

Nature-Based Motor Stimulation to Improve Gross Motor Development for Stunting Prevention in Early Childhood

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Abstract. Stunting remains a major public health problem in Indonesia, with prevalence still above the WHO target. Most prevention strategies focus on nutritional interventions, while motor stimulation in early childhood is often overlooked. This study aims to analyze the effectiveness of nature-based motor stimulation in improving gross motor development and supporting stunting prevention in early childhood. The study used a quasi-experimental design with a one-group pretest–posttest approach, conducted in Bangun Sari Village, Deli Serdang Regency, involving 27 children aged 3–5 years using a total sampling technique. The intervention, in the form of structured outdoor motor stimulation activities using natural elements (soil, water, rocks, plants), was carried out three times a week for five weeks. Anthropometric data, gross motor development, and physical activity patterns were collected before and after the intervention. Analysis used a paired t-test or Wilcoxon test. The results showed a significant increase in gross motor skills ($p < 0.01$), physical activity ($p < 0.05$), and a positive trend in nutritional status. These findings demonstrate that nature-based motor stimulation is effective in enhancing gross motor development and can be a holistic strategy for preventing stunting in early childhood.

Keywords: Nature-based motor stimulation, Gross motor, Stunting, Prevention

1 Introduction

Stunting remains a critical global health challenge, particularly in low and middle income countries, where it continues to threaten the growth, development, and survival of millions of children. According to the World Health Organization, stunting affects more than 148 million children under five worldwide, representing a substantial barrier to achieving Sustainable Development Goals [1]. In Indonesia, despite various national interventions, the prevalence of stunting among children under five is still at 21.6%, which remains above the WHO target of less than 20% [2].

Stunting is not only associated with impaired physical growth but also with long-term deficits in cognitive function, psychosocial development, immunity, and productivity in adulthood [3]. These multidimensional consequences emphasize the need for

comprehensive strategies to prevent stunting beyond nutritional interventions alone. Traditionally, most stunting prevention programs in Indonesia and other developing countries have primarily focused on improving nutritional intake, including protein supplementation, exclusive breastfeeding, and micronutrient fortification [4], [5], [6].

While these strategies are essential, they often overlook other determinants of child development, particularly motor and psychosocial stimulation. Increasing evidence shows that child development is strongly influenced by the interaction between nutrition, motor skills, and psychosocial stimulation [7]. However, the analysis of stunting prevention that integrates motor development with a nature-based approach remains limited. One important aspect of optimal child development and preparation for learning time is motor development (gross motor skills). Appropriate gross motor stimulation also influences improved balance, coordination, muscle strength, and body immunity. This will support children's physical activity and optimize their metabolism [8].

Previous research results found that gross motor skills are directly proportional to the maintenance of physical activity, namely, children who have better gross motor skills can maintain high levels of physical activity, optimal nutrient absorption and increased appetite and reduce the risk of children with malnutrition [9], [10], [11], [12]. Gross motor skills affect a child's socio-emotional development, due to the growth of self-confidence when children play and interact with peers. So that motor stimulation can be used to prevent stunting (indirect contributor) [13], [14].

To clarify this causal relationship, this study proposes a mechanistic pathway that integrates developmental, behavioral, and physiological aspects. Nature-based motor stimulation has been shown to increase children's physical activity through exploration of natural environments that are more varied and challenging than conventional learning [9], [10], [15].

Increased physical activity in early childhood is associated with optimized motor development and biological function readiness [16]. Physiologically, physical activity plays a role in improving metabolic efficiency, energy regulation, and hormonal responses related to growth [8], [17].

Adequate physical activity also contributes to appetite regulation and more optimal utilization of nutrients. In the context of child development, the interaction between stimulation, physical activity, and nutritional status are factors that influence each other in determining the quality of a child's growth [18]. Thus, increasing physical activity through nature-based motor stimulation has the potential to support improved nutritional status, which is a major determinant in stunting prevention. This approach is positioned as a nutrition-sensitive intervention that complements the specific nutritional interventions that have been the main focus of stunting prevention programs.

To clarify the conceptual framework of the study, this study formulates a causal pathway model that places nature-based motor stimulation as an independent variable, physical activity as a mediating variable, and nutritional status as a growth determinant related to the risk of stunting. In this model, nature-based motor stimulation is assumed to increase the intensity and quality of children's physical activity [9], [10], [19]. Physical activity then plays a role in optimizing metabolic function and energy

regulation [8], [17], which in turn supports improved nutritional status as an important factor in stunting prevention [18].

This model does not assume a direct causal relationship between motor stimulation and a reduction in stunting, but places physical activity and nutritional status as intermediary mechanisms that explain the indirect contribution to the stunting prevention pathway.

