and height (p = 0.016 95 % CI 0.14-1.28) with a mean difference of 0.7cm. The effect is greater in children who have a lower height for age index (p = 0.00 r = -0.61). Zinc supplementation and vitamin C significantly affected children's height and height for age index.

Corresponding Author:

Yuliasti Eka Purnamaningrm
Department of Midwifery, Poltekkes Kemenkes Yogyakarta, Yogyakarta, Indonesia
Mangkuyudan Street, MJ III/304 Yogyakarta, 55143. Telp/ Fax : (0274) 374331
Email : yuliasti.eka.purnamaningrum@gmail.com

INTRODUCTION

Health development in the 2015-2019 period focused on four priority programs, namely a reduction in maternal and infant mortality, a decrease in the prevalence of short (stunting) toddlers, control of infectious diseases and control of non-communicable diseases. Efforts to improve the nutritional status of the community, including a decrease in the prevalence of short toddlers, are one of the national development priorities listed in the main targets of Medium-Term Development Plan in 2015-2019.(1)

Stunting is a long-term consequence of lack of nutrition and has an impact on children's mental development disorders, school performance, and intellectual capacity that will affect nationally.(2) According to the Decree of the Minister of Health No. 1995/MENKES/SK/XII/2010 concerning Anthropometric Standards for Child Nutrition Status Assessment, the meaning of short and very short is nutritional status based on the index of Body Length for Age (PB/U) or Height for Age (TB/U) which is the equivalence of the terms stunted (short) and severely stunted (very short). Short toddlers (stunting) can be indicated if a toddler has been measured in length or height, then compared to the standard, and the results are below normal. Short toddlers are toddlers whose Z-score of the nutritional status is less than -2SD and categorized as very short if the Z-score is less from -3SD, based on their length or height according to their age when compared with the standard WHO-MGRS (Multicentre Growth Reference Study) in 2005.(3)

The percentage of nutritional status of short and very short toddlers in Indonesia in 2013 was 37.2%. If compared to the percentage in 2010 (35.6%) and 2007 (36.8%), it did not show a significant decrease or improvement. The percentage in the Special Province of Yogyakarta is 27.2%. According to WHO, the prevalence of short toddlers is a public health problem if the prevalence is 20% or more. Therefore, the percentage of short toddlers in the Special Region of Yogyakarta is still high and is a health problem that must be addressed.(1)

Kulon Progo Regency is one of 100 priority districts/cities for stunting interventions in Indonesia. The selection of priority districts/cities for stunting interventions based on the number and prevalence of stunting and the provincial poverty level (village-city). Kulon Progo has a population of 416 thousand people with a stunting prevalence of 26.31% (8127 children). The poverty level of Kulon Progo in 2016 reached 20.30%, and the total poor population was 84 thousand people.(4)

Stunting during childhood has a long-term effect in two ways, as a direct cause of short height in adults and suboptimal function in the future and as a marker of important early life processes that affect poor growth.(5) The long-term effect that can occur is the disruption of physical, mental, intellectual, and cognitive development. Children who get stunting up to the age of 5 years will be difficult to repair so that it will continue into adulthood and can increase the risk of offspring with low birth weight babies.(6) Woldehanna, Behrman, and Araya (2017) also stated that stunting children have less cognitive ability.(7)

Many factors increase the risk of stunting in toddlers. These factors include family economy, number of family members, clean water facilities, health services, and nutrient intake.(8) Parenting also plays a role in stunting. Toddlers who do not get the right parenting will not get nutritional intake by their needs so that it will affect the linear growth of toddlers.(9)

Zinc (Zn) deficiency in children is a risk factor that causes stunting.(10) The presence of Zn changes in growth caused by Zn is one of the substances that are classified as type 2 nutrition. Type 2 nutrition is an ingredient that is suitable for composition and is very important for proper regulation, positive with serum Insulin-like Growth Factor I (IGF-I).(11) IGF-I is a growth hormone mediator which is a growth-supporting factor in the growth process. The deficiency of growth hormone causes IGF-I concentration in circulation is low, in contrast to high growth hormone, IGF-I concentration will also increase.(12)

