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Effect of Traditional Hopscotch Game on Lower Limb Muscle Power in Early Childhood: A Quasi-Experimental Study

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Abstract

Background: Lower limb muscle power is a key component of gross motor development in early childhood, particularly for jumping-related activities. Although the traditional hopscotch game has been shown to enhance motor performance, evidence in early childhood populations remains limited.

Objective: To determine the effect of the traditional hopscotch game on lower limb muscle power in children aged 4–6 years.

Methods: A quasi-experimental non-randomized two-group pretest–posttest study was conducted involving 36 children aged 4–6 years. Participants were allocated into an intervention group (n = 18) and a control group (n = 18). The intervention group performed hopscotch play twice weekly for four weeks, while the control group continued routine school activities. Lower limb muscle power was assessed using the vertical jump test. Data were analyzed using paired and independent sample t-tests with a significance level of 0.05, and effect sizes were calculated using Cohen's d.

Results: The intervention group showed a significant improvement in vertical jump performance ($p < 0.001$; Cohen's $d = 1.00$), whereas no significant change was observed in the control group ($p = 0.245$; Cohen's $d = 0.28$). Post-intervention comparison revealed a significant difference between groups favoring the intervention ($p < 0.001$; Cohen's $d = 1.91$).

Conclusion: The traditional hopscotch game significantly improves lower limb muscle power in children aged 4–6 years and can be recommended as a simple, safe, and play-based physical activity in kindergarten settings.

Keywords
Hopscotch; Muscle Power; Gross Motor Skills; Early Childhood; Play-Based Exercise

Introduction

Early childhood represents a critical period of growth characterized by rapid development across physical, cognitive, social, and emotional domains. Among these domains, gross motor development plays a fundamental role, as it forms the basis for children's ability to interact with their environment through large muscle movements involving the trunk and limbs.[1] Gross motor skills typically develop earlier than fine motor skills because they rely on larger muscle groups that mature more rapidly, enabling children to perform basic locomotor activities such as walking, running, and jumping.[2,3] These foundational movements are essential not only for physical independence but also for supporting later participation in more complex physical activities and sports.

Jumping ability is a key component of gross motor performance in early childhood and is closely associated with lower limb muscle power. Muscle power refers to the capacity of muscles to generate force rapidly and is defined as the product of strength and speed.[4] Adequate lower limb muscle power enables children to perform explosive movements efficiently, including jumping, hopping, and quick changes in direction, which are frequently required during play and daily activities. Insufficient development of this capacity may limit motor performance and reduce opportunities for active engagement, potentially affecting overall physical fitness and motor competence in later childhood.

Play-based physical activity is widely recognized as an effective and developmentally appropriate approach to enhancing motor abilities in young children. Through play, children engage in spontaneous and enjoyable movements that stimulate neuromuscular development without the perception of structured exercise demands.[5] Previous studies have demonstrated that play-based approaches not only improve physical performance but also support cognitive, social, and emotional development by fostering motivation, enjoyment, and peer interaction.[6] Outdoor free play, in particular, has been shown to positively influence the development of fundamental motor skills by allowing children to explore varied movement patterns in natural settings.[7] Moreover, goal-oriented play activities encourage children to perform repeated and purposeful movements, thereby enhancing muscle activation, coordination, and motor control.[8,9]

Systematic evidence indicates that play-based assessments and interventions exhibit acceptable validity and reliability for evaluating and improving motor performance in early childhood[9]. Such approaches allow children to demonstrate functional motor abilities in a more natural and contextualized manner compared to highly structured exercise protocols. Consequently, integrating physical training principles into play activities represents a promising strategy for improving motor outcomes while maintaining child engagement.

Traditional games constitute a culturally relevant form of play-based physical activity and have gained increasing attention as tools for motor skill development. One such game is hopscotch, which involves repeated hopping and jumping movements performed on one or both legs. Previous studies have reported that hopscotch can significantly enhance lower limb muscle power and gross motor skills, particularly jumping performance, among school-aged children.[10,11] However, most existing research has focused on children in elementary school, leaving limited evidence regarding the effectiveness of hopscotch-based interventions in early childhood populations.

From a biomechanical perspective, hopscotch incorporates movement patterns that resemble plyometric exercises, which are characterized by rapid eccentric–concentric muscle contractions aimed at improving explosive power.[12,13,14] Repeated hopping and jumping actions stimulate the stretch–shortening cycle of the lower limb muscles, promoting neuromuscular adaptations that enhance force production and movement efficiency. Although plyometric training has been shown to be effective in improving lower limb power in various populations, its direct application in early childhood settings may be impractical or inappropriate due to safety and developmental considerations. In this context, hopscotch offers a playful and age-appropriate alternative that naturally embeds plyometric principles within a familiar game format.

