International Journal of Public Health Science (IJPHS)
Vol. 15, No. 3, September 2026, pp. 696~705
ISSN: 2252-8806, DOI: 10.11591/ijphs.v15i3.27020

Effectiveness of a structured ball game stimulation program on gross motor development among preschool children: a quasi-experimental study in Indonesia

Moh. Arip, Ely Mawaddah, Ade Wulandari, Mardiatun, Saskiyanti Ari Andini
Department of Nursing, Poltekkes Kemenkes Mataram, Mataram, Indonesia

Article Info

Article history:

Received Feb 13, 2026
Revised Jun 1, 2026
Accepted Jul 12, 2026

Keywords:

Ball games
Children aged 3-6 years
Developmental stimulation
Gross motor development
Motor learning

ABSTRACT

Gross motor development during ages 3-6 years is critical for children's independence and social confidence. This study induced a structured ball play stimulation program in Indonesian children using quasi-experimental design, testing the specific impact on gross motor indicators compared to local early childhood education (PAUD) routine activities. This quasi-experimental pretest–posttest control group study assessed ball game stimulation for gross motor development in 143 preschool children in Mataram, Indonesia (intervention n = 72; control n = 71). The intervention delivered structured ball activities three times weekly for six months (August 2025–January 2026): ball introduction, throwing/catching, kicking, and group games. Controls followed the regular curriculum. Outcomes used a standardized gross motor tool. Baseline demographics were homogeneous (age p = 0.998; gender p = 0.921). Results demonstrated dramatic improvements in the intervention group, with the "Normal" category increasing from 9.72% to 94.44%, while the "Doubtful" category decreased from 83.33% to 5.56%, and "Delayed" reached 0%. Conversely, the control group showed deterioration, with "Normal" decreasing to 0% and "Delayed" increasing to 88.73%. Mann-Whitney U test confirmed statistically significant differences between groups at posttest (p = 0.000), with intervention group mean score of 1.00 versus control group 2.79. These findings provide empirical evidence that structured ball game stimulation effectively improves gross motor development in preschool children.

Corresponding Author:

Moh. Arip
Nursing Department, Poltekkes Kemenkes Mataram
Mataram City, NTB, Indonesia
Email: moharip8998@gmail.com

1. INTRODUCTION

Gross motor development is a fundamental aspect of early childhood growth and development that cannot be ignored. Ages 3-6 are a critical period in child development, where the brain is like a sponge, absorbing everything it sees, hears, and feels [1]. At this time, children need appropriate and optimal stimulation in every aspect of their development, including gross motor skills [1]. Gross motor development is related to a child's ability to move large parts of his body, such as his hands and feet, and involves the coordination of most parts of the child's body [2]. If gross motor development aspects are not developed optimally, children will become less independent and less confident in their social environment [3].

Developmental disorders in Indonesian children remain epidemiologically relevant: national data show that 11% of toddlers experience developmental disorders, while motoric indicators for children aged

36–59 months (97.8%) are still below the target (98.3%). In East Java, it was even reported that 35% of toddlers experience gross motor delays [4], [5]. These findings emphasize the urgency of structured interventions for gross motor stimulation in preschool age, not just free activities, because programmed FMS learning is considered more effective than free play in achieving adequate motor development [6], and outdoor play programs have also been shown to improve locomotor and object control (although not always in all subtests) [7], [8].

The play-based intervention literature in Indonesia consistently demonstrates improvements in gross motor skills through traditional games (e.g., hopscotch) [5], traditional FMS-based models [9], and ball games (throw–catch; cheerful goal) [10], [11]. However, this evidence is dominated by single-group or pre-experimental designs [5], [10]. Therefore, a key gap is the need for quasi-experimental studies comparing the effectiveness of structured ball play stimulation programs in preschool children in the Indonesian context and explicitly linking the findings to regional and national problem burdens [5].

Research shows that some children still have difficulty performing gross motor movements. For example, in ball relay games, some children still have difficulty holding the ball and performing other manipulative movements [12]. Likewise, in several kindergartens, there are still children who have difficulty running, jumping, and throwing the ball [13]. Ball games have been identified as an effective strategy for stimulating gross motor development in early childhood. Ball games can activate and stimulate children's motor skills through a variety of engaging and enjoyable forms of play [14]. Throwing and catching games, in particular, have been shown to help children develop movements that coordinate their hands and feet in a simple way and can coordinate the muscles of the body [15].

