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Comparison of Short-Term Memory Levels of Stunted and Non-Stunted Children Aged 2–5 Years

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Abstract

Stunting remains a significant public health issue in developing countries, including Indonesia as it can adversely affect children's growth and development, particularly impairing the maturation of memory functions that may subsequently lead to diminished cognitive abilities. While the effects of stunting on memory functions have been investigated in Indonesia in the past, the findings have yielded inconsistent results. This cross-sectional study aimed to comparatively analyze the short-term memory levels in stunted versus non-stunted children aged 2–5 years in the area of Batua Community Health Center, Makassar City, Indonesia from August to October 2024. Short-term memory levels were evaluated using the Wechsler Preschool and Primary Scale of Intelligence (WPPSI) assessment. Stunting was determined through height-for-age (H/A) indicators, utilizing a Z-score threshold of less than -2. Data were subsequently analyzed using the Chi-Square test. Among the 114 participants, most were classified as non-stunted (n=76; 66.7%), yet a significant proportion demonstrated suboptimal short-term memory levels (n=75; 65.8%). Both stunted and non-stunted groups predominantly exhibited suboptimal performance in short-term memory, with no significant difference identified between the groups (p=0.675). In conclusion, the findings suggest that stunting is not associated with impairments in short-term memory among children aged 2-5 years. Further research involving multiple centers is warranted to validate these results.

Keywords: Growth and development, memory, nutritional status, stunting

Introduction

Malnutrition is a prevalent issue in developing nations as well as globally. Malnourished children are eight times more likely to face mortality than those who are well-nourished. Nutritional deficiencies during early childhood significantly impact both physical growth and neurological development, particularly in cases of chronic malnutrition, such as stunting. Stunting is characterized as a growth and developmental disorder in children, influenced by factors during the first 1,000 days of life, often referred to as the "golden period" or "critical period" for development. [1–3] This condition affects not only height but also cognitive, motor, language, and socio-emotional development, which can be assessed using screening tools such as the Denver Developmental Screening Test (DDST).[4]
As of 2020, the World Health Organization (WHO) reports that around 22% of children under five worldwide experience stunting. This figure represents a decrease from 169 million children, or 24.6% prevalence, reported in 2015.[5] In Indonesia, stunting prevalence was alarming, ranking as the fifth highest in Southeast Asia in 2020, with a reported rate of 25.1%.[6] However, the Indonesian Nutritional Status Survey (survei status gizi Indonesia, SSGI) findings indicate a decline in stunting prevalence, from 24.4% in 2021 to 21.6% in 2022. Despite this progress, the rates still exceed the WHO's threshold of 20%, prompting the Ministry of Health to implement targeted interventions aimed at mothers and children to reduce stunting rates further.[2]

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Stunting during early development can significantly impair growth and neurodevelopment in children, potentially leading to deficits in cognitive function.[3]

Cognitive function encompasses an individual's capacity to process and interpret information, which includes short-term memory. Short-term memory is crucial for storing and organizing information, allowing for its meaningful encoding before transferring it to long-term memory. This capacity is characterized by limited storage and processing ability, necessitating a dynamic interplay between these constraints and cognitive performance.[2,7]

Short-term memory plays a critical role in children's cognitive development, impacting their ability to solve problems and effectively assimilate educational content. Memory disorders during this formative period can impede a child's learning capabilities and may result in diminished productivity in adulthood.[2,7] One notable risk factor associated with memory disorders is stunting, which is prevalent in Indonesia. Current prevalence rates have not yet aligned with the targets established by the WHO, suggesting improved interventions and public health strategies are needed.[8]

The relationship between stunting and memory function has been investigated in Indonesia, but the findings remain inconsistent. Several studies have reported that stunted children exhibit poorer cognitive performance, particularly in short-term memory, compared with non-stunted children.[2,7,8] Most previous studies have focused on school-aged children (6–12 years), while evidence among preschool-aged children remains limited. Therefore, this study aimed to compare short-term memory function between stunted and non-stunted children aged 2–5 years, providing further insight into the potential impact of stunting on cognitive development during early childhood.

Methods

This cross-sectional study was conducted between August and October 2024 in the working area of *Puskesmas* Batua, Makassar City, Indonesia, to compare short-term memory function between stunted and non-stunted children aged 2–5 yearsThe study's protocol was approved by the Health Research Ethics Committee at Alauddin State Islamic University Makassar (No. E.067/KEPK/FKIK/VIII/2024; August 26, 2024). Written informed consent was obtained from the parents or legal guardians of all participants prior to data collection.

The study population consisted of children aged 2–5 residing in the Puskesmas Batua service area. Participants were recruited using a consecutive sampling method, adhering to specific criteria. The inclusion criteria for this study consisted of children aged 2 to 5 years residing within the *Puskesmas* Batua service area in Makassar City who possessed a complete maternal and child health book (Kesehatan Ibu dan Anak, KIA). Children with documented intellectual disability, brain tumors, neurological disorders, or a history of head trauma were excluded from the study.

