

Effects of Montessori-Based Stimulation on Fine and Gross Motor Development Among Children with Stunting: A Quasi-Experimental Study

Indah Rahmadaniah^{1,2}, Tukimin bin Sansuwito², Rini Anggeriani¹, Rinda Lamdayani¹,
Ade Marlisa Rahmadayanti¹, Aris Citra Wisuda³

1. Midwifery Study Program, Sekolah Tinggi Ilmu Kesehatan Abdurrahman Palembang, Palembang, South Sumatera, Indonesia
2. School of Nursing and Applied Sciences, Lincoln University College, Petaling Jaya, Selangor, Malaysia
3. Nursing Profession Study Program, Sekolah Tinggi Ilmu Kesehatan Bina Husada, Palembang, South Sumatera, Indonesia

*E-mail: indahdaniah16@gmail.com

Abstract

Stunting affects not only physical growth but also several aspects of child development, including gross and fine motor skills. Early stimulation interventions, such as Montessori-based activities, have been proposed to enhance developmental outcomes through structured sensorimotor experiences. This study aimed to evaluate the effects of Montessori-based stimulation on motor development among children with stunting and to compare its outcomes with those of conventional stimulation. A quasi-experimental study with intervention and control groups was conducted among 120 children with stunting aged 36–59 months. Participants were allocated to either a Montessori group ($n = 60$) or a conventional stimulation group ($n = 60$). The intervention was delivered over 12 weeks, three times per week, with each session lasting 60 minutes. Gross and fine motor development were assessed before and after the intervention using the Pre-Screening Developmental Questionnaire. Within-group changes were analyzed using the Wilcoxon signed-rank test, while between-group differences were examined using the Mann–Whitney U test. The Montessori group showed significant improvements in gross motor development ($p = 0.028$) and fine motor development ($p = 0.003$). In the conventional group, only fine motor development improved significantly ($p = 0.046$), whereas changes in gross motor development were not statistically significant ($p = 0.144$). However, no significant differences were observed between the Montessori and conventional groups in post-intervention comparisons ($p > 0.05$). Montessori-based stimulation may contribute to improvements in gross and fine motor development among children with stunting. However, the absence of significant between-group differences suggests that Montessori-based stimulation was not superior to conventional stimulation during the study period. Further studies with larger samples and randomized controlled designs are needed to clarify its role in supporting developmental outcomes in children with stunting.

Keywords: conventional, fine motor, gross motor, Montessori, stunting

Abstrak

Pengaruh Stimulasi Berbasis Metode Montessori terhadap Perkembangan Motorik Halus dan Motorik Kasar pada Anak Stunting: Studi Kuasi-Eksperimental. Stunting tidak hanya memengaruhi pertumbuhan fisik, tetapi juga berbagai aspek perkembangan anak, termasuk keterampilan motorik kasar dan motorik halus. Intervensi stimulasi dini, seperti aktivitas berbasis Montessori, telah diusulkan untuk meningkatkan hasil perkembangan melalui pengalaman sensorimotor yang terstruktur. Penelitian ini bertujuan untuk mengevaluasi pengaruh stimulasi berbasis Montessori terhadap perkembangan motorik pada anak stunting serta membandingkan hasilnya dengan stimulasi konvensional. Penelitian kuasi-eksperimental dengan kelompok intervensi dan kelompok kontrol dilakukan pada 120 anak stunting berusia 36–59 bulan. Partisipan dialokasikan ke dalam kelompok Montessori ($n = 60$) atau kelompok stimulasi konvensional ($n = 60$). Intervensi diberikan selama 12 minggu, tiga kali per minggu, dengan durasi 60 menit setiap sesi. Perkembangan motorik kasar dan motorik halus dinilai sebelum dan sesudah intervensi menggunakan Kuesioner Pra Skrining Perkembangan (KPSP). Perubahan dalam masing-masing kelompok dianalisis menggunakan uji Wilcoxon Signed-Rank, sedangkan perbedaan antar kelompok dianalisis menggunakan uji Mann–Whitney U. Kelompok Montessori menunjukkan peningkatan yang signifikan pada perkembangan motorik kasar ($p = 0,028$) dan motorik halus ($p = 0,003$). Pada kelompok stimulasi konvensional, hanya perkembangan motorik halus yang mengalami peningkatan signifikan ($p = 0,046$), sedangkan perubahan pada perkembangan motorik kasar tidak signifikan secara statistik ($p =$

