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The Effect of Zinc Administration in Short Adolescent Mothers who Breastfeed on Zinc Level, Insulin-1 Growth Factors, and Infant Growth

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Abstract

BACKGROUND: Zinc is an important nutrient for humans at all stages of life, whose needs increase during pregnancy and lactation. Zinc concentrations in breast milk are considered adequate for the first 6 months of life, despite an increase in the volume of milk consumed, zinc in breast milk is likely to be sufficient if there is no diet, weaning. Zinc levels in breast milk cannot compensate for the increased zinc requirements of the premature neonate due to higher than normal zinc requirements, small liver size with reduced zinc stores, and a shortened digestive system.

AIM: This study aims to measure serum zinc levels, IGF-1, and growth of infants aged 6 months in short adolescent mothers who are breastfeeding and have been intervened with zinc supplementation.

MATERIALS AND METHODS: This study is a quantitative study using a quasi-experimental design and a pretest-posttest approach with a control group. The sampling technique used purposive sampling with inclusion criteria, namely, infants from breastfeeding mothers aged <19 years, history of SEZ, and maternal height <150 cm so that the total sample size was 60 respondents (30 control samples and 30 intervention samples). Analysis of the data collected in the study was processed analytically with the independent sample t-test and paired t-test.

RESULTS: From this study, it was found that the paired sample t-test results obtained p < 0.001, indicating that there was a difference before and after the intervention, so it can be concluded that there was an effect of giving zinc supplementation on serum zinc and IGF-1 levels of infants in the intervention group. Through the independent t-test, we got the value of p = 0.001 < = 0.05. This shows that there is an effect of zinc supplementation on serum zinc and IGF-1 levels in infants. The results of the Z-Score test for body weight and Z-Score values for body length obtained p < 0.001. This illustrates that there is a difference between the intervention group and the control group, so it can be concluded that there is an effect of zinc supplementation on the growth of infants aged 6 months.

CONCLUSION: There was a significant difference between before and after the intervention in the two groups so that zinc supplementation was effective in influencing serum zinc levels, IGF-1, and infant growth.

Introduction

The main factors that influence growth and development include nutrition, which can have an impact on cognitive and social development in children [1]. Therefore, it is very important to ensure adequate nutrition for pregnant women [2]. According to Unicef (2019), during pregnancy and breastfeeding, nutritional needs increase rapidly, and almost half of pregnant women (49%) experience problems related to nutrition. A malnourished mother can face serious health problems for herself, while the fetus she contains will not achieve optimal growth and development. Especially for mothers who are underweight, or whose height is <150 cm, during pregnancy, of course, they need better nutritional status for fetal growth so that babies with low birth weight and stunting do not occur [1].

Several studies have provided strong evidence that nutritional problems are often found in infants and children. In particular, stunting as a manifestation of chronic malnutrition is very common in children aged 1–3 years (26%) and decreases to 13% at the age of 7–9 years. The cause of the high incidence of stunting in children aged 1–3 years is still unclear. However, this is thought to be due to early marriage, low economic status, due to poor diet (low energy and micronutrients) during pregnancy and followed by poor quality early weaning, which causes low birth weight and at 6 months of age and prevalence of low birth weight. Stunting has more than 2-fold [3].

Micronutrients are nutrients needed by organisms throughout life in small amounts to perform various physiological functions. They do not function as energy stores but are important in cellular metabolism and are associated with enzyme systems where they act both as cofactors for activated metal ions. Enzymes or as metallo-enzyme-specific constituents function in the body and in the protection of the body against oxidative damage. Various micronutrients including Vitamin A, iodine, iron, zinc, calcium, Vitamin D, Vitamin B complex, and Vitamin C [4].

Zinc is an important nutrient for humans at all stages of life, whose needs increase during pregnancy and lactation. Zinc plays a role in the processes of growth, development, and differentiation, which interacts with general protein, carbohydrate, and fat metabolism [1]. On the other hand, zinc is required for the activity of more than 90 enzymes related to carbohydrate and energy metabolism, protein synthesis, nucleic acid synthesis, heme biosynthesis, synthesis and action of growth hormone, and insulin growth factor-I (Linder, 2010). In addition, there is also a link between zinc and hormones related to bone metabolism such as testosterone, thyroid hormone, insulin, and Vitamin D. Based on this, it can be concluded that zinc is a micronutrient that has a positive role in growth and development [5]. This is in line with the review articles which concluded that zinc is an essential nutrient for human health, to survive. Adequate levels of zinc intake can increase physical growth, reduce diseases that can occur in children, and even reduce mortality in developing countries [4].

