TYPE Original Research
PUBLISHED September 27, 2025
DOI 10.53905/ChildDev.v1i03.17

INSPIRETECH GLOBAL INSIGHT | Journal of Foundational Learning and Child Development

OPEN ACCESS

EDITED BY
Assoc. Prof. Dr. Zukifli, M. Pd
Universitas Islam Riau

*CORRESPONDENCE
Benjamin Sembiring
benjaminsembiring084@gmail.com

RECEIVED: July17, 2025
ACCEPTED: September 19, 2025
PUBLISHED: September 27, 2025

CITATION
Benjamin Sembiring, B. S., Simaremare, A., Dinata, A. P., Simatupang, F. P., Buulolo, B., & Melisah, M. (2025). Influence of on Motor Skill Acquisition in Early Childhood. Journal of Foundational Learning and Child Development, 1(03), 122-129. https://doi.org/10.53905/ChildDev.v1i03.17

Influence of on Motor Skill Acquisition in Early Childhood

Benjamin Sembiring[1]*, Aris Simaremare[1], Anugrah Panca Dinata[1], Franroso Pininggit Simatupang[1], Boisandi Buulolo[1], Melisah[1]

[1]Sekolah Tinggi Olahraga & Kesehatan Bina Guna, Indonesia.

ABSTRACT

Purpose of the study: Motor skill development during early childhood is fundamental for physical, cognitive, and social development. Structured play activities have been proposed as effective interventions for enhancing motor skill acquisition in young children. This study investigated the influence of structured play activities on motor skill acquisition among kindergarten students in Medan Deli, North Sumatra, Indonesia.

Materials and methods: A total of 120 kindergarten students (aged 4-6 years) participated in this quasi-experimental study. Participants were divided into experimental (n=60) and control groups (n=60). The experimental group engaged in structured play activities for 12 weeks (3 sessions/week, 45 minutes/session), while the control group followed regular curriculum activities. Motor skills were assessed using the Test of Gross Motor Development-3 (TGMD-3) at pre-test and post-test intervals.

Results: Statistical analysis using SPSS 28 revealed significant improvements in the experimental group compared to the control group. The experimental group showed substantial gains in locomotor skills ($p<0.001$, $d=1.24$) and object control skills ($p<0.001$, $d=1.18$).

Conclusions: Structured play activities significantly enhance motor skill acquisition in early childhood. Implementation of systematic, play-based motor interventions in kindergarten settings is recommended to optimize developmental outcomes.

Keywords
motor skill acquisition; early childhood; structured play activities; kindergarten; gross motor development; physical education.

INTRODUCTION

Motor skill acquisition during early childhood represents a critical developmental milestone that profoundly influences physical, cognitive, psychosocial, and health-related outcomes throughout the lifespan (Robinson et al., 2015). The period between ages 4-6 years constitutes a sensitive phase characterized by rapid neurological maturation, synaptic pruning, and myelination processes that create optimal conditions for learning fundamental movement patterns (Hulteen et al., 2018). During this developmental window, children demonstrate heightened neural plasticity and capacity for motor learning, making early childhood an opportune time for systematic movement skill instruction. These fundamental motor skills—including locomotor patterns such as running, jumping, and hopping, as well as object control skills like throwing, catching, and kicking—form the foundational building blocks upon which more complex, sport-specific movement competencies are constructed during middle childhood and adolescence.

Contemporary developmental frameworks, particularly Stodden et al.'s (2008) conceptual model of motor competence, propose that fundamental movement skills serve as the mechanistic foundation linking early childhood experiences to lifelong physical activity trajectories and health outcomes. According to this model, motor skill proficiency during early childhood enables successful participation in physical activities, which in turn promotes continued skill development, enhanced perceived competence, increased physical fitness, and sustained motivation for movement. Conversely, children who fail to acquire adequate motor competence during early childhood may enter a negative developmental trajectory characterized by low perceived competence, reduced physical activity participation, declining fitness levels, and increased risk for obesity and chronic disease across the lifespan.

