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The Effect of Tactile – Kinesthetic Stimulation on Bone Mineralization and Length among Stunting Children Aged 6-11 Months

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KEYWORDS
Tactile – Kinesthetic, Bone formation, Osteocalcin. Length, Stunting

ABSTRACT:

Background. Stunting is growth faltering caused by as poor nutrition, recurrent infections, a lack of psychosocial stimulation. Growth faltering is associated to bone growth disorder. In order to prevent and overcome stunting not only nutrition but also an adequate stimulation is needed. This study looked at the effects of tactile – kinesthetic stimulation on bone mineralization, osteocalcin levels and body length among stunting children.

Method. Eighty stunting children (mean of age 8 ± 1,71) were randomly assigned into two groups (n = 40 each group). Tactile – Kinesthetic Stimulation (TKS) was administrated by trained parents twice daily for three months in the intervention group. The control group was given a routine care of stunting program from public health center. The bone mineralization (osteocalcin serum) and length of body in both groups were measured at enrollment and after week twelve.

Results and Discussion. During the 3 moths TKS period, the intervention group had a significant increment in length and osteocalcin serum compared to control group ($p < 0.005$) at 3.17 cm and 11.5 ng/ml respectively. Moreover, this study also showed that providing TKS demonstrated a strong correlation in a positive direction to length. The TKS treatment could increase the length of stunting children by 86.5%. There was a positive correlation among osteocalcin levels, intake of vitamin A, protein and calcium on improving length ($p<0.05$).

Conclusion. TKS was significantly effective in promoting bone mineralization particularly osteocalcin levels and length among stunting children. There was also a strong correlation that TKS could elevate the length of 0.865-times.

INTRODUCTION

Growth faltering or stunting is indicated by length or height for age z-score more than two standard deviations below the WHO Child Growth Standard, (WHO, 2015a). The impairment of growth and development is caused by poor nutrition, recurrent infections, insufficient psychosocial stimulation (WHO, 2015a). Stunting leads to decrease immune function, metabolic disruptions, physical growth limitations and cognitive impairment during the first 1,000 days of life (Djauhari, 2017) Growth faltering is associated with bone development disorder. Osteocalcin regulates the metabolism of bone and muscle, as well as the process of bone mineralization and matrix maturity (Komori, 2020). Increased bone mineralization, osteocalcin levels, and glucose metabolism will all be triggered by exercise and appropriate psychosocial stimulation (Wang et al., 2021).

Stunting remains major public concern not only in Indonesia but also in the world. The number of stunting children under five is about 4.5 million in Indonesia and 149.2 worldwide (UNICEF; WHO; World Bank Group, 2023). The results of the Indonesian Nutritional Status Survey (SSGI) (2022) showed that the percentage of stunting has decreased from 24.4% in 2021 to 21.6% in 2022; however, a significant effort is still needed to

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reduce the rate by 3.8% year in order to meet the government's target of 14% in 2024. A strange number was found in Blora, which was increased from 21.4% the previous year to 25.8% (Liza Munira, 2023)

The government's program for preventing and treating stunting consists of specific and sensitive nutritional intervention. One of the 2022 stunting prevention programs to improve nutritional intake by providing stunting children with one egg per day (Sjarif, 2022). Other nutritional programs consisted of administration of macro and micro nutrients as well as a combination of 2-3 nutrients (Aryastami & Tarigan, 2017) diversification of menus and dietary patterns and supplementation, could not prevent stunting and did not have a positive effect on the increase in length of stunting children under five (Rosmalina et al., 2018). WHO advised to combine physical activity, psychosocial stimulation, infection prevention, and nutritional interventions. Stunting can benefit from psychosocial stimulation including auditory, visual, tactile, kinesthetic, parenting class, and exercise such as playing, exercising, and moving (De Onis et al., 2013; WHO, 2018). A different psychosocial and physical exercise program by the Indonesian Health Ministry is not specified for stunting children. (Kementrian Kesehatan RI, 2020).