Despite its potential benefits, hopscotch has not been optimally utilized in kindergarten environments as a structured physical activity aimed at enhancing muscle power. Observational findings suggest that physical activities in early childhood education settings are often dominated by routine or low-intensity tasks that do not specifically target lower limb power development. This gap is particularly important given that early childhood is considered a "golden age" for motor development, during which appropriate physical stimulation can produce lasting effects on motor competence and physical fitness.[13]

Therefore, there remains a clear research gap concerning the effectiveness of traditional hopscotch play as a targeted intervention to improve lower limb muscle power in children aged 4–6 years. Addressing this gap is essential to provide evidence-based recommendations for integrating culturally relevant, play-based physical activities into early childhood education. Accordingly, this study aimed to examine the effect of the traditional hopscotch game on changes in vertical jump performance as an indicator of lower limb muscle power in children aged 4–6 years. Additionally, this study sought to compare post-intervention outcomes between children who participated in hopscotch play and those who continued routine school activities.

Methods

Study Design

This study employed a quantitative quasi-experimental design using a non-randomized two-group pretest–posttest approach. This design was selected to evaluate the effect of a structured play-based intervention on lower limb muscle power under controlled yet practical conditions within an early childhood education setting. Randomization was not implemented due to ethical and practical considerations related to the participants' age and the school-based context, which required maintaining stable classroom routines and minimizing disruption to learning activities.

Study Setting and Duration

The study was conducted at Al Huda Kindergarten, Kerten, Laweyan District, Surakarta, Central Java, Indonesia. Data collection and intervention implementation took place over four weeks, from September to October 2025. All intervention sessions and outcome measurements were conducted within the school environment to ensure participant familiarity and safety.

Participants

The study population consisted of all children aged 4–6 years enrolled at Al Huda Kindergarten (N = 56). Participants were selected using purposive sampling to ensure alignment with the study objectives.[15] Inclusion criteria were: (1) children aged 4–6 years, (2) physically healthy as reported by parents and teachers, and (3) parental consent to participate in the study. Exclusion criteria included: (1) a history of musculoskeletal or cardiopulmonary disorders, and (2) absence from one or more intervention sessions.

Based on these criteria, a total of 36 children were eligible and included in the study. Participants were allocated into an intervention group (n = 18) and a control group (n = 18) using non-random assignment. Allocation considered proportional representation from each classroom (A1, A2, B1, and B2) and input from classroom teachers to maintain balanced group composition and facilitate intervention feasibility. Baseline comparability between groups was assessed prior to intervention implementation.

Variables

The independent variable was participation in the traditional hopscotch game intervention. The dependent variable was lower limb muscle power, operationalized as vertical jump height measured in centimeters. All outcome data were collected quantitatively at baseline (pretest) and after completion of the four-week intervention period (posttest).

Intervention Protocol

The intervention group participated in a structured traditional hopscotch game program conducted twice per week for four consecutive weeks, resulting in a total of eight sessions. Each session lasted 15 minutes and consisted of three phases: warm-up (5 minutes), core hopscotch play (5 minutes), and cool-down (5 minutes). The control group continued routine school activities without additional physical intervention.

The hopscotch game was modified to suit early childhood motor abilities and to emphasize jumping movements aimed at stimulating lower limb muscle power.[16] The playing area was marked on a flat outdoor surface using chalk. Children completed the game without using a marker object (gacuk) and performed three consecutive rounds per session. The first round involved single-leg jumps using the right leg, the second round used the left leg, and the third round consisted of double-leg jumps. This modification was intended to promote balanced neuromuscular stimulation while maintaining simplicity and safety.

All intervention sessions were supervised directly by the principal investigator, who has a background in physiotherapy, and were supported by classroom teachers to ensure correct movement execution, adherence to the protocol, and participant safety. Intervention fidelity, including frequency, duration, and session structure, was monitored throughout the study.

The hopscotch intervention was modified to match early childhood motor abilities and to emphasize jumping movements aimed at stimulating lower limb muscle power. The layout and movement sequence of the hopscotch game are illustrated in Figure 1.