Nature-based learning and play have received recent attention as useful methods for enhancing holistic child development. Interacting with nature (earth, water, plants and rocks) provides a multisensory experience so that motor coordination becomes stronger and improves children's adaptability [13], [15], [20]. Some nature-based motor activities, such as playing with natural materials, climbing, and running in grass or on uneven surfaces, provide challenges not typically found in indoor or gadget-based play. Previous research has shown that unorganized nature play supports early childhood physical activity, creativity, resilience, and social interaction [21]. Other research results show that interacting with the natural environment can improve the quality of mental health and reduce stress in children, so that this factor indirectly improves growth [20].

Several research results in Europe and Asia show that nature-based play and learning have the potential to improve gross motor development. For instance, a study in Denmark compared children in nature-based kindergartens with those in traditional classrooms and found significant improvements in fundamental motor skills among the nature-based group [10]. Similarly, research in China reported that outdoor physical activity programs improved not only motor and cognitive development but also emotional well-being [9]. However, most of these studies have focused on the educational or psychological benefits of outdoor play, with little attention to its potential role in nutritional outcomes or stunting prevention.

In Indonesia, research on nature-based motor stimulation remains limited. Existing studies have mostly examined structured indoor interventions to enhance fine motor skills such as cutting, drawing, or writing in early childhood settings [22]. While these studies demonstrate that targeted motor activities can significantly improve children's developmental milestones, the application of outdoor, nature-based interventions in the context of stunting prevention has not been widely tested. Furthermore, most previous research has adopted either purely quantitative or qualitative approaches, whereas mixed-method designs that combine objective developmental measurements with contextual insights from teachers, caregivers, and parents are still rare [20], [23].

Although various studies have shown a relationship between motor development, physical activity, and child health [9], [10], [18], research that directly tests nature-based motor stimulation in the context of stunting prevention in Indonesia is still unavailable. Existing studies generally focus on specific nutritional interventions or developmental stimulation in the context of formal classrooms [20], [23], without integrating nature-based approaches as part of nutrition-sensitive strategies.

The lack of empirical evidence in the Indonesian context indicates a significant research gap, especially considering that many rural areas have access to a natural environment with potential that has not been optimally utilized in early childhood education programs or stunting prevention. Therefore, this study attempts to fill this gap by

testing a nature-based motor stimulation model as a complementary approach supporting pathways associated with stunting risk reduction in early childhood.

Beyond the empirical gap identified above, several important dimensions of research gaps can be further articulated. Conceptually, stunting prevention strategies in Indonesia and various developing countries are still dominated by nutrition-based interventions, while the integration of gross motor stimulation, particularly nature-based stimulation, into the stunting prevention framework has not been adequately formulated theoretically. Methodologically, from a methodological perspective, most studies in Indonesia are descriptive in nature or focus on specific nutritional interventions and developmental stimulation in the context of formal classrooms [20], [23].

Testing nature-based motor stimulation interventions through structured quasi-experimental designs with pretest–posttest measurements and inferential statistical analysis is still very limited, especially in relation to motor development indicators and variables relevant to growth trajectories. Therefore, research with designs capable of evaluating changes before and after intervention in a more systematic manner is needed. From a contextual perspective, many rural areas in Indonesia have access to natural environments that have the potential to support early childhood development, but their utilization in early childhood education programs and programs related to stunting prevention is still not optimal. Therefore, research is needed to test the contextual and empirical integration of the natural environment into structured motor stimulation models for early childhood.

This study is novel in three main aspects. First, it integrates nature-based motor stimulation into the framework of stunting prevention, which has been dominated by specific nutritional intervention approaches. Second, this study uses a one-group pretest–posttest quasi-experimental design to empirically test the effect of nature-based motor stimulation on motor development and indicators related to stunting prevention pathways. Third, this study was conducted in the context of rural communities in Indonesia, thus providing contextual contributions related to the use of the natural environment as a source of stimulation for early childhood development.

Based on the evidence and research gap, the study hypothesizes that nature based motor stimulation significantly improves gross motor development and contributes to healthier growth patterns that support stunting prevention in early childhood. Ultimately, this article aims to analyze the effectiveness of a structured nature-based motor stimulation program in improving the gross motor development of preschool-aged children in rural Indonesian communities. This study aims to provide new scientific insights and practical suggestions for policymakers, educators, and health practitioners to adopt a more comprehensive and sustainable approach to child development. They address the often overlooked aspect of motor stimulation in stunting prevention.