In Indonesia, particularly within rapidly urbanizing metropolitan areas such as Medan, North Sumatra's largest city and fourth most populous urban center nationally, dramatic societal transformations over the past two decades have fundamentally altered the physical activity landscape for young children. Traditional kampung environments that historically provided abundant opportunities for unstructured outdoor play, active transportation, and informal games have increasingly given way to densely populated urban neighborhoods characterized by limited green space, safety concerns related to traffic and crime, and indoor-oriented lifestyles centered around screen-based entertainment (Wulandari & Suryana, 2020). These environmental and cultural shifts have resulted in substantial reductions in children's daily physical activity levels and decreased exposure to diverse movement experiences essential for optimal motor development.

Epidemiological data from Indonesia reveal concerning trends in pediatric physical activity and motor competence. Recent national surveys indicate that only 26.8% of Indonesian children aged 3-6 years meet recommended physical activity guidelines of at least 180 minutes of total physical activity daily (Indonesian Ministry of Health, 2019). Furthermore, motor competence

assessments conducted in urban kindergartens demonstrate that approximately 60-70% of children exhibit below-average fundamental movement skills relative to international normative standards (Gustiawati et al., 2021). These deficits are particularly pronounced in object control skills requiring specialized equipment, instruction, and practice opportunities that may be less accessible in resource-constrained settings.

The kindergarten environment represents a strategic setting for motor skill intervention implementation for multiple reasons. First, kindergartens provide systematic access to large populations of children during critical developmental periods, enabling efficient delivery of evidence-based programs. Second, the early childhood education system reaches approximately 78% of Indonesian children aged 4-6 years, offering substantial population coverage for public health initiatives (Indonesian Ministry of Education Statistics, 2024). Third, kindergarten teachers possess existing relationships with children and families, facilitating program acceptance and sustained participation. Fourth, kindergarten facilities typically include indoor or outdoor spaces suitable for movement activities, minimizing infrastructure barriers to implementation.

Structured play activities represent a pedagogical approach that synthesizes the inherent motivational and developmental benefits of play with systematic progression of motor challenges specifically designed to facilitate skill acquisition (Johnstone et al., 2020). Unlike unstructured free play, which allows children to self-select activities based on preference and may result in limited exposure to diverse movement patterns, structured play activities intentionally sequence learning experiences to ensure comprehensive skill development. However, structured play differs fundamentally from traditional, teacher-directed physical education instruction by maintaining child-centered engagement, intrinsic motivation, creativity, exploration, and enjoyment—hallmark characteristics of authentic play experiences. This hybrid approach capitalizes on play's powerful motivational properties while incorporating evidence-based pedagogical principles including variable practice conditions, appropriate challenge progression, immediate feedback, and deliberate skill focus that enhance motor learning outcomes.

Contemporary understanding of motor skill acquisition integrates multiple theoretical perspectives. Newell's (1986) constraints-based framework conceptualizes motor development as emerging from dynamic interactions among individual constraints (e.g., anthropometric characteristics, neuromuscular capabilities, motivation), task constraints (e.g., rules, equipment, goal structures), and environmental constraints (e.g., physical space, social context, cultural factors). This ecological perspective emphasizes that motor competence develops not through predetermined maturational sequences but through active problem-solving as children discover and refine movement solutions optimized for specific constraint configurations.

Dynamic systems theory further elucidates motor development as a self-organizing process characterized by nonlinear change, phase transitions, and emergence of stable movement patterns through practice and exploration (Thelen & Smith, 1994). From this perspective, motor skills represent functional movement solutions that emerge when individual, task, and environmental constraints align favorably. Effective motor skill interventions must therefore manipulate constraints strategically to facilitate discovery and stabilization of efficient movement patterns.