The minimum sample size was calculatedusing the Isaac and Michael formula. A degree of freedom of 3.841 was established, corresponding to a 5% margin of error. The parameters for the calculation included a population size of 91, an actual probability of 0.5, a false probability of 0.5, and a bias difference of 0.05. he calculation yielded a minimum required sample size of 74 participants.

Short-term memory nction was assessed usingthe validated Indonesian adaptation of the Wechsler Preschool and Primary Scale of Intelligence-Fourth Edition (WPPSI-IV).[9] Assessment was conductedindividually by a trained Child Clinical Psychologist who was blinded to the participants' stunting status. Short-term memory was evaluated using the Digit Span and Picture Memory subtests, which constitute the Working Memory Index of the WPPSI-IV.[10] Testing was performed under standardized conditions according to the administration manual.[11] The assessment required approximately 30-–minutes for children aged 2–4 years to 45-60 minutes for those aged 4–5 years. Raw scores were converted to scaled scores (range: 1–19) and then to composite index scores (range: 40–160) as per the manual. For categorical analysis, scores were dichotomized into average/above average (≥91) and below average (<91), based on established WPPSI classifications used in Indonesia.[12]

Stunting status was the primary exposure variable and was assessed using the height-for-age (H/A) index. Children with a height-for-age Z-score below −2 standard deviations, based on WHO Child Growth Standards, were classified as stunted. Height was measured using a calibrated Holtain/Microtoise stadiometer. Eachmeasurements were performed three times, and the average value was the used for analysis. The Holten/Microtoice stadiometer was affixed to the wall, featuring a movable horizontal headpiece to ensure accurate measurements. Calibration was performed at the beginning and end of the examination session using the zero-verification method. We extended the tape measure fully to the floor, and the "0" mark (or the pointer on the headpiece) must align exactly with the zero/starting point on the wall mounting.[13]

Data was analyzed using SPSS version 23.0 (IBM, USA). Descriptive statistics were used to summarize participant characteristics. Stunting status and short-term memory categories were presented as frequencies and percentages. Associations between stunting status and short-term memory function were analyzed using the Chi-square test. Statistical significance was established at p≤0.05.

Results

Thebaseline characteristics of the participants according to short-term memory level are presented in Table 1. Most participants were female (53.5%), aged 36–60 months (63.2%), and had a birth order of three or lower (76.3%). No significant differences were observed in gender, age group, or birth order between children with optimal and suboptimal short-term memory levels.

Table 2 presents participant characteristics according to stunting status. Similarly, no significant differences in gender, age group, or

Table 1 Baseline Characteristics of Study Participants According to Short-Term Memory Level

Characteristics	Optimal		Suboptimal		p-value
	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)	
Gender					
Male (n=53)	21	39.60	32	60.4	0.256
Female (n=61)	18	29.50	43	70.5	
Age					
24-36 months (n=42)	10	23.8	32	76.2	0.074
36-60 months (n=72)	29	40.3	43	59.7	
Birth Order					
≤3 (n=87)	29	33.3	58	66.7	0.723
>3 (n=27)	10	37.0	17	63.0	

Note: p-values were obtained using the Chi-square test

Table 2 Baseline Characteristics of Study Participants According to Stunting Status

Characteristics	Non-stunting		Stunting		p-value
	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)	
Gender					
Male (n=53)	33	62.3	20	37.7	0.353
Female (n=61)	43	70.50	18	29.5	
Age					
24–36 months (n=42)	29	69.0	13	31.0	0.680
36–60 months (n=72)	47	65.3	25	34.7	
Birth order					
≤3 (n=87)	59	67.8	28	32.2	0.640
>3 (n=27)	17	63.0	10	27.0	

Table 3 Distribution of Stunting Status and Short-Term Memory Levels Among Study Participants

Variable	Frequency (n)	Percentage (%)
Nutritional status		
Non-stunting	76	66.7
Stunting	38	33.3
Short-term memory levels		
Optimal	39	34.2
Suboptimal	75	65.8

birth order were observed between stunted and non-stunted children (p>0.05)

The distribution of stunting status and short-term memory level is shown in Table 3. Of the 114 participants, 38 (33.3%) were classified as stunted and 76 (66.7%) as non-stunted. Regarding memory performance, 39 children (34.2%) demonstrated optimal short-term memory, whereas 75 (65.8%) had suboptimal short-term memory.

The association between stunting status and short-term memory level is presented in Table 4. Suboptimal short-term memory was observed in 67.1% of non-stunted children and 63.2% of stunted children. Statistical analysis using the Chi-square test showed no significant association between stunting status and short-term memory level (p=0.675).

Discussion

Stunting is a chronic condition resulting from prolonged inadequate nutrition and recurrent infections during the first 1,000 days of life, a critical period for physical growth and brain development.[14] Previous studies have associated stunting with impaired neurodevelopment, reduced immune function, and increased susceptibility to both infectious and non-communicable diseases.[3] Given its potential impact on brain maturation, stunting has been hypothesized to adversely affect cognitive functions, including memory

The present study found no stastically significant association between stunting status and short-term memory performance among children aged 2–5 years.Although most participants demonstrated suboptimal short-term memory performance irrespective of nutritional status, the observed differences between stunted and non-stunted children were not statistically significant. These finding should be interpreted as a indicating a lack of statistically significant association within the study population rather than as evidence that stunting has no effect on cognitive development.