0,144). Namun, tidak ditemukan perbedaan yang signifikan antara kelompok Montessori dan kelompok konvensional pada perbandingan pasca-intervensi ($p > 0,05$). Stimulasi berbasis Montessori berpotensi memberikan kontribusi terhadap peningkatan perkembangan motorik kasar dan motorik halus pada anak stunting. Namun, tidak adanya perbedaan yang signifikan antar kelompok menunjukkan bahwa stimulasi berbasis Montessori belum terbukti lebih unggul dibandingkan stimulasi konvensional selama periode penelitian. Penelitian lebih lanjut dengan jumlah sampel yang lebih besar dan desain randomized controlled trial diperlukan untuk memperjelas peran metode ini dalam mendukung hasil perkembangan anak stunting.

Kata Kunci: konvensional, Montessori, motorik halus, motorik kasar, stunting

Introduction

Stunting remains a major public health challenge at the global, national, and local levels and is characterized by impaired linear growth resulting from chronic malnutrition, particularly during the first 1,000 days of life (World Health Organization [WHO], 2021). Globally, more than 149 million children under five years of age are affected by stunting, representing approximately 22% of the under-five population (United Nations Children's Fund Indonesia [UNICEF Indonesia], 2023). In Indonesia, although the prevalence of stunting has shown a gradual decline, it remains relatively high, decreasing from 31.8% in 2020 to 24.4% in 2021, 21.6% in 2022, and 21.5% in 2023. These figures remain above both the WHO threshold of less than 20% and the national target of 14% by 2024 (Ministry of Health of the Republic of Indonesia [MoH], 2023).

Beyond its impact on physical growth, stunting adversely affects brain development, learning capacity, motor function, language acquisition, and long-term productivity (Muhoozi et al., 2017; Sumartini, 2023; Upadhyay et al., 2022). Children with stunting are at increased risk of delays in gross and fine motor coordination, language development, and social functioning, with several studies reporting a significant association between stunting and developmental delays (Basri et al., 2021; Beekun et al., 2022; Meylia et al., 2022; Nurfia, 2024). Previous interventions, including psychosocial stimulation through maternal training, enhanced parental stimulation practices, and literacy-based stimulation programs, have demonstrated positive effects on motor and language development among

stunted children (Dulal et al., 2021; Hati & Pratiwi, 2019; Nurfia, 2024). However, most existing studies have focused on general stimulation approaches or specific developmental domains, such as language and cognition, rather than comprehensive and structured interventions targeting both gross and fine motor development simultaneously. Furthermore, research has predominantly emphasized the determinants of stunting and broad psychosocial interventions, with limited attention given to structured activity-based learning models that integrate sensorimotor experiences.

One promising approach is the Montessori method, which emphasizes sensorimotor stimulation through practical life activities, sensory exploration, and purposeful object manipulation (Kusumawardani et al., 2020; Marshall, 2017; Vatansever & Ahmetoglu, 2019). Previous studies have demonstrated that Montessori-based and family-centered stimulation interventions can effectively enhance motor, cognitive, and language development among children, including those with malnutrition and special needs (Abessa et al., 2019; Naguib et al., 2022; Primayanti et al., 2022; Santoso et al., 2020). Nevertheless, these studies were conducted within broader developmental contexts and did not specifically evaluate the effectiveness of Montessori-based stimulation in improving motor development among children with stunting using controlled experimental designs.