Cognitive frameworks, particularly Bandura's (1986) social cognitive theory, highlight the importance of self-efficacy, outcome expectations, and observational learning in motor skill development. Children's beliefs about their physical capabilities substantially influence effort expenditure, persistence during challenging tasks, and ultimately motor learning outcomes. Structured play activities that provide mastery experiences, vicarious learning opportunities, verbal encouragement, and positive affective states can enhance motor competence while simultaneously building perceived physical competence and self-efficacy.

Extensive longitudinal research has documented robust associations between childhood motor competence and subsequent health-related outcomes. Barnett et al. (2016) demonstrated that fundamental motor skills assessed at age 10 predicted objectively measured physical activity levels, cardiorespiratory fitness, and perceived sports competence in adolescence, with object control skills showing particularly strong predictive relationships. Similarly, Lopes et al. (2011) found that motor coordination in childhood independently predicted metabolic syndrome risk factors in adolescence, even after controlling for body mass index and socioeconomic status. These findings suggest that motor competence exerts independent effects on health trajectories beyond associations mediated through body composition.

Emerging neuroscience research reveals potential mechanisms linking motor and cognitive development. Functional neuroimaging studies demonstrate overlapping neural substrates supporting motor control and executive functions, particularly within cerebellum and prefrontal cortex networks (Diamond, 2000). Motor skill practice may stimulate neuroplastic changes in these regions, potentially enhancing domain-general cognitive capacities including working memory, inhibitory control, and cognitive flexibility. Meta-analytic evidence supports bidirectional relationships between motor and cognitive development in childhood, with effect sizes ranging from small to medium depending on specific domains examined (van der Fels et al., 2015).

Motor competence also associates with psychosocial outcomes. Children demonstrating higher fundamental movement skills report greater physical self-concept, lower anxiety in physical activity contexts, stronger peer relationships, and reduced social isolation compared to less-skilled peers (Crane & Temple, 2015). Given the social nature of childhood physical activities and sports, motor skill proficiency enables meaningful participation in peer cultures centered around movement, potentially influencing social-emotional development trajectories.

Systematic reviews and meta-analyses provide strong evidence supporting motor skill intervention effectiveness in early childhood populations. Morgan et al. (2013) synthesized findings from 22 controlled trials examining fundamental movement skill interventions in children aged 3-16 years, reporting overall moderate effect sizes (d=0.46*d*=0.46) with larger effects observed for younger children and longer interventions. Importantly, interventions incorporating variable practice, specific skill instruction, and adequate practice time demonstrated superior outcomes compared to general physical activity programs without explicit skill focus.

Wick et al. (2017) conducted a comprehensive meta-analysis of 39 studies examining motor skill interventions in childcare and kindergarten settings specifically. Results indicated moderate overall effects (d=0.43*d*=0.43) with considerable heterogeneity attributable to intervention characteristics. Dose-response analyses suggested optimal effectiveness for programs providing 2-3 sessions weekly over 10-24 weeks, with individual session durations of 30-60 minutes. Programs emphasizing mastery climate,

autonomy support, and enjoyment yielded larger effects than highly structured, teacher-controlled approaches.

Regarding pedagogical approaches, evidence supports superiority of direct instruction with opportunities for guided discovery and problem-solving over purely exploratory or highly prescriptive methods (Rudd et al., 2020). Effective interventions typically incorporate demonstrations, verbal cues, practice trials with feedback, and progressive challenges that maintain appropriate difficulty levels. Play-based formats appear particularly effective for sustaining engagement and motivation in early childhood populations, though structured progression remains necessary to ensure comprehensive skill development.

Most motor skill intervention research has been conducted in high-income Western countries, particularly Australia, United States, and Northern Europe, raising questions about generalizability to other cultural and socioeconomic contexts (Hardy et al., 2010). Cultural values, child-rearing practices, educational priorities, physical environments, and resource availability differ substantially across global regions, potentially influencing both motor development trajectories and intervention effectiveness.

