

Comparison of Cognitive and Other Developmental Functions in Children With Stunting and Malnutrition

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Abstract

Background. Stunting is the impairment of growth and development due to malnutrition and/or chronic disease/infection. According to the Indonesia Basic National Health Survey 2013, prevalence of stunting in Indonesia reached 37.2%. Various studies have shown that impaired cognitive development may be found in children with stunting and malnutrition. This research has purpose to determine cognitive development in stunted children and malnourished children, using Bayley Scale of Infant Development III (Bayley-III).

Methods. A cross-sectional study in 51 children aged 6 month to 3 year old who fulfilled the inclusion criteria at the Outpatient Clinic of Dr.Cipto Mangunkusumo National General Hospital from June 2017 until January 2018. Cognitive development was assessed using the Bayley Scale of Infant Development Third Edition (Bayley-III).

Results. Twenty six children with stunting and 25 children with malnutrition without stunting with age of subjects were 11.0 month (2.0-34.0) and 16.0 month (7.0-25.6) respectively. Bayley-III percentile in cognitive scale were 12.5 (0.1-75) and 16.0 (0.1-99.9) with P (p-value)=0.55.

Conclusions: Stunted children showed lower cognitive scores compared to the children with malnutrition. Although it was not significant, but it showed that Bayley-III scores group of stunting and malnutrition groups of children with normal stature far below the 50 percentile (P50). This showed that both children with stunting and malnutrition possible to have decreased cognitive function. Further research is needed with a larger sample to get comprehensive conclusions. Early detection and intervention also should be aimed at children who are experienced growth faltering to prevent developmental problems, especially cognitive function.

Background

Short stature in children can be caused by several factors including constitutional factors (short parents), endocrine factors, recurrent/chronic infections, malnutrition and socio-economic factors.¹ Stunting is the impairment of growth and development due to malnutrition and/or chronic disease/infection.² The prevalence of stunting in Indonesia according to the Indonesia Basic National Health Survey reached 36.8% in 2007, decreased in 2010 to 35.6% and increased again to 37.2% in 2013.³⁻⁵ This has an impact on the quality of human resources in the future, because stunting can be accompanied by cognitive disorders.⁶

The emergence of stunting in children must be preceded by a state of malnutrition. Failure to thrive or growth faltering was firstly seen before reaching stage of malnutrition.⁷ Several epidemiological studies that have been conducted on stunting and malnutrition have not assessed cognitive function, so it does not describe the entire scope of the problems. Cognitive impairments have a further impact on quality of life and require more complicated and multidisciplinary management. Various studies have shown that

impaired cognitive function often persists even though weight and height can be corrected, or require supplementation and cognitive intervention that requires a very long time.^{6,7} The Indonesian Ministry of Health in collaboration with various professions including the Indonesian Pediatrics Association has established a 1000-day program and management stunting as a superior program.

This study's objective is to determine cognitive development and the difference in average Bayley Scale of Infant Development Third Edition (Bayley-III) scores between children less than 3 years old who are stunted and malnutrition with normal stature who experience failure to grow. This was a cross-sectional study in children aged 6 months to 3 years at the Outpatient Clinic of Dr. Cipto Mangunkusumo National General Hospital from June 2017 until January 2018. They were recruited from polyclinic: general pediatric, pediatric infection and tropical disease, pediatric allergy and immunology, pediatric nutrition and metabolic disease, endocrinology and neurology. Criteria for inclusion of subjects were children with stunting who have malnourished status and/or a history of growth faltering due to nutritional factors and/or chronic diseases/infections. Children are defined as stunted if their height-for-age is more than two standard deviations below the WHO Child Growth Standards median. (group 1); children with malnutrition and normal stature (group 2). Exclusion criteria were children with severe neurological disorders, such as cerebral palsy, congenital neuromuscular disorders; severe neurodevelopmental disorders, such as autism spectrum disorders; children with global developmental delay suspected due to toxic disorders, metabolic disorders congenital, or genetic disorders.

Methods

All of subjects underwent anthropometry examination includes weight, height, upper arm circumference, head circumference based on WHO growth curves and also neurological examinations. Children with growth faltering, malnutrition, and stunting referred to endocrine, nutritional, infectious, respiratory polyclinics to determine the cause of stunting. After that, children underwent cognitive functional evaluation using the instrument Bayley-III by 2 experienced child psychologists.

Bayley-III is one of instrument to assess the developmental functioning of infants, toddlers, and young children aged between 1 and 42 months. The Bayley-III provides coverage of the following five domains: cognitive, language, motor, adaptive, and social-emotional development. The independent variable was the nutritional status and stature of the child (stunting due to nutritional problems and/or chronic infection/disease and malnutrition with normal stature). The dependent variable was Bayley-III score.

The minimum sample size needed for each group was 20 subjects with total 40 subjects. Statistics analysis of the average score Bayley-III between groups 1 and 2 was performed using an unpaired t-test. Statistics analysis for the hypothesis testing of the Bayley-III mean difference between groups 1 and 2 was carried out using one-way analysis of variance (ANOVA). We used *Statistical Package for the Social Sciences* (SPSS) 21.0 software.