Research using a structured design and rigorous methodology is needed to provide strong empirical evidence on the effectiveness of ball play stimulation in developing gross motor skills in children aged 3–6 years. Such research can make important contributions to the development of curricula and learning practices in early childhood education institutions. It can also assist educators in selecting the most effective stimulation strategies to optimize children's gross motor development.

A clear gap remains, as much of the intervention research has focused on older preschoolers (5–6 years) [16], while evidence specific to children aged 3–4 years is comparatively limited despite the broader 3–6-year focus in syntheses and observational studies [17], [18]. Mechanistic explanations, such as coordination, balance, and manipulative practice pathways, also remain under-specified because even ball-game curricula provide only preliminary accounts of these mechanisms [19]. Therefore, rigorous trials are needed to compare different ball-play components and examine potential mediators of gross motor development within this younger age group [20].

Although research on gross motor development through various types of play exists, gaps remain in the literature. Most studies focus on older age groups (ages 5-6 years and older), while research on children aged 3-4 years is still limited. Research on the mechanisms by which ball games stimulate gross motor development still needs further development. This research is relevant because it will contribute to a deeper understanding of how ball game stimulation can optimize gross motor development in children aged 3-6 years. The results of this study are expected to provide practical guidance for educators and parents in selecting and implementing appropriate ball game activities to support optimal gross motor development in children.

2. METHOD

This study used a quasi-experimental design with a pretest–posttest control group. The design was chosen to compare gross motor development between children who received the intervention (intervention group) and those who did not receive the intervention (control group). By comparing pretest and posttest outcomes across both groups, the effectiveness of the intervention on gross motor development in early childhood could be evaluated.

This research was conducted from July 2025 to January 2026, covering all stages of the research, from initial data collection, pretest, ball game stimulation intervention, to posttest. The research took place in two Early Childhood Education in Karang Bedil Village, Mataram: Preschool Siti Rukayah as the intervention group and Preschool Kumara Asih as the control group. The selection of both locations was based on the availability of adequate facilities and human resources to support the research implementation. Although both preschools have relatively similar infrastructure and teaching staff characteristics, there are specific differences in the number of classrooms and supporting facilities, but this does not hinder the overall implementation of the research.

This study involved a population of children aged 3-6 years enrolled in Preschool Siti Rukayah and Preschool Kumara Asih, Karang Bedil Village, Mataram, during the study academic year. The study sample consisted of 143 children selected through a purposive sampling technique, with 72 children in the intervention group (Preschool Siti Rukayah) and 71 children in the control group (Preschool Kumara Asih).

Inclusion criteria included children aged 3-6 years, actively enrolled in one of the preschools, present during the pretest and posttest, having written parental consent, and being in adequate health for the gross motor test. Conversely, exclusion criteria included children with health conditions that preclude physical activity, significant physical limitations, absence of the measurement, and no parental consent. This approach ensured sample homogeneity and the validity of the research results on gross motor development.

This study identified two main interrelated variables. The independent variable was a gross motor development intervention regularly administered to the intervention group through structured and directed activities. This intervention was specifically designed to improve the gross motor skills of early childhood. Meanwhile, the dependent variable was the gross motor development of early childhood itself, which was the outcome or impact of the intervention. Gross motor development was measured using a standardized instrument with proven validity and reliability, focusing on evaluating children's ability to perform large movements involving the large muscles of the body. Therefore, this study aimed to determine the effect of gross motor intervention on improving the gross motor skills of early childhood through objective and measurable measurements.

This study used a standardized instrument to measure children's gross motor development through a four-category classification: Normal (N) for development according to age standards, Doubtful (DO) for development within the normal range requiring further observation, Delayed (D) for development below age standards, and Not Testable (NT) for conditions where the child could not be tested. The resulting ordinal data were converted into numeric scores (Normal = 1, Doubtful = 2, Delayed = 3) to facilitate statistical analysis. In addition to the classification instrument, the study integrated observation sheets to record children's behavior and gross motor skills during learning activities. Visual documentation in the form of photos and videos was used to comprehensively record the intervention process and children's development. Teacher-created progress notes complement the quantitative data with qualitative information to track changes in children's gross motor skills longitudinally. This multi-method approach ensured the validity and reliability of gross motor development measurements.