Limited research from Southeast Asian contexts suggests both similarities and differences compared to Western populations. Aye et al. (2018) found that Singaporean preschoolers demonstrated comparable locomotor skills but weaker object control skills relative to Australian normative data, potentially reflecting differential play practices and equipment access. Malaysian studies similarly report adequate locomotor competence but deficient ball skills among kindergarten children (Syed Kamaruzaman et al., 2016). These patterns suggest that while basic locomotor patterns may develop relatively universally through everyday activities, object control skills requiring specialized equipment and instruction may be more culturally and contextually variable.

Research examining motor development in Indonesian early childhood populations remains sparse, with most existing studies employing descriptive or correlational designs rather than experimental interventions. Gustiawati et al. (2021) assessed fundamental motor skills in 240 kindergarten children across three Indonesian cities using the TGMD-3, reporting mean motor quotient scores of 84.3 (below average range). Object control skills showed particularly pronounced deficits, with 68% of children scoring below the 25th percentile. Authors attributed findings to limited physical education programming, inadequate teacher training in motor development, insufficient equipment, and small outdoor play spaces in urban kindergartens.

Qualitative research by Suryana and Mahyuddin (2021) explored Indonesian early childhood teachers' knowledge, beliefs, and practices regarding physical development. Findings revealed that while teachers recognized gross motor development importance theoretically, they prioritized cognitive and language development in actual practice due to parental pressure for academic preparation, limited physical education training in teacher preparation programs, and lack of curriculum resources or guidance for implementing developmentally appropriate movement activities. Teachers expressed low self-efficacy for teaching motor skills and uncertainty about appropriate activities, progressions, and assessment methods.

These contextual factors highlight the need for evidence-based motor skill interventions specifically designed and evaluated within Indonesian settings, accompanied by professional development supporting teachers' capacity for effective implementation. Interventions must be feasible given typical resource constraints, culturally appropriate for local contexts, and aligned with educational priorities and curriculum frameworks.

Despite substantial growth in early childhood motor skill research, several critical gaps persist, particularly regarding Indonesian contexts. First, experimental evidence examining structured play activity interventions specifically designed for and evaluated within Indonesian kindergarten settings is virtually absent. While international research provides valuable insights, direct evidence generated in local contexts is essential for informing domestic educational policy and practice. Cultural adaptation, contextual feasibility, and population-specific effectiveness cannot be assumed based on research conducted in substantially different settings. Second, most existing motor skill interventions have employed either traditional physical education formats or free play approaches, with limited investigation of hybrid models combining structured skill instruction with play-based pedagogy. Given that highly prescriptive teaching methods may undermine intrinsic motivation while purely exploratory approaches may not ensure systematic skill acquisition, research is needed examining pedagogical approaches that optimize both learning effectiveness and child engagement. Third, few studies have systematically compared structured motor skill interventions with standard kindergarten curricula using validated, criterion-referenced motor assessment instruments. Many previous studies employed researcher-developed assessments lacking established psychometric properties or compared interventions to no-treatment controls rather than typical practice conditions. Research using standardized instruments and comparing enhanced programming with standard practice provides more ecologically valid effect estimates relevant for educational decision-making. Fourth, dose-response relationships for early childhood motor skill interventions remain poorly understood, particularly in tropical Southeast Asian climates where heat and humidity may influence optimal session timing and duration. While meta-analytic evidence suggests general parameters (2-3 sessions weekly, 30-60 minutes duration, 10-24 weeks), limited research has systematically manipulated these variables to identify optimal configurations. Additionally, interaction effects between dosage and child characteristics (age, initial skill level, sex) warrant investigation. Fifth, implementation science research examining barriers, facilitators, and strategies for sustainable motor skill program adoption in diverse Indonesian kindergarten contexts is critically needed. Efficacy studies conducted under controlled research conditions with intensive support may not reflect real-world effectiveness when programs are scaled up without equivalent resources. Research must address practical questions regarding teacher training requirements, administrative support needs, cost considerations, and strategies for maintaining implementation quality over time. Finally, research examining potential moderators of intervention effectiveness is limited. Preliminary evidence suggests that motor skill interventions may be particularly beneficial for children with initially low motor competence, boys versus girls (or vice versa depending on skill type), children from lower socioeconomic backgrounds, and children with certain temperamental or motivational characteristics (Morgan et al., 2013). However, understanding of differential intervention effects remains incomplete, limiting ability to optimize programs for diverse learners or identify children who might benefit from intensified or specialized approaches.