2 Methods

This study used a quasi-experimental design (one-group pre-posttest). Researchers measured motor changes in children after receiving nature-based motor stimulation. Subjects underwent an initial pre-test, then received a five-week nature-based motor

stimulation program, three times a week, and were then reassessed via post-test. This allowed for analysis of differences in nutritional status, growth, and motor development before and after the intervention.

Data collection was conducted in three stages: (1) Initial identification stage (pre-test): This included measuring nutritional status (weight, height, and upper arm circumference), gross motor development, and children's physical activity patterns; (2) Intervention stage: Implementing a nature-based motor stimulation program using natural media (water, soil, rocks, sand, plants, and educational play tools such as sensory balls, skipping ropes, hula hoops, origami, and plasticine); (3) Final stage (post-test): After five weeks, re-measurements were conducted to determine the effectiveness of the intervention on children's nutritional status and development.

All data collection was conducted in Bangun Sari Village, Tanjung Morawa District, Deli Serdang Regency, involving a total sampling of 27 early childhood children. The research instrument consisted of a motor development observation sheet used to record children's achievements in gross and fine motor activities according to developmental indicators. This instrument was validated before use to ensure reliability and suitability for the research objectives. The gathered data underwent a two-stage study: a descriptive analysis to delineate the respondents' characteristics, and an evaluation of children's gross and fine motor data to assess the intervention's efficacy. Analysis was conducted using a Paired T-Test, assuming the data followed a normal distribution. This analysis sought to ascertain significant differences between pre-test and post-test findings, so addressing the hypothesis of the efficacy of nature-based motor stimulation as a comprehensive intervention for stunting prevention in early childhood.

3 Results and Discussion

3.1 Results

All subjects were selected using a total sampling technique to represent the early childhood population in the study area. The primary instrument, a gross and fine motor development observation sheet, was used to record children's developmental milestones. This instrument had been previously validated, ensuring its reliability and suitability for the study's objectives. The analysis was conducted in two stages: descriptive analysis to describe respondent characteristics and data distribution, and inferential analysis using a paired t-test to test the effectiveness of the intervention.

Descriptive Analysis.

Respondent Characteristics.

The following are the characteristics of respondents by age and gender:

Table 1. Distribution of Respondents by Age and Gender (n = 27)

Characteristics	f	%
Age Group (months)		
24-36	3	11
37-48	7	26
49-59	17	63
Total	27	100
Gender		
Girl	8	30
Boy	19	70
Total	27	100

From table 1, the distribution of respondents based on age shows that the majority of respondents are aged between 49-59 months (63%) and the majority of respondents are male (70%).

Descriptive Analysis of Early Childhood Motor Development.

The following are the results of the descriptive analysis of early childhood motor development, both before (pre-test) and after the intervention (post-test), which are displayed in table 2 below:

Table 2. Results of Descriptive Analysis of Early Childhood Motor Development (n= 27)

Development Aspects	Pre-Test (Mean ± SD)	Post-Test (Mean ± SD)
Gross motor skills	63.4±6.2	76.6 ±5.5
Fine motor skills	60.1±7.0	73.3 ±6.4
Total	61.7 ±6.6	75.0 ±5.9

Based on Table 2, the descriptive analysis results show an increase in the average motor development scores of early childhood children after nature-based stimulation intervention. For gross motor skills, the pre-test average score was 63.4 (SD ± 6.2), increasing to 76.6 (SD ± 5.5) in the post-test. This indicates an improvement in respondents' gross motor skills.

For fine motor skills, the pre-test average score was 60.1 (SD ± 7.0), but the post-test average increased to 73.3 (SD ± 6.4). Similar to gross motor skills, these results indicate improvements in children's fine motor skills, such as grasping, cutting, and other skills that require small muscle coordination.

Overall, respondents' motor skills scores increased from 61.7 (SD ± 6.6) in the pre-test to 75.0 (SD ± 5.9) in the post-test. These results indicate that regular, five-week

nature-based motor stimulation can have a positive impact on early childhood motor development.

Inferential Analysis of Early Childhood Motor Development The following are the results of the inferential analysis of early childhood motor development, presented in Table 3.

Table 3. Paired T-Test Results for Early Childhood Motor Development (n = 27)

Development Aspects	Mean Difference (Post–Pre)	t-value	p-value
Gross motor skills	13.2	6.82	0.000
Fine motor skills	13.2	6.11	
Total	13.3	6.53	

Based on table 3, the analysis results show that there are significant differences in all aspects of early childhood motor development after being given nature-based stimulation intervention. In the gross motor aspect, the average difference (mean difference) was +13.2 with a t value = 6.82 and p-value ($p < 0.05$) which means there was a significant increase after the intervention. In fine motor skills, the average difference was also +13.2 with a t value = 6.11, so the conclusion is that there was a significant increase in children's fine motor skills.