The data collection procedure in this quasi-experimental study was systematically designed through three main, structured phases: a pretest phase, an intervention phase, and a posttest phase. The pretest phase, conducted in the first week of the study (July 2025), was a critical stage for establishing baseline data before the intervention was administered. Comprehensive preparation included coordination with the principal and teachers at Siti Rukayah Preschool (intervention group) and Kumara Asih Preschool (control group), preparing informed consent for parents or guardians, and conducting in-depth orientation for preschool teachers and staff regarding gross motor development measurement instruments. Pretest measurements were conducted individually in the playground or playroom of each preschool at an optimal time (morning, 30-45 minutes after the child arrives at school) to ensure the child is focused and energetic. Each child was tested by the researcher or a trained research assistant by performing a series of gross motor movements that evaluate abilities in activities involving large body muscles such as walking, running, jumping, throwing, catching, and balance.

The intervention phase was implemented for 6 months (August 2025 to January 2026) with a frequency of 3 times per week, a duration of 30-45 minutes per session, only in the intervention group at Siti Rukayah Preschool. The ball game stimulation program was designed based on the principles of early childhood gross motor development and play learning theory, including four main progressive components: i) Ball Introduction Activity (weeks 1-3) with various types of balls to increase familiarity and ball handling skills; ii) Throwing and Catching Activity (weeks 4-8) to develop eye-hand coordination and arm muscle strength; iii) Ball Kicking Activity (weeks 9-14) to increase leg muscle strength and balance; and iv) Group Ball Game Activity (weeks 15-24) to develop cooperation skills and gross motor skills holistically. Each intervention session followed a standard structure that included a warm-up (5-10 minutes), core activities with clear instructions and movement demonstrations, and a cool-down (5-10 minutes). Monitoring of intervention implementation was conducted through implementation checklists, child behavior observation sheets, visual documentation (photos and videos), and teacher progress notes to ensure intervention fidelity and objectively record child development. Meanwhile, the control group at Kumara Asih Preschool continued regular learning activities according to the applicable preschool curriculum, with researcher monitoring to ensure no additional interventions could affect the study results.

The post-test phase was conducted at the end of the intervention period (January 2026) using the same measurement procedures as the pre-test to ensure consistency and validity. The post-test was administered simultaneously to both the intervention and control groups at the same location under identical conditions as the pretest. The same measurement instrument was used throughout the study to ensure consistency in the assessment of gross motor development.

This study used two primary analytical approaches to evaluate the effectiveness of interventions on gross motor development. Descriptive analysis described sample characteristics through basic statistics,

including frequencies and percentages for categorical variables, and means, standard deviations, and extreme values for numeric variables. Respondent distribution was analyzed based on demographics and motor development at the pretest and posttest phases.

Comparative analysis compares the two groups through a series of hierarchical statistical tests. First, the Shapiro-Wilk or Kolmogorov-Smirnov normality test determines the distribution of the data, guiding the choice between parametric and non-parametric tests. Levene's homogeneity of variance test reinforces the choice of statistical procedure. Comparisons between groups use the Mann-Whitney U test. Significance is set at $\alpha = 0.05$, with analyzes performed using SPSS. The stages of ball game stimulation research are explained in Figure 1.