Tactile - kinesthetic stimulation (TKS), a form of baby massage and baby gym that includes touch stimulations and kinesthetic movement, is promoted as an effective intervention to enhance bone development in stunting babies. Clinical studies demonstrate that TKS increases bone growth, bone strength, and mineral acquisition. TKS in other models resulted in determined changes that benefited bone mineralization(Haley et al., 2013). TKS increased lean mass, elevated bone mineral content and improved markers of bone turn over and microstructure in rodents. TKS model provides mechanical stimulation through touch stimulation and joint movements that stimulate GH and IGF-1 activity. Insulin-like growth factor (IGF-1) is an important mediator of the effect of growth hormone on bone growth and stimulate cell growth and proliferation. Elevated expression of IGF-1 and related pathways may explain improved bone mineralization. Elevated bone specific IGF-1 was associated with improved bone mineralization (Haley et al., 2013).

Bone is a dynamic tissue which is continuously subjected to resorption and formation. Bone metabolism can be assessed by measuring biochemical markers of bone remodeling in serum or urine. Biochemical markers of bone resorption and formation could thus provide insight into the mechanistic effects of TKS on bone development. Bone formation has also been identified as an indicator for catch-up growth for babies indicated by osteocalcin as specific biochemical markers. In circulation osteocalcin is considered by osteoblasts and serum osteocalcin is positively correlated with bone mineral density (Haley et al., 2012). Modified physical exercise and tactile stimulation has been shown to be effective in improving the growth and development of risk stunting.(Sutarmi et al., 2022) TKS has been used to enhance the growth and development of risks of stunting babies, and stunting children however their evaluation does not involve markers and only looks at physical parameters. Therefore, this study pointed out the effect of TKS on bone mineralization and length for stunting aged 6 – 12 months.

METHODS

Study Design

The design of the study was a Randomized Controlled Trial pre and post-test study design to see the efficacy TKS treatment to improve the bone formation through length of body and osteocalcin levels of stunting babies aged 6 to 12 months. This study was carried out at 43 stunting locus areas in 15 Public Health Centers of Blora Regency (Central Java, Indonesia) from January – July 2023. The subjects of this study were randomly divided into two groups. The treatment group received nutritional intervention according to the stunting program, additional nutrition with one egg a day and TKS treatment with frequency twice daily for 30 minutes each session, in the morning and afternoon for three months. The control group was approached a similar intervention to treatment group without TKS treatment. Before and after treatment, length and osteocalcin levels were recorded and measured for each group.

Participants

Population targets for the study were obtained from preliminary survey data from E-PPBM (Community-Based Nutrition Registration and Reporting) in January 2023. A total of 16,958 children under two years old, 885 indicated stunting and 147 babies aged from 6-12 months.

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There were 80 children aged under two years indicated stunting who met the inclusion and exclusion criteria as sample study. The inclusion criteria include: aged of 6-12 months, length for age <-2SD to -3SD as the WHO Child Growth Standards Median, (De Onis & Garza, 2003) good nutritional status and completely basic immunization according to the age during the study period. The exclusion criteria include physical defects, congenital defect, chronic illness and/or suffering from severe infectious diseases, skin diseases such as eczema. Subjects who did not treat the treatment of TKS treatment for three consecutive days would be drop out. Furthermore, the entire subjects were given an explanation of various matters relating to the research both in writing and orally, and signed an inform consent as proof of his willingness to follow this research procedure. Subjects who met the inclusion criterion were randomly divided into two groups. There were 40 subjects for intervention group and 40 subjects for control group.

The number of respondents who follow the study until completion of the study was 77, which was 39 respondents' intervention and 38 respondents treatment groups. Respondents who did not complete the study were dropped out because of unwilling to take blood for examination, moved to another area without notice and inaccessible to the researchers. The process of taking the research subjects was summarized in the consort diagram in Figure 1.

Research procedures

The research procedure was started with selection and training of enumerators consisted of 15 nutritionists and 15 laboratory experts from public health centres, 43 village midwives and 47 cadres accompanying stunting families. Selection of cadres enumerators based on the region and the number of respondents, each enumerator was responsible for 1-2 respondents residing in the areas closed to the respondent's location. The selected enumerators were trained on instruments, how to measure data and retrieve treatment respondents. Training of parents were carried out in several stages: training on data retrieval instruments and how to treat the respondents.