In most provinces in Indonesia, current intervention programs remain largely focused on monitoring physical growth through community health posts (*Posyandu*), while developmental stimulation, particularly for gross motors, fine motors, and language skills, receives compara-

tively limited attention. Preliminary observations conducted by the researchers in several *Posyandu* during child growth and development monitoring activities revealed that assessments primarily emphasize physical growth, whereas structured developmental stimulation is rarely implemented. Developmental screening was generally conducted using the Pre-Screening Developmental Questionnaire (*Kuesioner Pra Skrining Perkembangan* [KPSP]) in accordance with national guidelines for child growth and development monitoring in primary healthcare services. This situation reflects a critical gap between routine growth monitoring practices and the provision of structured developmental interventions for children with stunting. The urgency of addressing this gap is further reinforced by the persistence of motor developmental delays among stunted children, which may contribute to longterm consequences, including reduced educational achievement, lower productivity, and substantial economic losses at the population level (Haskas, 2020).

Therefore, this study aimed to evaluate the effectiveness of a structured Montessori-based stimulation program in improving gross and fine motor development among children with stunting. The novelty of this study lies in the application of Montessori-based stimulation as a structured developmental intervention specifically designed to enhance both gross and fine motor outcomes in this population. Unlike previous studies that primarily focused on the determinants of stunting or generalized stimulation approaches, this study provides empirical evidence from a quasi-experimental design with a control group to assess the effects of Montessori-based sensorimotor activities on motor development among children with stunting. The findings are expected to contribute to the evidence base regarding the potential role of Montessori-based stimulation as an educational and developmental strategy for supporting motor development in children affected by stunting.

Methods

Study Design. This study employed a quasi-ex-

perimental pre-test–post-test control group design. This approach was selected because random allocation was not feasible within the community-based setting due to ethical and logistical constraints, particularly regarding the assignment of children to intervention groups within existing health service structures. Nevertheless, the design enabled comparisons between the intervention and control groups to evaluate the effectiveness of the intervention.

Participants and Sampling. The study population consisted of 166 stunted children aged 3–5 years and their mothers registered in Palembang City. The sample size was determined using Slovin's formula with a 5% margin of error, given that the target population was clearly identified through community health service records. A total of 120 children were recruited and equally assigned to the experimental group ($n = 60$) and the control group ($n = 60$).

Participants were identified through community health centers (*Puskesmas*) and integrated health posts (*Posyandu*) using records provided by local health authorities. Eligible participants were selected through purposive sampling based on predefined inclusion and exclusion criteria.

Variables and Instruments. The independent variable was Montessori-based stimulation, while the dependent variables were gross and fine motor development. Potential confounding variables included child age, sex, nutritional status, maternal knowledge, parenting practices, and feeding patterns.

Children's motor development was assessed using the KPSP. Maternal knowledge, parenting practices, and feeding patterns were evaluated using structured questionnaires. Instrument validity was reviewed by experts in child development and public health, and reliability testing demonstrated Cronbach's alpha coefficients above 0.70.

Intervention Procedures. The experimental group received Montessori-based stimulation

focused on gross and fine motor development through structured sensorimotor and practical life activities, including carrying trays, pouring water, spooning exercises, and bead threading.

The intervention was conducted for 12 weeks, three times per week, with each session lasting 60 minutes. The program was delivered by the principal researcher and supported by trained research assistants. The control group received conventional stimulation routinely provided in *posyandu* and early childhood education settings, with the same frequency and duration as the intervention group.

Data Collection. Data collection was conducted by trained research assistants following standardized orientation on interview techniques, KPSP administration, and anthropometric measurements. Primary data were obtained through structured interviews and direct observations, while anthropometric assessments were conducted to confirm stunting status. Secondary data were obtained from the Palembang City Health Office.

Data Analysis. Data were analyzed using SPSS version 25. The Kolmogorov–Smirnov test indicated a non-normal distribution ($p < 0.05$); therefore, non-parametric analyses were performed. Descriptive statistics were used to summarize participant characteristics. The Wilcoxon signed-rank test was used to assess within-group changes, whereas the Mann–Whitney U test was applied to compare outcomes between groups. Statistical significance was set at $p < 0.05$.