Breast milk is the ideal food for babies in the 1st months of life. Exclusive breastfeeding for the 1st 6 months followed by breastfeeding plus complementary foods suitable for 1 year or more has been recommended by the American Academy of Pediatrics (AAP), the Centers for Disease Control and Prevention (CDC), and the World Health Organization (WHO) [6]. Breast milk contains many components (i.e., proteins, carbohydrates, lipids, and inorganic elements) that provide basic nutrition for infants during their first period of life. The qualitative composition of the components of breast milk from healthy mothers is similar, but the levels change during the lactation stage [7]. Breast milk can vary between populations, between lactations, among women in the population, and even among the mothers themselves during breastfeeding. Micronutrients (e.g., minerals and vitamins), macronutrients (e.g., fatty acids), energy density (kcal/g), and volume are all reported to vary, to some extent. Micronutrients and fatty acids can be wholly or partly derived from the mother's current diet, although macronutrients appear to be sufficient from short-term nutritional fluctuations because the mother can mobilize body reserves for milk synthesis during lactation. Unlike the macronutrient composition of milk, milk volume may be more sensitive to changes in the mother's condition. Hormones in milk, such as glucocorticoids and adipokines, correlate with concentrations in the maternal circulation [8].

The concentration of zinc in breast milk is highest in colostrum (around 8 mg/L). For breastfed neonates, the concentration of zinc in breast milk is considered adequate for the first 6 months of life, although there is an increase in the volume of milk consumed, zinc in breast milk tends to be adequate in the absence of a weaning diet [9]. The level of zinc in breast milk cannot keep up with the increased zinc requirements of preterm neonates due to higher than normal zinc requirements, small liver size with reduced zinc stores, and shorter digestive system. These factors place the premature infant in a negative zinc balance until about 2 months of age and necessitate the use of zinc supplements from birth [10].

Many challenges can arise in the effort to meet the nutritional needs of infants so that factors related to mothers must also be considered, including the young age of the mother and short height, because these are closely related to a number of social problems, due to early pregnancy and childbearing and even breastfeeding which can affect the welfare of themselves and their children [11].

Materials and Methods

This study was conducted in four Public Health Centers in Mamuju City, West Sulawesi Province for the period November 2020 until September 2021. This study was a quantitative study using a quasi-experimental design and a pretest-posttest approach with a control group. Sampling technique using purposive sampling with inclusion criteria, namely, infants from breastfeeding mothers aged < 19 years, history of SEZ, and maternal height <150 cm so that the total sample size was 60 respondents (30 control samples and 30 intervention samples). This research has been approved by the Research Ethics Commission of the Faculty of Medicine, Hasanuddin University, Makassar, and has also been registered with Clinical Trials.Gov with No. NCT05100550. Analysis of the data collected in the study was processed analytically with the independent sample t-test and paired t-test.

Results

This study was divided into two groups, namely, the group that was given the intervention and the control group. Before the intervention was given to breastfeeding mothers, a pre-test (O1) examination of serum zinc levels in infants and IGF-1 was carried out in both groups through blood collection from the umbilical cord, then intervention (X) was given by giving zinc supplementation to breastfeeding mothers in the intervention group for 12 weeks. After that, a post-test (O2) was performed when the baby was 6 months old by taking 1 cc of blood through the median cubital vein and measuring body weight and length (O3).

Table 1 shows the results of statistical tests on characteristics, in the control group, gender variable was obtained by 17 people (56.7%) male and 13 people (43.3%) female. In the intervention group, both male and female, each group consisted of 15 people (50%). In the weight variable in the control group, the mean value was ± SD 3292.17 ± 235.16 grams, and in the intervention group, the mean value was 2760 ± 154.60. Body length variable in the control group obtained a mean value of ± SD 48.23 ± 1.59 cm, and in the intervention group, the mean value was 48.13 ± 0.77. Moreover, the variable head circumference in the control group obtained a mean value of ± SD 33.36 ± 0.63 grams, and in the intervention group, the mean value was 33.40 ± 0.48.