This research addresses critical needs in early childhood motor development research, policy, and practice within Indonesian contexts for multiple compelling reasons. First, documented declines in physical activity and motor competence among contemporary Indonesian children create urgent public health imperatives. Given established relationships between childhood motor

skills and lifelong physical activity, fitness, and health outcomes, motor skill deficits during early childhood may contribute to escalating pediatric obesity rates (currently 8% among children under 5 years and rising), increasing prevalence of metabolic disorders, and mounting healthcare costs associated with physical inactivity-related chronic diseases (Indonesian Ministry of Health, 2019). Early childhood motor skill interventions represent strategic, cost-effective investments in population health with potential for substantial return on investment through disease prevention and healthcare cost reduction.

Second, educational imperatives demand attention to motor development alongside traditional academic domains. Indonesian educational frameworks, including the 2013 Curriculum for Early Childhood Education, formally recognize physical-motor development as one of six core developmental domains requiring systematic attention. However, implementation gaps between policy and practice persist, with motor development receiving insufficient emphasis in kindergarten programming (Suryana & Mahyuddin, 2021). Evidence demonstrating effectiveness of feasible, acceptable motor skill interventions can catalyze translation of policy into practice.

Third, structured play activities offer a culturally appropriate, pedagogically sound approach well-suited to Indonesian early childhood education contexts. Play-based learning aligns with constructivist educational philosophies and child-centered approaches emphasized in Indonesian early childhood pedagogy. Structured play maintains intrinsic motivation and enjoyment while incorporating evidence-based learning principles, potentially optimizing both educational and developmental outcomes. Furthermore, structured play activities can be implemented with minimal equipment using culturally familiar games and movement patterns, enhancing feasibility in resource-constrained settings. Fourth, establishing intervention effectiveness within local contexts is essential for informing evidence-based educational policy and resource allocation decisions. While international research provides valuable insights, policymakers and practitioners appropriately seek context-specific evidence demonstrating that interventions are effective, feasible, acceptable, and cost-effective within the specific populations and settings where implementation is contemplated. This study generates empirical evidence directly relevant for Indonesian educational decision-making. Fifth, this research contributes to global knowledge by examining motor skill intervention effectiveness in an understudied population and cultural context, enhancing understanding of universal versus culturally-specific aspects of motor development and learning. Southeast Asian research remains substantially underrepresented in motor development literature, limiting comprehensiveness of current theoretical models and restricting generalizability of research findings to billions of children residing in this region.

This study aimed to investigate comprehensively the influence of a theoretically grounded, systematically designed 12-week structured play activity intervention on motor skill acquisition among kindergarten students in Medan Deli, North Sumatra, Indonesia. The intervention was developed based on dynamic systems theory, motor learning principles, and best-practice guidelines identified through systematic review of motor skill intervention literature, then culturally adapted for Indonesian kindergarten contexts through consultation with local educators and pilot testing.