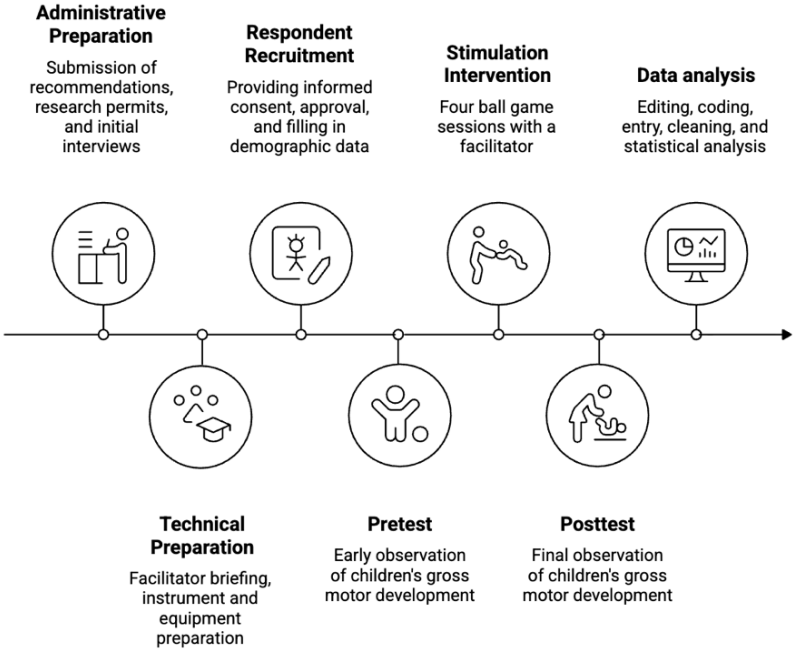

Figure 1. Stages of ball game stimulation research

3. RESULTS AND DISCUSSION

Table 1 shows that Siti Rukayah Preschool and Kumara Asih Preschool in Karang Bedil Village, Mataram, show significant differences in infrastructure and composition of teaching staff. Kumara Asih Preschool has more complete learning facilities with 3 classrooms, a waiting room, and 2 bathrooms, while Siti Rukayah Preschool excels in providing special rooms for babies (2 rooms) and a health room. In terms of teaching staff, Siti Rukayah Preschool has a more qualified composition of educators with 5 staff with D2/D3/S1 education and 1 nurse out of a total of 11 people, while Kumara Asih Preschool relies on 8 staff with high school/D1 education out of a total of 10 people.

Table 2 shows the distribution of demographic characteristics of respondents in the study with a total of 143 participants divided into the intervention group (n = 72) and the control group (n = 71). Based on the age variable, the majority of respondents were in the 3-4 years range (69.9%), with a balanced distribution between the intervention (69.4%) and control (70.4%) groups. For the gender variable, females dominated with a percentage of 56.6% compared to males 43.4%, with almost identical proportions in both groups. Levene's homogeneity test showed no significant differences between the intervention and control groups in the age ($p = 0.998$) or gender ($p = 0.921$) variables, indicating that both groups were well segmented and had homogeneous demographic characteristics, thus fulfilling the prerequisites for valid comparisons in experimental research designs.

Table 3 shows significant changes in gross motor development between the intervention and control groups. The intervention group experienced a dramatic increase in the “Normal” category from 9.72% (pretest) to 94.44% (posttest), while the “Doubtful” category decreased from 83.33% to 5.56%, and “Delay” reached 0%. In contrast, the control group showed the opposite pattern: the “Normal” category decreased from 9.86% to 0%, the “Doubtful” category increased from 84.51% to 11.27%, and the “Delay” category increased dramatically from 5.63% to 88.73%.

Table 1. Comparison of characteristics of Siti Rukayah Preschool and Kumara Asih Preschool, Karang Bedil Village, Mataram

Characteristics	Siti Rukayah Preschool	Kumara Asih Preschool
Facility		
Classroom/study room	2 rooms (halls)	3 classrooms
Sitting room	1 room	1 room
Administration/principal room	1 room	1 room
The waiting room	-	1 room
Children's bedroom	4 rooms	2 rooms
Baby room	2 rooms	-
Playground	2 places	1 room
Dining room	1 room	1 room
Bathroom	1 room	2 rooms
Health room	1 room	-
Kitchen	1 room	1 room
Playing field	1 field	1 field
Distribution of teaching staff based on educational background		
High school/d1	4 people	8 people
D2/D3/Bachelor's Degree	5 people	-
S1	1 person	2 people
Nurse	1 person	-
Total teaching staff	11 people	10 people

Table 2. Distribution of respondents based on demographic characteristics of the intervention group and control group

Characteristics	Category	Intervention group (n = 72)		Control group (n = 71)		Total		p-value
		f	%	f	%	f	%	
Age	3-4 years	50	69.4	50	70.4	100	69.9	0.998
	5-6 years	22	30.6	21	29.6	43	30.1	
	Total	72	100.0	71	100.0	143	100.0	
Gender	Man	31	43.1	31	43.7	62	43.4	
	Woman	41	56.9	40	56.3	81	56.6	0.921
	Total	72	100.0	71	100.0	143	100.0	