Vitamin C is important for forming collagen, and also structural protein. Collagen is needed to form bones and teeth and form scar tissue. Vitamin C is also important in increasing the body's resistance to infection. Vitamin C is needed in the process of growth through its role in collagen synthesis, through hydroxylases proline and lysine to hydroxyproline, essential ingredients for collagen formation is a consolidated protein. Normal collagen cannot be made without vitamin C. If the child has vitamin C deficiency, it will inhibit the formation of protein and collagen so it inhibits the growth process.(13,14) Vitamin C is an antioxidant that is important for the growth, function, and care of several types of cells in the body. Vitamin C influences the formation of osteoblast bone and thus has a positive impact on trabecular bone formation. Many growth factors that regulate through increased production of collagen stimulated by vitamin C. Vitamin C has an important role in maintaining bone health, vitamin C deficiency causes an increase in bone growth.(15)

Bening's research, *et al*. showed that the risk factors for stunting in children aged 2-5 years was lack of vitamin C, and factors that were not proven to affect the incidence of stunting were the adequacy level of energy, protein, vitamin A and calcium.(16) Aprilitasari's research showed that there was no difference in zinc intake between stunting and non-stunting toddlers, and there were no differences in calcium intake (Ca) between stunting and non-stunting children.(17)

Meanwhile, Kusudaryati's research, *et al*. showed that there was an effect of zinc supplementation (Zn) on the changes in the height for age anthropometric index in stunted children aged 24-36 months.(18) Likewise, Losong and Adriani's research showed iron and zinc intake, and hemoglobin levels had significant differences in stunting and non-stunting toddlers. Food intake in toddlers stunting needs to be increased, especially those containing high iron and zinc to prevent further stunting.(19)

Infancy, childhood, adolescence, pregnancy, and breastfeeding are periods that are vulnerable to zinc deficiency. Early childhood is one of the times when zinc is very much needed for growth.(20) Pimpin *et al*. stated that zinc administration, which has a significant effect, is the giving to children, not to maternal.(21) Furthermore, Liu *et al*. showed that administration of zinc supplementation is best given to children aged over 2 years.(22)

The age of 2 years is an important age at the start of the pursuit of stunting children's height.(23–26)This occurs even without the intervention provided.(24) The pursuit occurs until middle-aged children.(24),(26) However, high pursuit most occur until before the age of 5 years old.(23,25)

The importance of zinc and vitamin C for the linear growth of children, especially those that are still in its growth period, is the basis for researchers to research to determine whether there is an influence of zinc and vitamin C supplementation on changes in height for age anthropometric index in stunted children aged 24-59 months. This study was carried out on children aged 2-5 years because this age group has been separated from the first thousand days of life and exclusive breastfeeding so that they are most vulnerable to obtain improper parenting.

This study aimed to determine the effect of zinc and vitamin C supplementation on changes in height for age anthropometric index on stunting at 24-59 months of age in Kulon Progo Regency.

METHOD

This study was an experimental study with a randomized pre-post-test with control group design that was carried out by direct observation on stunting. Changes observed in this study were differences in changes in the height for age anthropometry index on stunting aged 24-59 months between the experimental group and the control group. This research was carried out in the working area of the Sentolo II Public Health Center (PHC) and Pengasih II PHC.

The population in this study was stunting in the Kulon Progo region. The sample size is obtained from calculations based on Lemeshow *et al*. formula for the sample size for two averaged population(27), with 95 percent confidence interval (α = 0.05), mean of change in Z for height score 0.2(18) and power 90 percent (β = 1.28). The minimum number of samples needed for each group is 32 people. The number of samples after being added 10% to 35 people for the experimental group and 35 people for the control group. Determination of subjects entered into the experimental group or control group using simple random sampling. Supplementation of zinc sulfate syrup at a dose of 5 mg and vitamin C at a dose of 50 mg is given 1x / day for 12 weeks (3 months). The treatment was carried out in the experimental group. In the control group, placebo syrup supplementation without zinc and vitamin C was performed. This research was carried out after obtaining approval

ISSN: 2599-3224 (Online), ISSN: 2302-6014 (Print)

from the Poltekkes Kemenkes Yogyakarta by obtaining a letter of ethical research worthiness from the Poltekkes Kemenkes Yogyakarta Research Ethics Committee No LB.01.01 / KE-01 / XVI / 355/2018 on 24 April 2018.