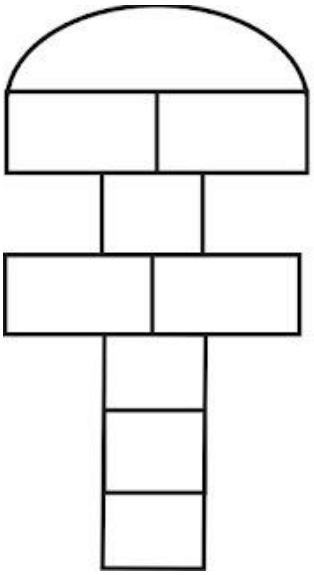

Figure 1. Layout and movement sequence of the modified hopscotch intervention

Outcome Measurement

Lower limb muscle power was assessed using the vertical jump test, which has been widely validated as a reliable and valid measure of lower limb explosive power.[17,18] Participants stood adjacent to a marked wall and were instructed to jump as high as possible after a preparatory standing reach measurement. Chalk was applied to the participants' fingertips to mark the highest point reached during the jump.

Each child performed three jump trials, and the highest recorded value was used for analysis. Vertical jump height was calculated as the difference between standing reach height and maximum jump height. Measurements were conducted twice for each participant: once before the intervention (pretest) and once after completion of the intervention period (posttest). Prior to testing, standardized instructions and demonstrations were provided to ensure participant understanding and safety.

Statistical Analysis

Data analysis was performed using SPSS version 27. Descriptive statistics were calculated for all variables. Baseline equivalence between the intervention and control groups was assessed using independent sample t-tests for continuous variables and chi-square tests for categorical variables. Normality of data distribution was examined using the Shapiro–Wilk test, and homogeneity of variance was assessed using Levene's test.[19] Within-group differences between pretest and posttest measurements were analyzed using paired sample t-tests, while between-group differences were analyzed using independent sample t-tests. The level of statistical significance was set at $\alpha = 0.05$. Effect sizes were calculated using Cohen's d to quantify the magnitude of intervention effects and were interpreted as small (0.2), moderate (0.5), or large (≥0.8).[20] Ninety-five percent confidence intervals (95% CI) were reported to indicate the precision and clinical relevance of the estimated effects.

Ethical Considerations

This study received ethical approval from the Health Research Ethics Committee of the Faculty of Health Sciences, Universitas Muhammadiyah Surakarta (Ethical Approval No. 1541/KEPK-FIK/IX/2025). The approval was valid from 19 September 2025 to 19 September 2026. Written informed consent was obtained from the parents or legal guardians of all participants prior to study enrollment, and all procedures were conducted in accordance with ethical principles for research involving human participants.

Results

Participant Characteristics

A total of 36 children aged 4–6 years completed the study and were included in the final analysis, with equal allocation to the intervention group (n = 18) and the control group (n = 18). Baseline characteristics included age, sex, and classroom distribution. The mean age was 5.09 ± 0.54 years for male participants and 5.12 ± 0.67 years for female participants. Participant recruitment, eligibility assessment, group allocation, and inclusion in the final analysis are summarized in the study flow diagram (Figure 1). The distributions of sex and classroom assignment are presented in Tables 1 and 2.

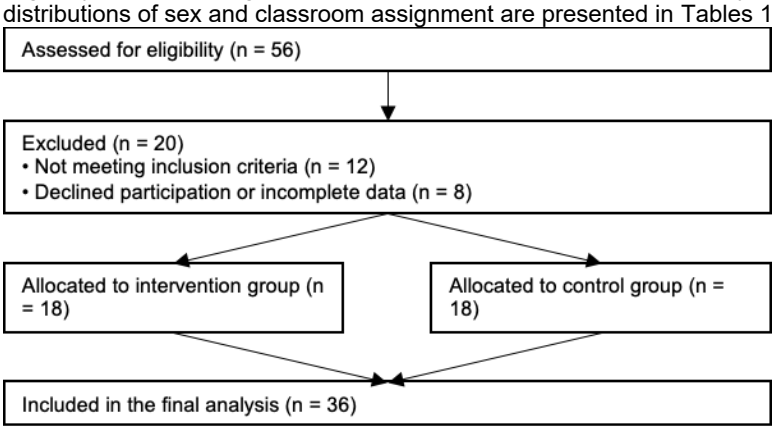

Figure 1. Flow diagram of participant recruitment and allocation

Table 1. Age Characteristics by Sex

Sex	n	Mean (years)	SD	Minimum	Maximum
Male	17	5.09	0.54	4.30	6.00
Female	19	5.12	0.67	4.10	6.00

Table 2. Sex Distribution by Classroom

Classroom	Male, n	Female, n	Total
A	11	9	20
B	6	10	16
Total	17	19	36

Baseline Equivalence Between Groups

Baseline equivalence between the intervention and control groups was assessed prior to intervention implementation. Independent sample t-tests were used for continuous variables, and chi-square tests were applied for categorical variables. No significant differences were observed between groups with respect to age, sex, or classroom distribution (all $p > 0.05$), indicating that the groups were comparable at baseline (Table 3).