Levene's homogeneity of variance test

Table 3. Comparison of gross motor development distribution of the intervention group (n = 72) and the control group (n = 71)

No	Gross motor development category	Intervention group				Control group			
		Pretest		Posttest		Pretest		Posttest	
		f	%	f	%	f	%	f	%
1	Normal	7	9.72	68	94.44	7	9.86	0	0.00
2	Doubtful	60	83.33	4	5.56	60	84.51	8	11.27
3	Delay	5	6.94	0	0.00	4	5.63	63	88.73
4	Unable to test	0	0.00	0	0.00	0	0.00	0	0.00
Total		72	100.00	72	100.00	71	100.00	71	100.00

Table 4 presents the results of the data normality test using the Shapiro-Wilk Test for the Gross Motor variable in both research groups. The normality test was conducted on pretest and posttest data with samples from the intervention group (n = 72) and the control group (n = 71). The analysis results show that all data were not normally distributed, both in the pretest and post-test in both groups. The Shapiro-Wilk statistical value for the gross motor pretest for the intervention group was 0.847, and the control group was 0.821, while for the gross motor posttest the value obtained was 0.872 for the intervention group and 0.756 for the control group.

Table 4. Normality test data

Variables	Group	n	Shapiro-Wilk test statistics	Information
Gross motor pretest	Intervention	72	0.847	Not normal
	Control	71	0.821	Not normal
Gross motor posttest	Intervention	72	0.872	Not normal
	Control	71	0.756	Not normal

Shapiro-Wilk test

Table 5 showed that a significant difference between the intervention and control groups on the posttest measurement (p = 0.000). The intervention group showed a dramatic improvement in performance with the posttest score decreasing to 1.00 (SD = 0.000), while the control group increased to 2.79 (SD = 0.410). Although both groups showed similar baseline balance at pretest (intervention: M = 1.97; control: M = 1.96; p = 0.098), the opposite pattern of change indicates the effectiveness of the ball play stimulation intervention. The lower scores in the intervention group post-intervention reflect an increase in gross motor skills, considering the scoring system used. These findings provide empirical evidence that ball play stimulation significantly improves gross motor development in children aged 3-6 years compared to the control group without intervention.

Table 5. Comparative analysis of intervention and control groups

Measurement	Group	n	Mean	Elementary school	SE	95% CI	Min	Max	Median	p-value
Pretest	Intervention	72	1.97	0.167	0.020	1.93-2.01	1	2	2	0.098
	Control	71	1.96	0.195	0.023	1.91-2.01	1	2	2	
Posttest	Intervention	72	1.00	0,000	0,000	1.00-1.00	1	1	1	0.000
	Control	71	2.79	0.410	0.049	2.69-2.89	2	3	3	

Mann-Whitney U Test

The distribution of respondents' demographic characteristics showed a total of 143 participants divided into the intervention group (n = 72) and the control group (n = 71). The majority of respondents were in the 3–4-year age range (69.9%), with a balanced distribution between the intervention (69.4%) and control (70.4%) groups. For the gender variable, females dominated with a percentage of 56.6% compared to males at 43.4%. Levene's homogeneity test results showed no significant differences between the intervention and control groups in terms of age (p = 0.998) or gender (p = 0.921). This finding is significant because it indicates that both groups were well-segmented and had homogeneous demographic characteristics, thus fulfilling the prerequisites for valid comparisons in experimental research designs.

This group homogeneity is consistent with methodological standards in motor intervention research in preschool children. Previous research on physical education programs for children aged 3-5 years also emphasized the importance of equivalence in baseline characteristics between intervention and control groups to ensure internal validity [21]. Their empirical study of a Flag Rugby game program to improve gross motor skills in preschool children aged 5-6 years used randomization to ensure group equivalence [22].

The age range of 3–6 years, which is the focus of this study, represents a critical period for gross motor development. Preschool age is a key stage for acquiring fundamental movement skills, such as jumping, and developing overall motor competence [23]. The limited number of studies examining the determinants of motor performance during this period underscores the importance of further research in this area [23].