Several child-related characteristics assessed in this study, including age, sex, and birth order, were not significantly associated with short-term memory performance. The absence of an age-related effect is consistent with previous studiesreporting that memory performance during early childhood is influenced by multiple developmental and environmental factors rather than chronological age alon.[15] Similarly, Pathman et al. suggested that age-related differences in memory organization during early childhood are highly task-dependent and influenced by contextual factors rather than chronological age alone. These findings indicate that short-term memory development during the preschool period may not follow a linear trajectory and is likely shaped by multiple interacting influences.[16]

Consistent with previous studies, differences were observed between boys and girls, in line with evidence suggesting comparable memory performance across sexes during the preschool period.[17] Birth order was also not associated with short-term memory performance, supporting previous findings that cognitive outcomes are

Table 4 Analysis of Differences in Short-Term Memory Levels based on Stunting Incidence Status

Nutritional Status	Short-Term Memory Levels				p-value
	Optimal		Suboptimal		
	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)	
Non-stunting	25	32.9	51	67.1	0.675
Stunting	14	36.8	24	63.2	

Note: p-values were obtained using the Chi-square test more strongly influenced by environmental and familial factor than by birth order itself.[18]

One possible explanation for the non-significant association observed in this study is the high degree of neuroplasticity during the preschool period. At this stage of development, compensatory developmental mechanisms may partially mitigate the effects of early nutritional deficits on specific cognitive functions. Furthermore, previous studies suggests that the cognitive consequences of stunting may be more consistently reflected in overall cognitive performance or executive functioning than in isolated domains such as short-term memory, particularly among younger children. Consequently, assessment of a single cognitive domain may underestimate thebroader eurodevelopmental impact of stunting.[19,20]

Environmental and contextual factors that were not measured in the present study may also contribute to the observed findings. Socioeconomic status, parental education, and the quality of cognitive stimulation in the home environment have been shown to play a substantial role in shaping cognitive and memory development in early childhood.[8]repeated infection, and inadequate psychosocial stimulation. Children are defined as stunted if their height-for-age is more than two standard deviations below the WHO Child Growth Standards median. According to the Indonesia Basic National Health Survey 2013, Indonesia's stunting prevalence reached 37.2%. Various studies have shown that impaired cognitive development is found in children with stunting and undernutrition. This study aims to determine cognitive development in stunted and undernutrition with normal stature children using the Bayley Scale of Infant Development III (Bayley-III Children who receive adequate psychosocial stimulation may demonstrate relatively preserved memory performance despite experiencing growth faltering, whereas children with normal anthropometric status but limited stimulation may still exhibit poorer memory outcome. The absence of adjustment for these factors may have reduced the ability to detect differences between stunted and non-stunted children.[21]

In addition, individual developmental trajectories and the potential for catch-up growth may further explain the absence of significant group differences. Longitudinal studies have demonstrated that some children who experience early growth faltering subsequently attain cognitive performance comparable to their non-stunted peers, depending on postnatal environmental conditions and caregiving quality. Such heterogeneity in developmental responses may obscure group-level differences when assessed using a cross-sectional design during the preschool period.[22]

Furthermore, the relationship between stunting and neurodevelopment is temporally complex. Because rapid brain development occurs primarily during the prenatal period and the first two years of life, short stature identified during the preschool years may not necessarily reflect nutritional deficits during the most critical stages of neurodevelopmen.[23]

Methodological factors may also have contributed to the findings. The categorization of short-term memory performance into optimal and suboptimal levels may reduce sensitivity to subtle variations in cognitive ability. Previous studies suggests that continuous cognitive measures or composite cognitive indices are more sensitive in detecting associations between nutritional status and cognitive outcomes. Therefore, modest differences between stunded and non-stunded children may not have been detected in the present study.

Several limitations warrant consideration. Socioeconomic status, parental education, environmental stimulation, and genetic factors—well-established determinants of cognitive development—were not measured or controlled for in this study and therefore could not be incorporated into the analysis. The absence of control for these potential confounders necessitates cautious interpretation of the findings. Additionally, the study design limits causal inference, and the unequal distribution of participants between groups may have reduced statistical power. The findings are also specific to the study population and assessment tools used, which may limit generalizability.

In conclusion, no statistically significant association was observed between stunting status and short-term memory performance among children aged 2–5 years in this study. These findings do not exclude the possibility that stunting may affects other domains of cognitive development or that associations may emerge under different environmental or methodological conditions. Future studies employing longitudinal designs, larger sample size, comprehensive cognitive assessment, and adjustment for environmental and socioeconomic factors are needed to further clarify the relationship between stunting and cognitive development duringearly childhood.

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