Table 1: Distribution of infant characteristics

Variable	Control (n = 30)		Intervention (n = 30)	
	n (%)	Mean ± SD	n (%)	Mean ± SD
Gender				
Male	17 (56.7)		15 (50)	
Female	13 (43.3)		15 (50)	
Body weight		3292.17 ± 235.16		2760 ± 154.60
Body length		48.23 ± 1.59		48.13 ± 0.77
Head circumference		33.36 ± 0.63		33.40 ± 0.48

*Source: Primary Data, 2021.

The data in Table 2 show that there was an increase in the statistical results of serum zinc and infant IGF-1 in both groups after zinc supplementation was given. Serum zinc levels in the control group obtained a mean ± SD pretest value of 43.99 ± 5.26 g/dl and a mean post-test value of 48.53 ± 6.45 g/dl, while for the intervention group, the mean ± SD pre-test was 46.53 ± 6.35 g/dl and the mean value ± SD post-test was 53.92 ± 5.82 g/dl. Meanwhile, the IGF-1 level in the control group obtained the mean ± SD pretest of 0.67 ± 0.95 and the mean post-test value of 1.42 ± 1.48, while for the intervention group, the mean ± SD pre-test was 1.03 ± 1.67 and the mean ± SD post-test was 3.04 ± 2.08. Paired sample t-test results obtained p < 0.001, indicating that there is a difference before and after the intervention, so it can be concluded that there is an effect of zinc supplementation on serum zinc and IGF-1 levels of infants in the intervention group.

Table 2: Analysis of differences in serum zinc (Zn) levels and insulin-like growth factor-1 (IGF-1) levels in infants in the intervention group and the control group

Variable	Pre-test (n = 30)	Post-test (n = 30)	%	p*	p**
	Mean ± SD	Mean ± SD			
Baby serum zinc					
Control	43.99 ± 5.26	48.53 ± 6.45	8.77	<0.001	0.001
Intervention	46.53 ± 6.35	53.92 ± 5.82	13.59	<0.001	
Insulin-like growth factor-1					
Control	0.67 ± 0.95	1.42 ± 1.48	41.43	<0.001	0.001
Intervention	1.03 ± 1.67	3.04 ± 2.08	66.58	<0.001	

*Source: Primary Data, 2021, *Paired samples t-test; p < 0.05, **Independent samples t-test; p < 0.05.

Comparison of serum zinc and IGF-1 levels in infants between the control group and the intervention group after giving zinc supplementation done through the independent t-test, gave the value of p = 0.001 < = 0.05. This shows that there is an effect of zinc supplementation on serum zinc and IGF-1 levels in infants.

Based on the data in Table 3, it shows that the Z-Score of body weight in the control group obtained a mean ± SD value of 0.38 ± 0.67 and the intervention group of 1.13 ± 0.59. The Z-Score of body length in the control group obtained a mean ± SD value of –0.69 ± 0.66, and in the intervention group, it was 1.00 ± 0.77. The results of the independent samples t-test, both on the Z-Score of body weight and the Z-Score of body length, obtained p < 0.001. This illustrates that there are differences between the intervention group and the control group, so it can be concluded that there is an effect of zinc supplementation on the growth of infants aged 6 months.

Table 3: Analysis of differences in growth in infants aged 6 months in the intervention group and the control group

Variable	Control (n = 30)	Intervention (n = 30)	p*
	Mean ± SD	Mean ± SD	
Z-score Berat Badan	0.38 ± 0.67	1.13 ± 0.59	< 0.001
Z-score Panjang Badan	–0.69 ± 0.66	1.00 ± 0.77	< 0.001

*Source: Primary Data, 2021, *Independent samples t-test; p < 0.05.

Discussion

The results of this study showed that there was an effect of zinc supplementation on serum zinc levels, IGF-1, and the growth of infants aged 6 months between the intervention group and the control group before and after the intervention.