Table 3. Baseline Characteristics of the Intervention and Control Groups

Variable	Intervention (n = 18)	Control (n = 18)	p-value
Age (years), mean ± SD	5.00 ± 0.55	5.21 ± 0.66	0.375
Sex, n (%)			0.317
• Female	11 (57.9)	7 (41.2)	
• Male	8 (42.1)	10 (58.8)	
Classroom, n (%)			0.310
• A	12 (57.1)	6 (40.0)	
• B	9 (42.9)	9 (60.0)	

Assumption Testing

Normality of vertical jump scores was examined using the Shapiro–Wilk test. All pretest and posttest data in both groups demonstrated normal distributions ($p > 0.05$). Homogeneity of variance between groups was confirmed using Levene's test ($p = 0.795$), indicating that parametric statistical analyses were appropriate.

Table 4. Normality Test Results (Shapiro–Wilk)

Group	Measurement	Statistic	df	p-value
Intervention	Pretest	0.918	18	0.117
Intervention	Posttest	0.945	18	0.357
Control	Pretest	0.980	18	0.954
Control	Posttest	0.930	18	0.192

Within-Group Comparisons

Paired sample t-tests were conducted to evaluate changes in lower limb muscle power within each group.

In the intervention group, vertical jump height increased significantly from pretest to posttest, with a mean difference of −4.67 cm ($p < 0.001$). The calculated effect size indicated a large effect (Cohen's $d = 1.00$).

In contrast, the control group showed no significant change between pretest and posttest measurements ($p = 0.245$), with a small effect size (Cohen's $d = 0.28$).

Table 5. Within-Group Comparisons of Vertical Jump Performance

Group	Mean Difference (cm)	SD	t	df	p-value	95% CI
Intervention	−4.67	4.67	−4.24	17	<0.001	−6.99 to −2.35
Control	−0.83	2.94	1.20	17	0.245	−0.63 to 2.29

Between-Group Comparison

Independent sample t-tests were performed to compare changes in vertical jump performance between the intervention and control groups. The analysis demonstrated a significant between-group difference favoring the intervention group ($p < 0.001$).

The mean difference between groups was 5.28 cm, with a large effect size (Cohen's $d = 1.91$). The 95% confidence interval did not cross zero, indicating a consistent and clinically meaningful difference.

Table 6. Between-Group Comparison of Vertical Jump Changes

Analysis	Mean Difference (cm)	SE	t	df	p-value	95% CI
Equal variances assumed	5.28	0.92	5.74	34	<0.001	3.41 to 7.15

Summary of Results

Overall, children in the intervention group demonstrated a significantly greater improvement in lower limb muscle power compared with those in the control group. The magnitude of the observed effect was large, and confidence intervals indicated a robust and consistent intervention effect across participants.

Discussion

This study demonstrated that participation in the traditional hopscotch game produced a significant improvement in lower limb muscle power among children aged 4–6 years. Children in the intervention group showed a markedly greater increase in vertical jump performance compared with those in the control group, indicating that hopscotch-based play can serve as an effective play-

oriented stimulus for enhancing explosive lower limb function in early childhood. These findings directly address the study objective and confirm that the intervention yielded a statistically and clinically meaningful effect.

From a neuromuscular perspective, the observed improvement in lower limb muscle power can be explained by enhanced recruitment and coordination of fast-twitch (type II) muscle fibers, which are primarily responsible for generating rapid and forceful contractions.[4,21] Repetitive jumping and hopping movements inherent in hopscotch likely activated the stretch–shortening cycle of the lower limb muscles, leading to improved force production efficiency. Such adaptations are consistent with previous evidence showing that jump-based or plyometric-like activities enhance muscle power through improved neural drive, motor unit synchronization, and contraction velocity.[12,13]

The hopscotch game used in this study incorporated repeated single-leg and double-leg jumps, which stimulated major lower limb muscle groups, including the quadriceps, hamstrings, gastrocnemius, soleus, and hip stabilizers. Repeated exposure to these movement patterns may have facilitated neuromuscular adaptations, such as improved intermuscular coordination and motor control, enabling children to generate greater vertical displacement during jumping tasks.[22] Importantly, these adaptations were achieved through a playful and developmentally appropriate activity rather than structured exercise, supporting the suitability of play-based interventions in early childhood.