Ethical Considerations. Ethical approval was obtained from Lincoln University College, and research permission was granted by the Palembang City Health Office (No. 061-2025). Written informed consent was obtained from parents or legal guardians before participation. All study procedures were conducted with consideration for the safety, well-being, and comfort of the children. Participants in the control group continued to receive routine developmental stimulation services throughout the study period.

Results

Table 1 presents the baseline characteristics of participants in the intervention and control groups. Variables assessed included child age, sex, breastfeeding history, stunting status, parenting practices, maternal knowledge, and feeding practices. No statistically significant differences were observed between the two groups across any baseline characteristics ($p > 0.05$). These findings indicate that the intervention and control groups were comparable at baseline, thereby reducing the likelihood of selection bias and supporting the validity of subsequent comparisons.

Table 2 presents the within-group changes in gross and fine motor development before and after the intervention. In the intervention group, significant improvements were observed in both gross motor development ($p = 0.028$) and fine motor development ($p = 0.003$) following 12 weeks of Montessori-based stimulation. The corresponding effect sizes indicated a moderate magnitude of change for both gross motor development ($r = 0.39$) and fine motor development ($r = 0.39$).

In the control group, a statistically significant improvement was observed only in fine motor development ($p = 0.046$), whereas the improvement in gross motor development was not statistically significant ($p = 0.144$). The observed effect sizes were smaller ($r = 0.26$), indicating a weaker magnitude of change compared with the intervention group. Overall, these findings suggest that Montessori-based stimulation was associated with greater within-group improvements in motor development among children with stunting.

Table 3 presents the results of the Mann–Whitney U test comparing post-intervention motor development outcomes between the intervention and control groups. No statistically significant differences were found between the two groups in gross motor development ($U = 1717.0$, $Z = -0.457$, $p = 0.647$) or fine motor development ($U = 1781.5$, $Z = -0.099$, $p = 0.921$).

Although the intervention group demonstrated significant within-group improvements in both gross and fine motor development, the between-group analysis showed that these improvements were not significantly different from those observed in the control group. Therefore, Montessori-based stimulation was not statistically superior

to conventional stimulation in improving motor development outcomes during the study period. Nevertheless, the larger effect sizes observed in the intervention group suggest a potentially greater practical benefit that warrants further investigation using larger samples and randomized controlled study designs.

Table 1. Baseline Characteristics of Respondents

Characteristic	Intervention (n=60)	Control (n=60)	p-value
Child's age (months), mean $\pm$ SD	45.45 $\pm$ 7.65	45.47 $\pm$ 7.55	0.996
Gender			
Male	29 (48.3%)	32 (53.3%)	0.585
Female	31 (51.7%)	28 (46.7%)	
History of breastfeeding			
Breastfed	29 (48.3%)	24 (40.0%)	0.360
Non-breastfed	31 (51.7%)	36 (60.0%)	
Stunting status			
Stunting	48 (80.0%)	47 (78.3%)	0.823
Severely stunting	12 (20.0%)	13 (21.7%)	
Parenting style			
Positive	37 (61.7%)	39 (65.0%)	0.706
Negative	23 (38.3%)	21 (35.0%)	
Mother's knowledge			
Very low	4 (6.7%)	5 (8.3%)	0.915
Low	32 (53.3%)	31 (51.7%)	
High	24 (40.0%)	24 (40.0%)	
Dietary pattern			
Appropriate	32 (53.3%)	30 (50.0%)	0.716
Inappropriate	28 (46.7%)	30 (50.0%)	

Table 2. Within-Group Changes in Gross and Fine Motor Development Following the Intervention

Variable	Intervention Group Pre (Mean $\pm$ SD)	Intervention Group Post (Mean $\pm$ SD)	p-value	Effect Size (r)	Control Group Pre (Mean $\pm$ SD)	Control Group Post (Mean $\pm$ SD)	p-value	Effect Size (r)
Gross motor	1.78 $\pm$ 0.415	1.60 $\pm$ 0.494	0.028	0.39	1.67 $\pm$ 0.475	1.53 $\pm$ 0.503	0.144	0.26
Fine motor	1.85 $\pm$ 0.360	1.70 $\pm$ 0.462	0.003	0.39	1.80 $\pm$ 0.403	1.73 $\pm$ 0.446	0.046	0.26