Pregnant women, nursing mothers, and children under 5 years of age are at the highest risk of micronutrient deficiencies (MNDs). Iron, iodine, folate, Vitamin A, and zinc deficiencies are the most widespread micronutrient deficiencies (MNDs) and are common contributors to poor growth, intellectual impairment, perinatal complications, and an increased risk of morbidity and mortality. The greatest concern is the fact that cycles of micronutrient deficiencies (MNDs) are passed from generation to generation, with far-reaching consequences on future populations. To end, the cycle of malnutrition is very important. A multidimensional, coordinated, and sustainable strategy is needed to combat MND. Short-term and long-term solutions are needed, namely, by giving zinc supplements [12].

The need for zinc will continue until breastfeeding. Babies should be breastfed intensively for the first 6 months of life. Case reports show that breast milk does not completely protect against zinc deficiency. Therefore, complementary food sources containing zinc should still be given. Zinc in breast milk is essential for the growth and development of newborns. Zinc deficiency can cause adverse effects on growth, motor development, and immunity, in infants, significantly higher than the level in the 3rd month. The concentration of zinc in breast milk decreases by 40% between the 1st and 3rd months of breastfeeding [13].

Breast milk is known to contain various biologically active compounds, including immunological growth factors, cytokines, hormones, oligosaccharides, antimicrobial peptides, enzymes, and immunoglobulins [14]. Zinc plays a role as an important nutritional factor in breast milk for optimal infant growth and development related to the regulation of maintaining differentiated mammary epithelium and the production and secretion of specific milk components during lactation. The functional role for zinc as a key modulator in MEC differentiation, and secretory function, during lactation, suggests that zinc is not only essential for the nutritional needs of nursing infants but also plays a fundamental role in the mother for optimal regulation of mammary gland development and function to ensure health, breast and successful lactation [15].

There was positive correlation between the zinc concentration in breast milk and the plasma zinc concentration of infants and the plasma zinc concentration of breastfeeding mothers. The results of this study indicate that breastfed infants aged 4–6 months have a risk of zinc deficiency and this risk is related to the mother's zinc status and breast milk zinc concentration. Zinc reserves during pregnancy should be a source of zinc used by newborns during the early period of life, dietary zinc intake has an important role to maintain zinc status during that period. About 13.6% of breastfeeding mothers have low levels of zinc; and maternal plasma zinc concentrations were lower in zinc-deficient infants compared with zinc-sufficient infants. In addition, we found a positive correlation [16].

The hormone IGF-1 is a mediator of human growth hormone (HGH) and functions to stimulate the body's growth, regulating growth hormone-independent anabolic reactions in many types of cells and tissues. IGF-1 is an atypical peptide composed of almost 99% protein bound. IGF-1 uses specific cell receptors located on the surface of cell membranes to complete many mitogenic cell functions which include the induction of cell growth, cell division, and differentiation. IGF-1 tends to initiate anabolic effects, increasing glucose and amino acid utilization while inhibiting protein catabolism [14].

Zinc acts on the intracellular growth hormone (GH) transduction pathway by activating protein kinase C. In this case, the "zinc finger" serves as the DNA-binding domain of transcription factors, and the zinc atom is essential for DNA binding and gene expression of many proteins. Somatotroph cells, especially in the Golgi apparatus and GH secretory granules, are rich in zinc. It is essential for GH dimerization, which is essential for storage and secretion. In this connection, zinc deficiency may affect GH synthesis and secretion, possibly leading to altered GH action through dysfunction of the zinc finger protein. The extent of this alteration is such that DNA biosynthesis is impaired due to zinc restriction on deoxythymidine kinase activity [17].

Zinc stimulates bone protein synthesis and bone formation. Zinc enhances the anabolic effect of IGF-1 on osteoblasts and inhibits osteoclast activity (bone resorption). This study is in line with the research conducted by Merialdi (2004). It was found that the length of the femoral diaphysis was greater in fetuses than mothers who received zinc supplementation ($p < 0.05$) [18].

Conclusion

There was a significant difference between before and after the intervention in the two groups so that zinc supplementation was effective in influencing serum zinc levels, IGF-1, and infant growth.

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