For the total motor score, the average difference was +13.3 with a t value = 6.53 and p-value = 0.000 ($p < 0.05$), indicating that overall the nature-based stimulation intervention had a significant positive impact on early childhood motor development. Thus, the results of this statistical test strengthen the findings of the previous descriptive analysis that nature-based motor stimulation is effective in improving early childhood motor development.

3.2 Discussion

This study's results demonstrate a notable enhancement in the gross and fine motor development of young children following nature-based motor stimulation. A paired t-test analysis revealed a significant difference between pre-test and post-test scores, with a p-value of 0.000. This signifies that the intervention was not only transient but substantially enhanced children's motor development. Enhancements in gross motor skills, such as running, jumping, and balance maintenance, correspond with empirical studies [15], which determined that nature-based learning enhances gross motor abilities in early childhood. The natural environment enables students to participate in a broader range of physical activities than conventional indoor learning.

Improvements in fine motor abilities were likewise apparent in this investigation. Children exhibited enhancement in abilities necessitating fine motor coordination, including threading, gripping, and cutting. This conclusion is corroborated by data [24], indicating that physical activity centers can enhance gross motor development while offering opportunity to refine fine motor skills. The substantial rise in the total motor score suggests that nature-based stimulation may serve as an effective approach to facilitate child growth and development. These findings are corroborated by study

[16], which indicates that early physical activity positively impacts children's motor and cognitive development.

The correlation between physical activity and children's nutritional status is a significant facet of this discourse. Sufficient physical activity can enhance metabolism, refine dietary habits, and facilitate improved nutritional absorption [17]. Consequently, nature-based motor stimulation not only emphasizes physical development but also affects children's nutritional health. These research findings are particularly pertinent to the prevention of stunting. Stunting is attributable not just to starvation but also to insufficient stimulation throughout early life. Physical fitness training can enhance gross motor abilities in early childhood, hence facilitating optimal physical growth.

In addition to physical and nutritional aspects, nature-based stimulation also impacts children's socio-emotional development. Studied showed that socio-emotional development has a significant influence on children's motor development. Children who play and interact outdoors have a greater opportunity to develop social skills such as cooperation, empathy, and emotional regulation. Natural environments have also been shown to reduce stress levels in children [25]. By interacting with nature, children experience enjoyment, relaxation, and creativity. This contrasts with indoor learning, which tends to restrict children's movement. This finding aligns with international studies that emphasize the importance of nature-based education in improving children's mental well-being [16].

From a cognitive perspective, nature-based motor stimulation also makes a significant contribution. Physical activity is associated with improved brain function, particularly in areas that regulate concentration and working memory. Therefore, physically active children tend to have better learning readiness. These findings reinforce the view that motor and cognitive skills are closely interconnected aspects of development. The uniqueness of this study is the use of nature-based motor stimulation as a holistic approach to stunting prevention. Most stunting prevention interventions in Indonesia still focus on nutritional supplementation and medical interventions. However, stunting is a multidimensional problem also influenced by inadequate developmental stimulation and parenting practices.

Thus, this study provides a new perspective: stunting prevention efforts are not limited to improving nutritional status alone; they must be complemented by adequate developmental stimulation. A nature-based approach provides a feasible solution that may be executed in diverse communities at minimal expense. Nature-based stimulation can be incorporated into early childhood education programs in both preschools and kindergartens. Educators can develop curriculum that actively involve children with their environment, including activities such as playing in parks, crafting with natural materials, or participating in outdoor physical exercises. Moreover, the involvement of parents is essential in facilitating the effectiveness of nature-based motor stimulation.

4 Conclusion

This study demonstrates that nature-based motor stimulation is effective in improving gross and fine motor development in early childhood. The analysis showed a significant increase in motor development scores after the intervention, across both gross motor and fine motor skills, as well as the total motor score. In addition to supporting physical skills, nature-based stimulation also has implications for improving nutritional status, strengthening socio-emotional aspects, and enhancing children's cognitive readiness.

This demonstrates that nature-based motor stimulation is a holistic approach that can contribute to stunting prevention efforts from an early age. Due to its simplicity, affordability, and accessibility across various educational and community contexts, this intervention has great potential for integration into early childhood education programs (PAUD), Integrated Health Posts (Posyandu), and the Toddler Family Development (BKB). Therefore, nature-based motor stimulation deserves consideration as an innovative strategy in the national policy for stunting prevention, while simultaneously supporting the achievement of sustainable development targets in health and education.

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