Table 3. Between-Group Comparison of Post-Intervention Gross and Fine Motor Development Outcomes

Variable	U	Z	p-value
Gross motor	1717.0	-0.457	0.647
Fine motor	1781.5	-0.099	0.921

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Although the intervention group demonstrated significant within-group improvements in both gross and fine motor development, the between-group analysis showed that these improvements were not significantly different from those observed in the control group. Therefore, Montessori-based stimulation was not statistically superior to conventional stimulation in improving motor development outcomes during the study period. Nevertheless, the larger effect sizes observed in the intervention group suggest a potentially greater practical benefit that warrants further investigation using larger samples and randomized controlled study designs.

Discussion

Impact of Montessori-Based Stimulation on Motor Development in Children with Stunting. The findings of this study indicate that Montessori-based stimulation was associated with significant improvements in both gross and fine motor development among children with stunting. Montessori activities emphasize practical life and sensorial experiences, including carrying trays, pouring liquids, transferring objects, and threading beads, which require coordinated body movements and refined hand control. Through repeated and purposeful sensorimotor practice, these activities may support postural control, coordination, and motor skill acquisition. Previous evidence has shown that structured and intentional physical activities positively influence motor competence in young children, particularly when they target fundamental movement skills (Jiang et al., 2025).

From a neurodevelopmental perspective, children with stunting are at increased risk of de-

layed motor development due to impaired neural connectivity, reduced sensory integration, and other biological vulnerabilities. Early childhood represents a critical period of neuroplasticity during which enriched sensorimotor experiences can facilitate motor learning and support developmental adaptation. Consistent with previous studies, structured physical activities and coordinated play have been associated with improvements in motor competence during early childhood (Jiang et al., 2025). Therefore, Montessori-based stimulation may provide an enriched learning environment that promotes motor development through repetitive, goal-directed, and developmentally appropriate activities.

The developmental characteristics of the participants may also have contributed to the improvement observed. Most children were in the preschool period, a stage characterized by rapid motor skill acquisition and high responsiveness to environmental stimulation (Cai et al., 2025). Furthermore, parental involvement may have reinforced the intervention effects, as Montessori activities closely resemble everyday caregiving tasks and can be continued at home. Previous studies have demonstrated that active parental engagement in developmental stimulation contributes positively to motor development outcomes. Taken together, these findings suggest that Montessori-based stimulation may support motor development among children with stunting by providing structured opportunities for repeated sensorimotor practice within both educational and family environments.

Effects of Conventional Stimulation on Motor Development in Children with Stunting.

The findings showed that conventional stimulation was associated with significant improvements in fine motor development but not in gross motor development. Conventional activities typically involve routine tasks such as drawing, holding a spoon, grasping objects, and imitating simple movements, which primarily stimulate hand-eye coordination and fine motor control. Consequently, these activities may pro-

vide sufficient stimulation for fine motor development while offering limited opportunities to develop whole-body coordination and gross motor skills.

Previous research suggests that gross motor development is more effectively supported through structured and dynamic physical activities, including running, jumping, balancing, and exploratory play, which are often absent from conventional stimulation programs (Dewi et al., 2025). In addition, contextual factors such as nutritional status, maternal knowledge, feeding practices, and caregiving environments may influence developmental outcomes. Adequate nutrition and responsive caregiving have consistently been associated with better motor development during early childhood (Triswanti et al., 2025). Although a relatively high proportion of positive parenting practices were observed in the control group, the absence of structured whole-body activities may explain the limited improvement in gross motor development. These findings highlight the importance of incorporating more diverse and developmentally appropriate motor activities into routine stimulation programs for children with stunting.