The results showed significant changes in gross motor development between the intervention and control groups. The intervention group experienced a dramatic increase in the "Normal" category from 9.72% (pretest) to 94.4% (posttest), while the "Doubtful" category decreased from 83.33% to 5.56%, and "Delayed" reached 0%. In contrast, the control group showed the opposite pattern: the "Normal" category decreased from 9.86% to 0%, the "Doubtful" category increased from 84.51% to 11.27%, and the "Delayed" category increased drastically from 5.63% to 88.73%.

These findings are consistent with previous studies demonstrating the effectiveness of play-based interventions on preschoolers' gross motor development. Traditional games can significantly improve both gross and fine motor skills [24]. Similarly, Fernandes *et al.* [25] in their study of association between executive functions and gross motor skills in overweight/obese and eutrophic preschoolers found significant differences between pre and post stimulation.

The drastic decline in the control group from the "Normal" category to 0% and the increase in the "Delayed" category to 88.73% indicate a worrying phenomenon. Supriady, in his research on gross motor skill levels in preschool children, found that the majority of children were in the assessment categories of "poor" (60%), "very poor" (23%), and "below average" (17%). These findings indicate that without proper stimulation, children's gross motor development tends to stagnate or even regress.

Today's preschool children face a secular decline in their motor development, and intervention through physical education in preschool can be effective in remediating gross motor delays [26]. If teachers intervene, children can be placed on a positive developmental trajectory toward lifelong health [26]. Conversely, if these policy changes do not occur, children may continue to experience secular decline with detrimental consequences across multiple developmental domains [26].

Burgos-Hernández and Hernández-Alarcón [27] in a systematic review of the effectiveness of structured physical education programs on gross motor development in preschool children, concluded that

structured programs are an effective strategy for improving gross motor skills. This finding is consistent with the results of the present study, which demonstrate that structured ball-play stimulation has a significant positive impact on gross motor development.

The Mann-Whitney U test results showed a significant difference between the intervention and control groups on the posttest measurement ($p = 0.000$). The intervention group showed a dramatic improvement in performance with the posttest score decreasing to 1.00 ($SD = 0.000$), while the control group increased to 2.79 ($SD = 0.410$). Although both groups showed similar baseline balance on the pretest (intervention: $M = 1.97$; control: $M = 1.96$; $p = 0.098$), the opposite pattern of changes indicates the effectiveness of the ball play stimulation intervention.

Brian [21] investigated the cascading effects of gross motor development and the impact of intervention in early childhood, finding that structured physical education programs improve motor skills in children aged 3–5 years. Their study also demonstrated that the intervention dose influenced outcomes, with children receiving 10 hours of intervention per week showing greater improvements than those receiving 4 hours per week [21]. These findings support the importance of structured and adequately dosed interventions for optimizing gross motor development in early childhood.

Another practical implication relates to the importance of teacher qualifications in implementing motor stimulation programs. Approximately two-thirds of preschool educators offer gross motor and physical activities only once a week or less frequently, while only a quarter offer such activities at least daily [28]-[30]. These findings underscore the need for ongoing training and support for early childhood educators in implementing motor stimulation programs.

The difference in outcomes between the intervention and control groups cannot be separated from various factors that influence children's gross motor development. Parenting styles have a significant influence on the development of fine and gross motor skills in preschool children [31], [32]. There is a relationship between parenting patterns and gross motor development in preschool children [33].

There is a relationship between motor skills (fine and gross motor skills, motor reaction time) and executive function [34]-[37]. These findings indicate that improving gross motor skills through ball play stimulation may also have a positive impact on children's cognitive aspects. Although this study provides strong empirical evidence for the effectiveness of ball play stimulation, there are several limitations that need to be considered.

4. CONCLUSION

This study demonstrated that ball play stimulation significantly improved gross motor development in children aged 3-6 years. The intervention group demonstrated substantial improvement, with the "Normal" category increasing from 9.72% to 94.44% and the "Doubtful" category decreasing from 83.33% to 5.56%, while the control group demonstrated a decrease across all metrics. The Mann-Whitney U test confirmed a statistically significant difference between the groups at post-test ($p = 0.000$), with the intervention group achieving a mean score of 1.00 compared to the control group's 2.79. These findings provide empirical evidence supporting ball play as an effective intervention strategy for improving gross motor development in preschool-aged children. Future research should explore long-term retention effects and the feasibility of implementation across different educational settings. This study has several limitations, including that although age and sex were homogeneous, other key covariates (baseline health status, nutrition, habitual physical activity, parenting practices) were not measured, thus limiting control for alternative explanations. The significant attrition of participants in the control group suggests the possibility of differential exposure, testing effects, or procedural inconsistencies that require replication with standardized monitoring and randomization.