This study uses primary data. Data analysis was carried out quantitatively which was adjusted to the objectives achieved in this study. Univariate analysis was carried out to see the average changes in the height for age anthropometry index in each group. Bivariate analysis was used to analyze differences in the average changes in the height for age anthropometric index between the experimental group and the control group. The bivariate analysis was conducted with an independent t-test, Mann Whitney, and Pearson product-moment at a significant level of 5%.

The instruments used in this study include Forms of data collection and stationery, microtoise to measure children's height, maternal and child health books to calculate the age of children based on data on birth, WHO Anthro software 2005 to calculate Z/height scores.

RESULTS

This study examined the effect of Zinc and Vitamin C supplementation on changes in height for age anthropometry index. Other variables examined were the history of breastfeeding, the accuracy of giving complimentary food for breast milk, upper arm circumference during pregnancy, anemia of pregnancy, family income, mother's height, father's height, mother's education and father's education with a total of 70 respondents, namely 35 experimental group respondents and 35 control group respondents.

Characteristics of respondents in this study were the history of breastfeeding, the accuracy of giving complimentary food for breast milk, upper arm circumference during pregnancy, anemia of pregnancy, family income, mother's height, father's height, mother's education, and father's education. The homogeneity test results showed the distribution of characteristics in the homogeneous control and experimental group (p> 0.05).

Table 1. Characteristics of research respondents

Characteristics	Control Group		Experimental Group		p
	n	%	n	%	
Breast milk					
Not exclusive	21	60	22	62.9	1.00
Exclusive	14	40	13	37.1	
Complimentary food for breast milk					
Inappropriate	16	45.7	16	45.7	1.00
Appropriate	19	54.3	19	54.3	
Upper arm circumference					
Less chronic energy	16	45.7	11	34.3	0.33
Normal	19	54.3	24	68.6	
Anemia					
Yes	14	41.2	13	40.6	1.00
No	20	58.8	19	59.4	
Income					
< Rp.1.454,150	20	57.1	12	34.3	0.09
≥ Rp.1.454,150	15	42.9	23	65.7	
Mother's height					
Short	24	68.6	24	68.6	1.00
Normal	11	31.4	11	31.4	
Father's height					
Short	16	48.5	21	61.8	0.40
Normal	17	51.5	13	38.2	

Characteristics	Control Group		Experimental Group		p
	n	%	n	%	
Mother's education					
Basic	9	25.7	12	34.3	
Middle	25	71.4	23	65.7	0.35
High	1	2.9	0	0	
Father's education					
Basic	11	33.3	13	28.2	
Middle	20	60.6	21	61.8	0.48
High	2	6.1	0	0	

Based on the results of the study, it was found that the majority of respondents in both groups were given not exclusive breastfeeding and appropriate complementary food for breast milk, had normal upper arm circumference during pregnancy, had mothers without anemia during pregnancy, had short-height mothers, and had middle-educated parents. Most of the control group's income was less, while the experimental group had more. Most of the fathers in the control group had normal height, while the father's height of the experimental group was short. The distribution of characteristics of all respondents has a value of p> 0.05 which means the characteristics of the two homogeneous groups.

Different tests used independent t-test on the height variable because the data distribution was normal, while the height for age variable used Mann Whitney because the data distribution was not normal. The height of the experimental group was higher than the control group (87.1 compared to 85.8). The results of different tests on the height of the experimental and control groups at the beginning of the study showed no significant differences between the groups (p> 0.05). The height for the age variable showed that the median in the control group was greater than the experimental group (-2.67 compared to -2.95). The value of p = 0.02 indicates that there was a significant difference between the initial height for the age index of the experimental group and the control group.