Comparison of Montessori-Based and Conventional Stimulation. Although Montessori-based stimulation produced significant improvements in both gross and fine motor development within the intervention group, the between-group analysis revealed no statistically significant differences compared with conventional stimulation. Therefore, Montessori-based stimulation cannot be considered statistically superior to conventional stimulation in improving motor development outcomes during the study period. Nevertheless, the intervention group demonstrated larger effect sizes than the control group, suggesting a greater magnitude of within-group improvement.

Several factors may explain the absence of significant differences between-group. First, the intervention period may not have been sufficiently long to detect measurable differences

between groups. Second, the relatively small sample size may have limited the statistical power to identify modest intervention effects. Third, external influences such as home stimulation, parenting practices, and nutritional intake may have contributed to developmental gains in both groups. Similar findings have been reported in previous studies demonstrating that structured stimulation programs can support motor development, although their superiority over existing community-based interventions is not always evident (Abessa et al., 2019; Naguib et al., 2022).

Despite the lack of significant between-group differences, Montessori-based stimulation remains a promising approach because it integrates structured sensorimotor experiences, purposeful movement, and active learning opportunities. Activities such as walking along a line, transferring objects, pouring liquids, and manipulating materials align with principles known to support motor skill acquisition and developmental engagement (Roscoe et al., 2024). These characteristics may make Montessori-based stimulation a useful complementary strategy within early childhood education and community-based programs for children with stunting.

Several limitations should be acknowledged. The relatively small sample size and short intervention duration may restrict the generalizability of the findings and limit the detection of long-term developmental effects. In addition, variations in home stimulation, caregiving practices, and nutritional intake were not fully controlled. Future studies employing larger samples, longer follow-up periods, and randomized controlled designs are recommended to further evaluate the effectiveness of Montessori-based stimulation in supporting motor development among children with stunting.

Conclusion

This study found that Montessori-based stimulation was associated with significant within-group improvements in both gross and fine mo-

tor development among children with stunting following a 12-week intervention period, whereas conventional stimulation was associated with significant improvement only in fine motor development. However, no statistically significant differences were observed between the intervention and control groups in post-intervention motor development outcomes. These findings suggest that Montessori-based stimulation may serve as a supportive approach for promoting motor development in children with stunting by providing structured sensorimotor experiences that engage both gross and fine motor skills. Although Montessori-based stimulation was not statistically superior to conventional stimulation during the study period, its structured and activity-based nature may offer practical value for early childhood education and family-centered developmental programs. Further studies with larger sample sizes, longer follow-up periods, and randomized controlled designs are warranted to confirm its effectiveness and evaluate its long-term impact on developmental outcomes among children with stunting.

Acknowledgments

The authors gratefully acknowledge the support of the Palembang City Health Office, participating community health centers (*Puskesmas*) and integrated health posts (*Posyandu*), research assistants, and all children and their parents or legal guardians who generously participated in this study. Their valuable cooperation made this research possible. The authors used ChatGPT (OpenAI, GPT-5.5) to assist with English language editing, grammar refinement, and improving the clarity and readability of the manuscript. The authors also used Perplexity AI to support literature searching and reference verification. All AI-assisted outputs were critically reviewed, verified, and edited by the authors. The authors take full responsibility for the accuracy, integrity, and final content of the manuscript.

Data Availability Statement

The data used in this study is available from the

corresponding author upon reasonable request, subject to ethical and institutional restrictions.

Author Contributions

Indah Rahmadaniah: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Project Administration, Writing – Original Draft. **Tukimin bin Sansuwito:** Conceptualization, Methodology, Supervision, Validation, Writing – Review & Editing. **Rini Anggeriani:** Investigation, Data Curation, Validation, Resources, Writing – Review & Editing. **Rinda Lamdayani:** Investigation, Data Curation, Validation, Resources, Writing – Review & Editing. **Ade Marlisa R.:** Investigation, Data Curation, Validation, Visualization, Writing – Review & Editing. **Aris Citra Wisuda:** Conceptualization, Methodology, Formal Analysis, Validation, Supervision, Writing – Review & Editing. All authors have read and agreed to the published version of the manuscript.

Funding Information

This research received no external funding.

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