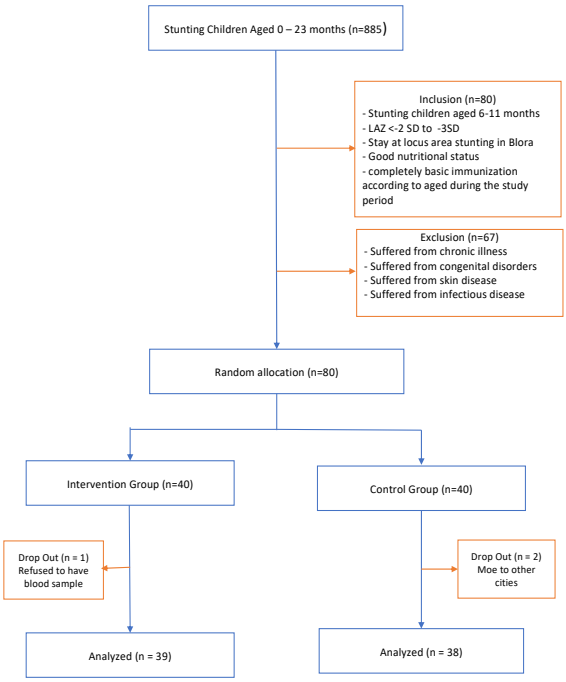

Figure 1. Consort of selecting subjects

Research procedures

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Measuring and Monitoring

Anthropometric measurements and serum samples are taken both before and after the intervention as part of the data collection stage. The data were measured at the beginning of the first week and at the end of the twelfth week. Data collection was carried out in Public Health Centre because of reasons of standardization on the basis of the measurement site, anthropometric kit and blood sampling procedures as well as serum storage. The measurements were conducted blindly between the nutritionist and the laboratory. Blood samples were obtained at baseline and the end of the study from stunting children age 6 to 11 months. Samples were centrifuged and plasma removed within 2 hours of blood collection; aliquots were stored in -80^{0}C freezers until shipped on dry ice for analysis. Serum samples were tested for biomarkers of osteocalcin were measured by an ELISA method from R&D Systems (Minneapolis, MN, USA) (Ela science, n.d.; Wieder Schain, 2009).

The baseline characteristics of the respondents including weight, length, age, sex, history of immunization, nutritional and health status were recorded. At the end of the twelfth week, the measurements of length and osteocalcin were taken to obtain post–intervention data.

In order to control the presence of additional factors that could affect the study's findings, food recall assessments conducted three times a day were used to track the amount of food consumed during the research process. Other accompanying diseases were also taken into account, as was the application of interventions based on information from the research activities checklist and records. Body length monitoring was also done on a monthly basis.

Intervention

The TKS treatment is a part of a tactile - kinesthetic stimulation for stunting children in forming of daily gym for stunting baby (Sutarmi et al., 2014) conducted by trained parents. The baby gym for stunting was provided twice a day in the morning and afternoon after shower, for three months. Each session consisted of 20 minutes divided into three minutes of preparation, 15 minutes of baby gym for stunting session, and two minutes of termination. A baby gym for stunting was started from the front of the body, so that the baby was laid down in a supine position. Firstly, the legs were massaged including Indian massage, sweeping top foot, Swedish massage, kinesthetic stimulation (knees-up), massage at stomach area: water wheels, chest: chest loving touch, arms and hands: lymphatic exercise, Indian Massage, elbow flexion-extension. Face area included, cheek bone massage, mouth circle, smile upper lip and bottom lip, lips and chin circle stimulation. For back massage, the baby was laid in prone position, the strokes started from the head area, with head loving touch, shoulder, back loving contact, arm loving connection, and feet loving communication. A series of TKS treatment was carried out six times for each strokes. The trained parents recorded and reported their intervention using WhatsApp group in form photos and videos activities. Monitoring and evaluating was also conducted by cadres ‘enumerators.