Table 2. The general picture of height and anthropometric index of height for age at the beginning of the study

	Mean (±SD)		p	Mean Difference (CI 95%)
Height	Experimental Group	87,1	0,40*	1,27 (-1,70-4,25)
	Control Group	85,8		
	Median (min-max)			
Height for age	Experimental Group	-2,95 {-4,32-(-)2,27}	0,02**	
	Control Group	-2,67 {-5,62-(-)2,01}		

*independent t-test
**Mann Whitney

Correlation test results for all respondents showed a significant correlation between the initial height for age index and the difference in height for age index (p <0.05) with moderate correlation strength (r = -0.43). The correlation test of each group showed that the difference in height had a significant correlation difference only in the group given zinc and vitamin C supplementation (p <0.05). More increases occur in children with a height for age index which is getting lower with a strong correlation strength (r = -0.61).

Table 3. Initial height for age index correlation test with height for age index difference

The difference in height for age	n	R	p
Initial height for age of the control group	35	-0,20	0,25
Initial height for age of the experimental group	35	-0,61	0,00
Overall height for age	70	-0,43	0,00

The mean difference test on height and height for age differences showed significant changes. The difference in mean height in the experimental and control groups reached 0.71 and showed a significant difference (p = 0.016) with 95% CI 0.14-1.28. The mean difference of the height for the age index of the two groups reached 0.29 and showed a significant difference (p = 0.001) with 95% CI 0.13-0.45.

Table 4. Different mean changes of height and height for age in the experimental group and control group

Variable	Experimental $\bar{x}$ ±SD	Control $\bar{x}$ ±SD	p	Mean Changes (CI 95%)
∆ Height (cm)	2,41 (±1,37)	1,70 (±1,01)	0,016*	0,71 (0,14-1,28)
∆ Height for age	0,20 (±0,34)	-0,10 (±0,35)	0,001*	0,29 (0,13-0,45)

*independent t-test

The mean difference test results in this study showed that there were significant differences in height and height for age index that were signed between the experimental group and the control group. The experimental group height difference was 2.41 (+1.37) and in the control group 1.71 (+1.01) with p = 0.016 (95% CI 0.14-1.28). The difference between the height for the age index of the experimental group was 0.20 (+0.34) and in the control group -0.10 (+0.35) with a p-value = 0.001 (95% CI 0.13-0.45).

DISCUSSION

Stunted or short and severely stunted or very short are nutritional status based on the height index according to age. Children are said to be short if they have a height for age -3 index up to <-2 and are very short if they have a height for age index <-3.3.(3) Stunting is the best indicator to describe the overall welfare of children. Around 161 million children worldwide were stunted in 2013.(2) In Indonesia, the percentage of short and very short toddlers reached 37.2%. This shows that stunting is still a public health problem in Indonesia.(1)

Stunting has an impact on children's health in both the short and long term. Short-term impacts are the increase in morbidity mortality, the decrease in growth, and the increase in expenditure on health costs. Long-term impacts are short posture during adulthood, the increasing risk of obesity, the decrease in reproductive health, the decrease in academic ability, and the decrease in working capacity and productivity.(28) Research by Woldehanna, Behrman, and Araya (2017) states that stunting in early childhood is significantly related to children's cognitive abilities. Stunting children have less cognitive abilities.(7)

According to Cruz, et al. (2017) birth weight, maternal education, maternal occupation, number of family members, number of children under 5 years of age in the family, living in the countryside, use of coal for cooking, living in a house made of straw or wood right, duration of breastfeeding, duration of exclusive breastfeeding, and time to start complementary food for breast milk are significant factors associated with stunting.(29) Research of Danaei et al. (2016) conducted in 137 developing countries showed that inhibited fetal growth, poor sanitation, and diarrhea are the main risk factor for stunting.