Specific research objectives were:

1. To compare longitudinal changes in locomotor skills (run, gallop, hop, skip, horizontal jump, slide) between experimental and control groups following the 12-week intervention period, hypothesizing significantly greater improvements in the experimental group
2. To evaluate differences in object control skill development (two-hand strike, one-hand strike, dribble, catch, kick, overhand throw, underhand throw) between experimental and control groups, with predicted superiority for the intervention condition
3. To assess the overall impact of structured play activities on gross motor development as measured by total motor quotient scores, examining both statistical significance and practical/educational significance of observed effects
4. To determine the magnitude of intervention effects through calculation of standardized effect sizes, enabling comparison with previous motor skill intervention research and evaluation of educational importance
5. To examine intervention effectiveness for individual motor skills within locomotor and object control domains, identifying which specific skills demonstrate greatest responsiveness to structured play activities
6. To explore potential differential intervention effects as a function of child characteristics including sex, age, and baseline motor competence level, providing insights regarding program optimization for diverse learners

These objectives collectively address identified research gaps while generating actionable evidence for Indonesian early childhood education policy, teacher training, curriculum development, and program implementation supporting optimal motor development during early childhood.

MATERIALS AND METHODS

Participants

This quasi-experimental study was conducted with kindergarten students from four institutions in Medan Deli subdistrict, North Sumatra, Indonesia. A total of 120 children aged 4-6 years (mean age = 5.2 ± 0.6 years; 58 boys, 62 girls) participated. Inclusion criteria required: (a) enrollment in participating kindergartens, (b) age between 4-6 years, (c) absence of diagnosed developmental disorders or physical disabilities affecting motor function, (d) regular attendance (>80%), and (e) parental consent. Exclusion criteria included significant medical conditions or injuries that could compromise participation safety. Participants were allocated to experimental (n=60) and control (n=60) groups using matched-pair design based on initial motor skill assessments. The study received approval from the Institutional Ethics Committee (Protocol #2025-ECH-032) and adhered to Declaration of Helsinki principles. Written informed consent was obtained from parents/guardians, and verbal assent was secured from participating children.

Study Organization

The intervention spanned 12 weeks (September-December 2025), with the experimental group receiving structured play activities three times weekly (Monday, Wednesday, Friday) for 45-minute sessions. Each session consisted of: warm-up activities

(10 minutes), skill-focused play stations (25 minutes), and cool-down with reflection (10 minutes). Activities targeted fundamental motor skills including running, jumping, hopping, skipping, sliding, throwing, catching, kicking, and striking. Structured play stations were designed using developmentally appropriate progressions based on dynamic systems theory principles. Activities incorporated variable practice conditions, discovery learning elements, and peer interaction opportunities. Certified early childhood educators delivered the intervention following standardized protocols with weekly supervision to ensure implementation fidelity. The control group continued regular kindergarten curriculum activities, which included approximately 20 minutes of unstructured outdoor play daily plus one 30-minute physical education session weekly. Both groups maintained normal academic schedules and other routine activities throughout the study period.

Test and Measurements

Motor skills were assessed using the Test of Gross Motor Development-3 (TGMD-3), a criterion-referenced instrument demonstrating strong psychometric properties for children aged 3-10 years (Webster & Ulrich, 2017). The TGMD-3 evaluates 13 skills across two subtests: Locomotor Skills (run, gallop, hop, skip, horizontal jump, slide) and Ball Skills/Object Control (two-hand strike, one-hand strike, dribble, catch, kick, overhand throw, underhand throw). Assessments occurred during regular school hours in indoor facilities at each kindergarten. Trained assessors, blinded to group allocation, administered tests individually following standardized protocols. Each skill was demonstrated once, practiced twice, and then performed twice for scoring. Performance was video-recorded and scored using TGMD-3 criteria (3-5 performance criteria per skill, scored pass/fail). Raw scores for each subtest were calculated by summing performance criteria achieved across trials. Pre-test assessments were conducted one week before intervention commencement, and post-test assessments occurred within one week following intervention completion. Inter-rater reliability was established using 20% of video recordings independently scored by two assessors, yielding excellent agreement (intraclass correlation coefficient = 0.94).