Statistical Analysis

Data were subjected to statistical evaluation including descriptive statistics for subjects characteristics, Wilcoxon Signed Rank on the differences of the body length, paired t- test for evaluation of serum osteocalcin levels before and after being given baby gym for stunting in the intervention group, as well as correlation and linear regression tests for baby gym for stunting with boy length and osteocalcin levels. All statistical evaluations were carried out using SPSSS version 23.0.

Ethical Clearance

This research was approved by Health Research Ethics Committee, Medical Faculty, Diponegoro University Semarang No.450/EC/KEPK/FK-UNDIP/XII/2022.

RESULTS AND DISCUSSION

Results

The characteristics of the research subjects in the intervention group and control group were homogeneous in terms of gender, age, carbohydrate intake, calcium intake, vitamin A, sleep quality, parenting patterns and osteocalcin levels. Statistical tests showed that there was no significant difference ($p>0.05$) for sex, age, carbohydrate intake, calcium, vitamin A, infection disease, sleeping quality, parenting and osteocalcin and statistically different ($P<0.05$) for body length, intake of energy, protein, fat, vitamin D and Zinc. Table 1 compiled the characteristics of subjects’

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Table 1 Characteristics of subjects

Subject Characteristics	Intervention Group	Control Group	*p*
Sex, n (%)			
Male	24 (61,5)	24 (63,2)	0,883[a]
Female	15 (38,5)	14 (36,8)	
Age, month , mean ± SD	8 ± 1,71	8 ±1,29	0,767[b]
Energy			
Calorie, median ± SD	646,7 ± 63,26	567,6 ±111,11	0,010[c]
Intake Percentage Median ± SD	81 ± 6,17	71 ± 13,85	0,011[c]
Carbohydrate			
Median Number of Gram ± SD	44,8 ± 9,74	42,8 ± 7,72	0,827[c]
Intake (%) median ± SD	43 ±9,26	41 ± 7,39	0,748[c]
Protein			
Mean Number of grams ± SD	8,95 ± 1,88	6,52 ± 1,65	<0.001[b]
Intake (%) mean ± SD	59,69 ± 12,54	43,42 ± 10,99	<0.001[b]
Fat			
Mean Number of grams ± SD	4,95 ± 1,60	7,04 ± 0,99	<0,001[b]
Intake (%) mean ± SD	14,15 ± 4,59	20,13 ± 2,89	<0,001[b]
Vitamin A, n (%)			
No	20 (58,8)	14 (41,2)	0,202[a]
Yes	19 (44,2)	24 (55,8)	
Vitamin D, n (%)			
No	38 (97,4)	31 (81.6)	0,029[d]
Yes	1 (2,6)	7 (18,4)	
Calcium, n (%)			
No	36 (92,3)	36 (94,7)	1,00[d]
Yes	3 (7,7)	2 (5,3)	
Zinc, n (%)			
No	28 (71,8)	36 (94,7)	0,007[a]
Yes	11 (26,2)	2 (5,3)	
Infection Disease n (%)			
No	36 (92,3)	38 (100)	0,219[a]
Yes	3 (7,7)	0	
Sleeping			
Category, n (%)			
Bad	2 (5,1)	3 (7,9)	

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Moderate	20 (51,3)	15 (39,5)	0,563[a]
Good	17 (43,6)	20 (52,6)	
Parenting score, Mean ± SD	36,21 ± 7,81	37 ± 7,16	0,643[b]
Category, n (%)			
Less	28 (71,8)	12 (31,6)	0,746[a]
Good	11 (28,2)	26 (68,4)	

p[a] Chi Square, p[b] Independent T- test, p[c] Mann Whitney, *p[d] Fisher Exact*

Table 2, presented that the length and osteocalcin increased significantly by 3.97 and 17.81 ng/ml (p<0,05) respectively after receiving baby gym for stunting treatment. These results demonstrated that the increase in length of body and osteocalcin in the intervention group were higher than in the control group. The mean differential delta values of length of body and osteocalcin in the intervention group were 3.17 cm and 11.5 ng/ml, (p<0.05) respectively.