Results

Fifty-one children aged less than 3 years were enrolled in this study (26 children with stunting and 25 children with malnutrition without stunting). Age of subjects were 11.0(2.0-34.0) and 13.0(2.0-38.0) respectively (shown in Table 1). Most of them were male 34 (58.6%). Bayley-III percentile in cognitive scale were 12.5 (0.1-75) and 16.0(0.1-99.9) with $P=0.274$ respectively.

There were no significant differences in the Bayley-III scores between two groups. This was likely due to the insufficient samples size, but it showed that Bayley-III scores group of stunting and malnutrition groups of children with normal stature far below the 50 percentile (P50).

Subjects in groups 1 and 2 were mostly children with chronic infections diseases such as HIV, congenital heart disease, chronic kidney disease, laryngomalacia with problems of nutrient intake, chronic liver disease and chronic diarrhea after intestinal surgery.

Discussion

The results of this study indicated that group 1 (stunted) showed lower cognitive, motor, social emotional and adaptive behavior Bayley-III scores than group 2 (malnutrition with normal stature). The difference was mainly on motor aspect. Although these differences were not significant, these results were sufficient to show that stunted children showed lower developmental scores. Although group 2 not yet stunted but also showed score below P50 in all developmental scores. This also showed that stunting has not yet occurred, but cognitive impairment has happened.

Questions that always arise are why and how malnutrition and stunting affect brain development, especially cognitive; what are the long-term effects on a child's quality of life. The development of child's brain in the first 1000 days of life is very important. Brain volume develops rapidly since fertilization, at birth reaching 25% of adult brain volume (400 grams), age 1 year reaches 60% (850 grams), age 2 years reaching 80% (1100 grams), until finally age 12 years child's volume brain and weight is the same as an adults.⁸ This means that during this time pregnant women need good nutrition for fetal brain development. In addition to brain volume and weight, synapses formation also accelerated. The synapse density of children aged 2 years is almost the same as adults.⁹

After birth, especially until the age of 2 years, the brain development process is still running especially brain volume and weight, the process of synaptogenesis, myelinogenesis and branching of dendrites and axons. Cognitive function is closely related to the formation of myelin and synapses. Myelin functions as an axon wrapper which speeds up the delivery of information flow between neuron cells. Synapse is a connection between neuronal cells where neurotransmitters are released in the gaps that regulate all functions of the human brain. The more dense the more synapses connection between neuron cells are also getting faster and more complex. Branching dendrites that function as recipients of information from other neuron cells are also important.⁹

The acceleration of growth and development certainly requires good nutrition, both in quality and quantity. Carbohydrates are needed as a source of energy, cellular metabolism and the formation of brain

structures globally. Proteins are needed for the formation of hippocampal structures, synaptogenesis (especially essential amino acids for the formation of neurotransmitters), synthesis of growth factors and cell proliferation and differentiation. Fat is needed for the formation of myelin and synapses, as well as the visual cortex. Micronutrients (vitamins and minerals) are needed mainly for cell metabolism, synapse formation and myelin.¹⁰

Malnutrition due to inadequate intake of protein, carbohydrates, fats and micronutrients as well as repeated infections can cause impaired brain function and structure, tissue damage, growth retardation, impaired cell differentiation, reduced synaptic and neurotransmitter formation, delayed myelination and overall reduction in dendritic branching development, and interferes with the formation of neuronal circuits. Eventually, chronic malnutrition that causes stunting and wasting will result in delays in the development of cognitive processes and permanent cognitive impairment.¹¹

A study of two groups of children with a history of malnutrition, when carried out cognitive tests at the age of 5-7 years and 8-10 years. The group with a history of malnutrition showed cognitive scores (selective attention with color cancellation test, executive function, visuospatial function, verbal and visual memory), language function (verbal comprehension, verbal learning) was lower than the group that had never experienced malnutrition during the test. There were improvement in the scores when the test was repeated at the age of 8-10 years, although it remained lower than the group without malnutrition. This showed that stunted has more effect on higher cognitive functions than cognitive disorders and can be settled.¹²

A study involving 5771 infants showed that children who experienced weight faltered from birth to 9 months had a significantly lower intelligence quotient (IQ) score (2.71 points) at 8 years of age. Weight gain from birth to 8 weeks has a positive correlation with IQ at 8 years of age while weight gain from 8 weeks to 9 months does not have a linear correlation with 8 years old IQ. It was concluded that failure to thrive in infancy is associated with a permanent IQ deficit at the age of 8 years, and the critical period of growth faltering is birth to 2 months of age.¹³ A study in Burkina Faso with 532 subjects also showed that children with stunting showed lower neuropsychological scores at age 6-8 years of age compared to the non-stunting children.¹⁴