Danaei et al. also mentioned that zinc deficiency is a risk factor for stunting.(10) The results of this study indicate that most of the history of breastfeeding in stunting children is not exclusive breastfeeding. The success of exclusive breastfeeding is influenced by a history of Early Breastfeeding Initiation (IMD). Simanjuntak, et al. (2018) stated that children under five who did not receive early breastfeeding were at risk of 1,555 times stunting compared to children under five who received early breastfeeding initiation.

Roohani, et al. (2013) stated that infants and children are a group at risk of experiencing zinc deficiency due to the increasing zinc requirements during growth. Infants up to the age of 6 months will meet their zinc needs if they consume enough diet with zinc. After the age of 6 months, the fulfillment of zinc needs is obtained from additional food. In many low-income countries, supplementary feeding is delayed and cereal food is given. This type of food contains only a small amount of zinc, so it does not meet the needs. However, early provision can also interfere with the absorption of zinc from breast milk because of the high content of phytate. Zinc deficiency has an impact on physical growth and development. The biggest impact occurs during the rate of rapid growth processes, such as during pregnancy, baby, and puberty.(20)

Hill (2013) states that zinc has an important role in cell growth as well as differentiation and metabolism, so zinc deficiency can have an impact on susceptibility to infection and stunted growth. The administration of zinc supplementation has a positive influence on children's linear growth. Zinc supplementation has a greater effect on stunting children than non-stunting children.(30)

This study aims to determine the effect of zinc and vitamin C supplementation on changes in height for age anthropometric index with the experimental group given a placebo syrup. Each group consists of 35 respondents aged 2 to 5 years and given treatment for 12 weeks. Zinc supplementation was given to the experimental group as much as 5 mg once a day. The results showed that zinc supplementation significantly affected changes in height and height for age index of children ($p = 0.016$ 95% CI 0.14-1.28 and $p = 0.001$ 95% CI 0.13-0.45). The effect of zinc on height for age is greater in children who have a lower height for age index ($p = 0.00$ $r = -0.61$).

The results of this study are consistent with the research conducted by Kusudaryati, Muis, and Widajanti (2017) which stated that zinc supplementation in stunting children had a significant effect on changes in Z/height score ($p = 0.006$). The treatment in the experimental group was in the form of giving syrup containing $ZnSO_4$ as much as 20 mg 2 times/week for 3 months. The mean change in the Z score in the control group was 0.1 (+ 0.08), while in the experimental group showed a greater result of 0.2 (+ 0.07). Kusudaryati, Muis, and Widajanti (2017) also showed that there was a positive influence on changes in height ($p < 0.001$). The mean body height increase in the experimental group was 2.4 (+0.27), while in the control group it was only 2.0 (+0.29).(18)

A meta-analysis by Imdad and Bhutta (2011) on 36 studies with an average treatment duration of 24 weeks with zinc doses averaging 10 mg/day showed that giving zinc supplementation to children <5 years had a positive impact on linear growth (effect size = 0.13 95% CI 0.04-0.21).(31) Another meta-analysis conducted by Mayo, et al. (2014) showed similar results. Mayo, et al. (2014) stated that zinc supplementation had a small but significant effect on height gain (mean difference -0.09 95% CI -0.13 - (-0.06)). The greater benefit is shown in older groups.(32)

Systematic review and meta-analysis by Pimpin (2016) on 24 pregnancy studies and 54 pediatric research studies stated that zinc supplementation in children increased their height and height for age index. Zinc supplementation is given around 8.9 mg/day on average for 7.1 months. Children's height increased by 0.69 cm ($p = 0.02$), and children's height for age index increased by 0.09 ($p = 0.001$). However, supplementation in pregnancy did not have a significant effect ($p = 0.06$).(1)

Liu, et al. (2018) also mentioned positive results in the administration of Zinc supplementation. The study involved in the systematic review and meta-analysis of Liu, et al. (2018) gave treatment for around 38.9 weeks with an average daily dose of 8.5 mg/day. Liu, et al. (2018) stated that giving zinc supplementation at infancy and early childhood gave a positive impact on growth (mean difference of height for age 0.12 95% CI 0.05-0.19, BB 1.37 95% CI 0.50-2.25). Liu, et al. (2018) also stated that the benefits of giving zinc supplementation were greater if given after 2 years of age compared to the benefits if given when they were babies. This is because children get zinc intake from maternal breast milk or the presence of zinc deposits from a pregnancy that is better than that when he was born. Another cause is the rapid growth in the first year of life compared to the following year. In populations that lack nutrition, growth tends to be higher at the beginning of life and then begins to flatten.(22)