Table 2. The differences between length and osteocalcin before after TKS intervention

Variables	**Group**		***p***
	Intervention (n=39)	**Control (n=38)**	
Length			
Pre intervention	65,71 ± 2,49	64,91 ± 1,85	0,115[b]
Post intervention	74,06 ± 2,15	70,09 ± 1,68	<0,001[b]
p-value	<0,001[a]	<0,001[a]	
Osteocalsin (ng/ml)			
Pre intervention	92 ± 26,30	92,13 ± 28,31	<0,983[b]
Post intervention	110,26 ± 25,23	92,45 ± 89	0,005[b]
p-value	<0,001[a]	<0,001[a]	
Delta			
Lenght	8,35 ± 1,31	5,18 ± 0,77	<0,001[b]
Osteocalsin	14 ± 13,7	2,5 ± 12,6	<0,001[c]

Data were presented by Mean ± SD, *p[a] Paired T test, , p[b] Independent T test, p[c] Mann-Whitney test*

Tabel 3. The result of correlation between osteocalcin levels and othe counfounding factors related to length (n=77)

Variables	**Delta of Length**	
	r	***p***
Delta_Osteocalsin	0,540	<0,001
Intervention	0,865	<0,001
Intake Vit_A	0,181	0,116

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Intake calcium	-0,174	0,129
Chronic diseases	-0,067	0,567
Sleeping behavior	0,010	0,933
Parenting	0,019	0,866
Intake calorie	-0,284	0,012
Intake of carbohydrate	-0,024	0,834
Intake of protein	-0,430	<0,001
Fat intake	0,461	<0,001

Table 3 demonstrated that giving TKS treatment revealed a very strong correlation with the positive direction towards length for age z-score, which was TKS intervention could increase the length of body of stunting children aged 6-12 months by 86.5%. This implies that the more frequently given baby gym for stunting treatment, the higher the length of body addition in stunting children aged 6-12 months. There is a fairly strong correlation with a positive direction between osteocalcin levels and fat intake towards length increase ($p<0,05$).

Discussion

Stunting is a condition in which a child's body length growth is delayed or impaired due to chronic nutritional deficiency, recurrent inactivity and lack of psychosocial stimulation and physical exercise.(WHO, 2015b) Stunting is usually measured by length for age z - scores <-2SD.(Kemenkes RI, 2020)

Stunting in the first 1,000 days of life leads to a physical growth barrier, a linear growth disorder affecting bone growth.(Martorell & Zongrone, 2012; Young et al., 2017) Stunting children are more likely to have bone growth disorders due to hormonal imbalances, unbalanced nutritional intake, recurrent infections, lack of psychosocial stimulation, and physical inactivity.(Millward, 2017; Syed et al., 2018)

The production of Growth Hormone (GH) is influenced by the interplay of factors that cause stunting at the cellular level. In order to promote the processes involved in bone growth, GH causes the liver to produce Insulin-Like Growth Factor-1 (IGF-1).(Harahap et al., 2015; Tritos & Klibanski, 2016; Walker et al., n.d.) The activity of the osteoblasts that produce osteocalcin affects bone growth. Osteocalcin regulates bone growth, bone matrix maturity, and the metabolism of bones and muscles.(Tripathi et al., 2017) Osteocalcin levels are more frequently detected during childhood growth(Lee et al., 2021), and appropriate stimulation and physical activity have an impact on elevated osteocalcin levels in serum.(Chahla et al., 2015; Komori, 2020; Moriishi et al., 2020)

Enhancing bone growth can be achieved with physical exercise that combines movement exercises and massage stimulation. By mechanically stimulating GH activity and IGF-1 secretion, physical exercise of the upper and lower limbs promotes bone growth metabolism and increased osteocalcin parameters, a marker of bone formation.(Litmanovitz et al., 2016; Tripathi et al., 2017) Furthermore, touch stimulation with massage activates a vague system that affects intestinal motility and insulin secretion, helping to improve food absorption; it also stimulates neurotransmitter activity that promotes increased levels of serotonin and dopamine and suppresses cortisol secretion. This parasympathetic response is brought on by stimulation of pressure receptors in the skin and muscle, which in turn stimulates the secretion of GH and IGF-1.(Montaseri et al., 2020; Yoanita et al., 2021) Additionally, touch stimulation improved psychological well-being.(Field et al., 2010; Sridharaswari et al., 2019)