Future research should employ a randomized/cluster randomized trial design with more rigorous implementation monitoring to minimize selection bias, procedural inconsistencies, and repeated measures effects. This approach is expected to enhance the causal validity of the results. It is also recommended to include longer-term follow-up (e.g., 6–36 months) to assess motor skill retention and physical activity trajectories, as longitudinal/clustered intervention studies demonstrate the importance of evaluating sustained effects.

FUNDING INFORMATION

Authors state thanks to the Ministry of Health for the funding given (Funding Number: HK.12/Poltekkes Mataram/2025/19823).

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Moh. Arip	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Ely Mawaddah	✓	✓			✓	✓			✓	✓				
Ade Wulandari	✓	✓			✓	✓			✓	✓				
Mardiatun	✓				✓					✓				
Saskiyanti Ari Andini	✓				✓					✓				

C : **C**conceptualization
M : **M**methodology
So : **So**software
Va : **Va**lidation
Fo : **Fo**normal analysis
I : **I**investigation
R : **R**resources
D : **D**Data Curation
O : Writing - Original Draft
E : Writing - Review & Editing
Vi : **Vi**personalization
Su : **Su**vision
P : **P**project administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

The data that supports the findings of this study are available from the corresponding author, [MA], upon reasonable request.

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BIOGRAPHIES OF AUTHORS

Moh. Arip is a nursing educator and professional affiliated with the Department of Nursing, Poltekkes Kemenkes Mataram, West Nusa Tenggara, Indonesia. In his role, he contributes to the implementation of vocational health education through teaching activities, academic mentoring, and strengthening the clinical competencies of nursing students. The focus of his academic work is oriented towards improving the quality of nursing services and patient safety, in line with the mandate of health education institutions under the Ministry of Health of the Republic of Indonesia. He can be contacted at: moharip8998@gmail.com.

Ely Mawaddah is a lecturer/academic at the Department of Nursing, Mataram Ministry of Health Polytechnic (*Poltekkes Kemenkes*), located in West Nusa Tenggara, Indonesia. In her capacity as a nursing educator, she contributes to the implementation of the Tri Dharma of Higher Education through educational activities, student competency development, and involvement in community-based health practices and services according to local needs. Her professional focus is on strengthening the quality of nursing care, improving patient safety, and developing the capacity of health human resources. She can be contacted at email: elymawaddah@gmail.com.

Ade Wulandari is a dedicated nursing professional affiliated with the Department of Nursing at Poltekkes Kemenkes Mataram in NTB, Indonesia. With a keen interest in healthcare education and patient care, she actively engages in academic pursuits to advance nursing practices within her community. Her commitment to enhancing nursing skills among her peers is reflected in her participation in local and national nursing initiatives, aiming to improve healthcare outcomes in Indonesia. Her contributions are a testament to the vital role of nursing education in fostering a skilled workforce dedicated to public health. She can be contacted at email: adewulandari0401@gmail.com.

Mardiatun serves as a dedicated nursing professional at the Department of Nursing, Poltekkes Kemenkes Mataram in NTB, Indonesia. With a commitment to advancing nursing education and practice, Mardiatun has contributed to the academic and practical training of nursing students, emphasizing the importance of evidence-based practice in patient care. Through involvement in various research projects and community health initiatives, Mardiatun seeks to bridge the gap between theoretical knowledge and practical application in nursing. Mardiatun actively engages with local health challenges, promoting health literacy and advocacy within the community. She can be contacted at email: mardiatunmkep@gmail.com.

Saskiyanti Ari Andini is a nursing professional affiliated with the Department of Nursing at Politeknik Kesehatan Kemenkes Mataram situated in Nusa Tenggara Barat (NTB), Indonesia. With a focus on advancing healthcare education and practice, she contributes to the academic and professional development of nursing through her involvement in teaching and research. She can be contacted at email: saskiyantiandini@gmail.com.