CONCLUSION

Based on the research, it can be concluded that zinc supplementation and vitamin C significantly influence the change in height for age anthropometry index (p = 0.001 95% CI 0.13-0.45) with a mean difference of 0.29. The supplementation of zinc and vitamin C significantly affected changes in height (p = 0.016 95% CI 0.14-1.28) with a mean difference of 0.71. Zinc and vitamin C supplementation had a greater effect on children who had a lower height for age index (p = 0.00; r = -0.61). The provision of zinc and vitamin C supplementation affected changes in the height for age anthropometric index.

REFERENCES

1. Pusdatin KR. Situasi Balita Pendek. 2016;
2. de Onis M, Branca F. Childhood stunting: A global perspective. Matern Child Nutr. 2016;12:12–26. https://doi.org/10.1111/mcn.12231
3. Kemenkes RI. Kepmenkes No.1995/Menkes/SK/XII/2010 tentang Standar Antropometri Penilaian Status Gizi Anak. 2010. p. 40.
4. TIM NASIONAL PERCEPATAN PENANGGULANGAN KEMISKINAN. 100 Kabupaten/Kota Prioritas untuk Intervensi Anak Kerdil (Stunting) Ringkasan. Jakarta; 2017.
5. Dewey KG, Begum K. Long-term consequences of stunting in early life. Matern Child Nutr. 2011;7(SUPPL. 3):5–18. https://doi.org/10.1111/j.1740-8709.2011.00349.x
6. Kusudaryati DDP. Kekurangan Asupan Besi dan Seng Sebagai Faktor Penyebab Stunting pada Anak. PROFESI. 2014;10(26):57–61.
7. Woldehanna T, Behrman JR, Araya MW. The effect of early childhood stunting on children ' s cognitive achievements : Evidence from young lives Ethiopia. Ethiop J Heal Dev Complet. 2017;31(2).
8. Oktarina Z, Sudiarti T. Faktor Risiko Stunting Pada Balita (24—59 Bulan) Di Sumatera. J Gizi dan Pangan. 2014;8(3):175–80. https://doi.org/10.25182/jgp.2013.8.3.177-180
9. Kartasurya AHS dan MI. Faktor Risiko Kejadian Stunting pada Anak Usia 12-36 bulan di Kecamatan Pati, Kabupaten Pati. J Nutr Coll. 2012;1(1):30–7.
10. Danaei G, Andrews KG, Sudfeld CR, Fink G, McCoy DC, Peet E, et al. Risk Factors for Childhood Stunting in 137 Developing Countries: A Comparative Risk Assessment Analysis at Global, Regional, and Country Levels. PLoS Med. 2016;13(11):1–18. https://doi.org/10.1371/journal.pmed.1002164
11. Hamza RT, Hamed AI, Sallam MT. Effect of zinc supplementation on growth Hormone Insulin growth factor axis in short Egyptian children with zinc deficiency. Ital J Pediatr. 2012;38(21):1–7. https://doi.org/10.1186/1824-7288-38-21
12. Backeljauw P. Insulin-Like Growth Factor -I Deficiency. Vol. 55, Hormone Research in Paediatrics. 2008.
13. Granner DK RV. Biokimia Harper, Buku Kedokteran EGC. 27th ed. EGC; 2012. 518–521 p.