Chang's research also showed the effects of stunting by comparing groups non-stunting children in terms of fine motor skills with stunting group. Children with stunting had poor scores on test of rapid sequential continuous hand movements than the group of non-stunting children. Even in the group children with stunting had received nutritional intervention, stimulation or both, test results still showed lower scores than the group of non-stunting children. The conclusion of this study is that children with lower fine motor scores risk having lower IQs and poor school performance.¹⁵

Longitudinal studies with 1674 children studied the effects of early stunting (ages 6-18 months) and concurrent stunting (ages 4.5-6 years) on cognitive abilities. It showed that the cognitive abilities of school-age students are associated with early stunting, but a stronger correlation is with concurrent

stunting. So, interventions to prevent growth faltering not only focus on the age of under 2 years, but also continue until the age of 5 years.¹⁶

A case-control study with 77 case group (malnutrition) and 59 control group of babies born with normal weight, then experience moderate to severe malnutrition in the first year of life and the babies were followed and IQ tests were carried out in childhood, adolescence and young adults. The case group showed lower IQ score than the control group, both in childhood, adolescents and adolescents as young adults. This study concluded that moderate to severe malnutrition during infancy is associated with significant IQ disorders in young adulthood, even when physical growth has been corrected. Episodes of malnutrition during the first year of life give a risk of significant cognitive impairment during his lifetime.
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The reason of these can be happened is persistent epigenetic effect due to malnutrition at an early age. Malnutrition at an early age can trigger epigenetic changes that persist for decades into adulthood and correlate with cognitive impairment. Deoxyribonucleic Acid (DNA) methylation is an epigenetic mechanism that is widely studied as a molecular carrier of nutritional influences during critical windows of development, assuming there is no change in environmental conditions.¹⁸

Mechanism of stunting can interfere cognitive function is correlated with low protein diets. Children with stunting have lower levels of essential amino acids than non-stunting children. Inadequate intake of essential amino acids has a negative effect on growth, because amino acids play a role in protein formation and synthesis of mammalian Target of Rapamycin Complex 1 (mTORC1). The role of mTORC1 is mainly in bone and chondral plate growth, skeletal muscle growth and homeostasis, nerve myelination processes, small intestinal homeostasis, hematopoiesis and iron metabolism, immune function and organ development. mTORC1 is very sensitive to the availability of essential amino acids for its activation, because growth factors and energy cannot overcome the lack of essential amino acids to activate mTORC1.¹⁹

Conclusion

Our study concluded that the stunted children had lower scores Bayley-III (cognitive, motor and adaptive behavior) compared to the children with malnutrition without stunting. This research succeeded in proving that the malnutrition group had shown lower than average development scores (P50). This study also showed that early detection and intervention should be aimed at children who are malnourished and in children who are experiencing growth faltering before malnutrition and stunted to prevent developmental problems, especially cognitive function.

Declarations

Ethics approval and consent to participate

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by The Ethics Committee of the Faculty of Medicine Universitas of Indonesia no.483/UN2.F1/ETIK/2017. Informed consent was obtained from all individual participants included in the study.

Consent to publication

None declared. We didn't use individual person's data in any form (including any individual details, images or videos).

Availability of data and material

Data and material are available for transparency.

Competing interests

No competing interests should be declared

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Authors' Contributions

All authors contributed to the study conception and design. Material preparation and analysis were performed by Setyo Handryastuti, Hardiono D.Puspongoro, Amanda Soebadi, Achmad Rafli, Ivan Riyanto Widjaja. Data collections were performed by Surastuti Nurdadi, Anita Chandra, Feka Angge Pramita. The first draft of the manuscript was written by Setyo Handryastuti and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript and agreed to publication.

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Tables

Table 1. Comparison of Bayley-III scores of children with stunting and malnutrition with normal stature.

	Stunting due to malnutrition (n = 26)	Malnutrition with normal stature (n = 25)	<i>P-value</i> (<i>P</i>)
Sex (n)	16	14	0.688 ^a
Male	10	11	
Female			
Age (months)	11 (2-34)	16±9.63	0.341 ^b
Bayley-III score			
Cognitive	6.5 (1-12)	6.8±4.19	0.550 ^b
Language	15.3± 6.44	15.4±6.12	0.976 ^c
Motor	8.9±5.26	10.6±6.31	0.298 ^c
Social-emotional	8.1±4.21	7.5±4.41	0.624 ^c
Adaptive behavior	58.2±17.50	63.7±16.64	0.253 ^c
Percentile			
Cognitive	12.5 (0.175)	16 (0.1-99.9)	0.550 ^b
Language	20.5 (0.1-95)	18 (0.2-94)	0.843 ^b
Motor	1 (0.1-75)	4 (0-79)	0.183 ^b
Social-emotional	25 (0.4-99)	16 (1-99.9)	0.533 ^b
Adaptive behavior	7 (0.1-75)	12 (0.1-58)	0.657 ^b

a Chi-square b Mann-Whitney c Unpaired t test