The results of this study confirmed that, when TKS treatment were given to stunting baby aged 6 to 12 months, twice a day, six days a week, for a period of twelve weeks, length of body and osteocalcin increased by roughly 3.97 and 17.81 respectively. The results of this study are consistent with earlier research demonstrating that, in infants under the age of four weeks, physical activity with passive motion exercises

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performed once a day for 15–30 minutes each time for four weeks increased body length by 1.7–2.24 cm and improved bone mineralization and bone strength as measured by dual-energy x-ray absorptiometry (DEXA) and quantitative ultrasound (QUS).(Shaw et al., 2018) Interventions, which were carried out every day for the same duration and frequency until the eighth week, were also demonstrated to significantly increase length of body. (El-Farrash et al., 2020)

The study by Erdem et al. reported that providing massage stimulation to new-borns once a day for 15-20 minutes, led to a length increase of 2,51 ±0,19 cm(Erdem et al., 2015) and three to four times higher IGF-1 levels in the treatment group(Sezer Efe et al., 2020) In premature babies stimulated by premature massage, IGF-1 rates also increased significantly.(Hartanto & Bahtera, 2015; Yoanita et al., 2021). Subsequent research has demonstrated that touch stimulation combined with physical exercise has better positive effects on anthropometric measurements, as well as increased levels of IGF-1,(Asmarani et al., 2020; Hartanto & Bahtera, 2015; Trisna-Windiani et al., 2015)bone specific alkaline phosphatase (BSAP) and alkaline phosphatase (AP) as well as a 32% increase in U-MidOc (Álvarez-Álvarez et al., 2019; Diego et al., 2014; Haley et al., 2012).

The TKS treatment, known as baby gym for stunting with tactile – kinesthetic stimulation, has shown to have positive effects on body length increase ($p<0.05$) and vitamin A, protein, and calcium intake in stunting baby aged 6 to 11 months. Consistent with previous studies, tactile kinesthetics combined with baby gym exercises can significantly increase the length of the body in babies at risk of stunting ($p<0,05$) (Sutarmi, Astuti, Siswanto, Kunarti, & Susilowati, 2022).Harmonized outcomes were also observed in a locus stunting study conducted in the Indonesian region with older participants, ages 6 to 24 months, using a combination of exercise movement and massage in conjunction with the well-known “sasak” culture called OBISA. The result increased Body length by 4.73 cm after receiving an OBISA massage, however this study needs to adjust for dietary intake.(Sudarmi et al., 2021).

TKS intervention was associated with an elevated level of osteocalcin. Serum levels increased by ng/ml 11.5 ng/ml, statistically significant increase with the intervention $P < 0,05$. The variations in osteocalcin levels observed in this study corresponded to the 10–80 ng/ml range of normal limits for osteocalcin levels in children aged 6–12 months (Komori, 2020; Ndiaye et al., 1995). The osteocalcin is an important biochemical marker in bone mineralization processes, particularly in bone formation (Komori, 2020). This is consistent with previous report of (Chen et al., 2010) who stated that assisted exercise in premature babies twice daily for 5 weeks effectively improved bone strength as shown by increased bone metabolism and osteocalcin.(Chen et al., 2010) Furthermore, physical exercise given gradually from mild to moderate in pre-adolescent children diagnosed with DM type 2, demonstrated that osteocalcin is positively associated with even unstructured physical activity(Chahla et al., 2015).

Although length is specific parameter for stunting children and osteocalcin is a sensitive and specific marker of osteoblastic marker for bone formation, it is not enough to predict of bone development. It is needed other parameter for bone resorption.

CONCLUSION

Stunting is growth faltered because of lack of nutrition, repeated infection and lack of psychosocial stimulation and physical exercise. TKS is a model that involves a psychosocial stimulation and physical exercise with tactile – kinesthetic stimulation. TKS that administered twice daily for three months effectively improved the length by speeding up the process of bone mineralization. Stunting babies aged of 6 to 12 months can benefit from TKS treatment by having higher improvement of 0.865 times. This suggests that the more frequently TKS treatment is administered, the higher the length is enhanced.

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