14. Maggini S, Wenzlaff S, Hornig D. Essential role of vitamin c and zinc in child immunity and health. J Int Med Res. 2010;38(2):386–414. https://doi.org/10.1177/147323001003800203
15. Patrick Aghajanian, Susan Hall, Montri D. Wongworawat dan SM. The Roles and Mechanism of Actions of Vitamin C in Bone: New Development. J Bone Min. 2015;30(11):1945–55. https://doi.org/10.1002/jbmr.2709
16. Salsa Bening, Ani MArgawati dan AR. Asupan Gizi Makro dan Mikro sebagai Faktor Risiko Stunting Anak Usia 2-5 Tahun di Semarang. Medica Hosp. 2016;1(1, November 2016):45–50. https://doi.org/10.36408/mhjcm.v4i1.245
17. Aprilitasari AH. Perbedaan Asupan Zinc (Zn) dan Kalsium (Ca) antara Anak Balita Stunting dan Non Stunting di Kelurahan Panularan Kota Surakarta. 2017.
18. Pertiwi D, Kusudaryati D, Muis SF, Widajanti L. Pengaruh suplementasi Zn terhadap perubahan indeks TB / U anak stunted usia 24-36 bulan. J Gizi Indones. 2017;5(2):98–104. https://doi.org/10.14710/jgi.5.2.98-104
19. Losong NHF, Adriani M. Perbedaan Kadar Hemoglobin , Asupan Zat Besi , dan Zinc pada Balita Stunting dan Non Stunting. e-jurnal unair. 2017;117–23. https://doi.org/10.20473/amnt.v1i2.6233
20. Roohani N, Hurrell1 R, Kelishadi R, Schulin R. Zinc and its importance for human health : An integrative review. J Res Med Sci. 2013;18:144–57.
21. Pimpin L, Liu E, Shulkin M, Duggan C, Fawzi W, Mozaffarian D. The Effect of Zinc Supplementation during Pregnancy and Youth on Child Growth up to 5 Years A Systematic Review and Meta-Analysis. Vol. 30, The FASEB Journal. 2016.
22. Liu E, Pimpin L, Shulkin M, Kranz S, Duggan CP, Mozaffarian D, et al. Effect of Zinc Supplementation on Growth Outcomes in Children under 5 Years of Age. Nutrients. 2018;10(377):1–20. https://doi.org/10.3390/nu10030377
23. Desmond C, Casale D. Catch-up growth in stunted children : Definitions and predictors. PLoS One. 2017;12(12):1–12. https://doi.org/10.1371/journal.pone.0189135
24. Prentice AM, Ward KA, Goldberg GR, Jarjou LM, Moore SE, Fulford AJ, et al. Perspective Critical windows for nutritional interventions against stunting 1 – 3. Am J Clin Nutr. 2013;97(911):911–8. https://doi.org/10.3945/ajcn.112.05233225. LIVES BPY. Nutrition , Stunting and Catch-Up Growth. 2015;(November).
26. Prendergast AJ, Humphrey JH. The stunting syndrome in developing countries. Paediatr Int Child Health. 2014;34(4):250–65. https://doi.org/10.1179/2046905514Y.0000000158
27. Lemeshow S, Jr DWH, Klar J, Lwanga SK. Adequacy of Sample Size in Health Studies. WHO; 1994.
28. Stewart CP, Iannotti L, Dewey KG MK& OA. Childhood Stunting : Context, Causes, and Consequences. Matern Child Nutr. 2013;9(2):27–45. https://doi.org/10.1111/mcn.12088
29. García Cruz LM, González Azpeitia G, Reyes Súarez D, Santana Rodríguez A, Loro Ferrer JF, Serra-Majem L. Factors associated with stunting among children aged 0 to 59 months from the central region of Mozambique. Nutrients. 2017;9(5):1–16.
30. Darnton-Hill I. WHO Zinc supplementation and growth in children. 2013.
31. Imdad A, Bhutta ZA. Effect of preventive zinc supplementation on linear growth in children under 5 years of age in developing countries: A meta-analysis of studies for input to the lives saved tool. BMC Public Health. 2011;11(SUPPL. 3):S22. https://doi.org/10.1186/1471-2458-11-S3-S22
32. E M-W, JA J, A I, S D, XHS C, ES C, et al. Zinc supplementation for preventing mortality , morbidity , and growth failure in children aged 6 months to 12 years of age (Review). cochrane. 2014;(5).