The findings of this study align with previous research reporting positive effects of traditional games and jump-based activities on lower limb muscle power and gross motor skills in children.[10,11,23]. However, most prior studies focused on school-aged children, whereas the present study extends this evidence to younger children aged 4–6 years. This is particularly relevant given that early childhood is considered a critical or “golden” period for motor development, during which appropriate physical stimulation can produce lasting benefits for motor competence and physical fitness.[13,14,24]

The absence of significant improvement in the control group further supports the conclusion that routine school activities alone may be insufficient to elicit meaningful gains in lower limb muscle power. This finding is consistent with reports indicating that unstructured or low-intensity daily activities often do not provide adequate mechanical or neuromuscular loading to stimulate power development in young children.[7] In contrast, goal-oriented play activities, such as hopscotch, encourage repeated, purposeful movements that impose sufficient stimulus to promote neuromuscular adaptation.[8,9]

Motivational and psychosocial factors may also have contributed to the observed outcomes. During the intervention, children appeared enthusiastic and engaged, suggesting high intrinsic motivation. Playful environments are known to enhance children’s willingness to exert effort and sustain physical activity, which may indirectly augment training effects.[6] Moreover, emotional readiness and enjoyment have been linked to improved movement quality and physical performance in children, as psychological well-being supports optimal motor execution.[25,26]

Age- and sex-related differences may have also influenced the magnitude of improvement. Older children within the sample (5–6 years) tended to exhibit greater gains in vertical jump performance, which is consistent with evidence that neuromuscular maturation and motor coordination improve with age.[27] Additionally, some studies have reported that young girls may demonstrate superior balance and self-controlled movement execution compared with boys, potentially facilitating more stable and effective jumping mechanics.[28] Although the present study was not powered to formally test subgroup differences, these factors may partially explain individual variability in response to the intervention.

Beyond physical benefits, hopscotch-based play may also support broader developmental outcomes. Traditional games encourage problem-solving, spatial awareness, and self-regulation as children navigate movement sequences and maintain balance across hopping patterns.[29] Such multidimensional benefits further strengthen the rationale for integrating traditional games into early childhood education curricula.

Despite its strengths, this study has several limitations that should be acknowledged. The quasi-experimental design without randomization limits causal inference, although baseline equivalence between groups was established. The relatively small sample size and single-school setting may restrict the generalizability of the findings. In addition, the study did not include long-term follow-up, preventing evaluation of the sustainability of the observed improvements. Future studies should consider randomized controlled designs, larger and more diverse samples, and extended follow-up periods to assess long-term motor development outcomes.

Overall, the findings indicate that the traditional hopscotch game is an effective, safe, and culturally relevant intervention for improving lower limb muscle power in early childhood. Integrating hopscotch into kindergarten routines as a structured play-based activity may provide a practical strategy for enhancing gross motor development during a critical developmental period.

Conclusion

This study demonstrated that participation in the traditional hopscotch game significantly improved lower limb muscle power in children aged 4–6 years, as indicated by meaningful increases in vertical jump performance. Compared with routine school activities, hopscotch-based play produced a substantially greater enhancement in explosive lower limb function, with large effect sizes and clinically relevant confidence intervals. These findings confirm that a culturally familiar, play-based activity can effectively stimulate neuromuscular adaptations during early childhood.

From a practical perspective, hopscotch represents a simple, safe, and developmentally appropriate form of physical activity that can be readily integrated into kindergarten routines. The intervention requires minimal equipment, is easily implemented by teachers, and promotes high levels of engagement and enjoyment among children. Incorporating hopscotch into regular school activities may therefore support gross motor development while maintaining a playful learning environment aligned with early childhood education principles.

Although the quasi-experimental design and limited sample size restrict causal inference and generalizability, the consistent and robust improvements observed suggest that hopscotch-based play has meaningful potential as an early motor development strategy. Future research employing randomized controlled designs, larger multisite samples, and long-term follow-up is warranted to confirm these findings and to examine the sustainability of motor performance gains over time.

Author Contribution

Salma Fadila Nisa: Conceptualization; Methodology; Data curation; Formal analysis; Writing—original draft.
Mahendra Wahyu Dewangga: Conceptualization; Formal analysis; Writing—review & editing; Supervision.
Rinna Ainul Maghfiroh: Methodology; Writing—review & editing.

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Conflict of Interest Statement

The authors declare no conflict of interest.

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Ethics Statement

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