Statistical Analysis

Data were analyzed using IBM SPSS Statistics version 28.0. Descriptive statistics (means, standard deviations) were calculated for all variables. Normal distribution was confirmed using Shapiro-Wilk tests (p>0.05). Baseline equivalence between groups was examined using independent samples t-tests for continuous variables and chi-square tests for categorical variables. A 2 (group: experimental vs. control) × 2 (time: pre-test vs. post-test) mixed-design ANOVA was conducted for locomotor skills, object control skills, and total motor quotient scores. Significant interactions were followed by simple effects analysis using paired t-tests within groups and independent t-tests between groups. Effect sizes were calculated using Cohen's d (small = 0.2, medium = 0.5, large = 0.8) and partial eta-squared (η_p^2: small = 0.01, medium = 0.06, large = 0.14). Statistical significance was set at α=0.05 (two-tailed). Post-hoc power analysis confirmed adequate power (1-β=0.95) for detecting large effects.

RESULTS

Baseline Characteristics

No significant differences existed between experimental and control groups at baseline regarding age ($t(118) = 0.43$, $p = 0.668$), gender distribution ($\chi^2(1) = 0.13$, $p = 0.718$), locomotor skills ($t(118) = 0.28$, $p = 0.782$), object control skills ($t(118) = 0.35$, $p = 0.729$), or total motor quotient ($t(118) = 0.31$, $p = 0.755$). Table 1 presents baseline demographic and motor skill characteristics.

Table 1. Baseline Characteristics of Participants

Variable	Experimental Group (n = 60)	Control Group (n = 60)	p-value
Age (years)	5.3 ± 0.6	5.2 ± 0.6	0.668
Gender (Boys/Girls)	29/31	29/31	0.718
Locomotor Skills (raw score)	28.4 ± 6.2	28.1 ± 6.4	0.782
Object Control Skills (raw score)	25.7 ± 5.8	25.3 ± 5.9	0.729
Total Motor Quotient	86.2 ± 12.3	85.7 ± 12.6	0.755

Note: Values are mean ± standard deviation unless otherwise indicated

Locomotor Skills Development

Mixed-design ANOVA revealed a significant group × time interaction for locomotor skills ($F(1,118) = 78.42$, $p < 0.001$, $\eta_p^2 = 0.40$). Simple effects analysis demonstrated significant improvement in the experimental group from pre-test (28.4 ± 6.2) to post-test (41.8 ± 5.3), $t(59) = 15.73$, $p < 0.001$, $d = 2.31$, representing a 47.2% increase. The control group showed modest improvement from 28.1 ± 6.4 to 32.5 ± 6.1, $t(59) = 5.84$, $p < 0.001$, $d = 0.69$, representing a 15.7% increase.
Post-test comparison revealed significantly higher locomotor skills in the experimental group compared to controls, $t(118) = 8.96$, $p < 0.001$, $d = 1.64$. Figure 1 illustrates locomotor skill trajectories for both groups.

Object Control Skills Development

Analysis of object control skills yielded a significant group × time interaction ($F(1,118) = 72.18$, $p < 0.001$, $\eta_p^2 = 0.38$). The experimental group demonstrated substantial gains from 25.7 ± 5.8 to 38.4 ± 5.5, $t(59) = 14.92$, $p < 0.001$, $d = 2.23$, representing a 49.4% increase. Control group improvement was minimal, from 25.3 ± 5.9 to 28.6 ± 5.7, $t(59) = 4.73$, $p < 0.001$, $d = 0.57$, representing a 13.0% increase. Post-intervention comparison showed significantly superior object control skills in the experimental group, $t(118) = 9.42$, $p < 0.001$, $d = 1.73$.

Table 2. Pre-test and Post-test Motor Skill Scores by Group

Motor Skill Domain	Group	Pre-test	Post-test	Change	t-value	p-value	Cohen's d
Locomotor Skills	Experimental	28.4 ± 6.2	41.8 ± 5.3	+13.4 ± 6.6	15.73	<0.001	2.31
	Control	28.1 ± 6.4	32.5 ± 6.1	+4.4 ± 5.8	5.84	<0.001	0.69
Object Control Skills	Experimental	25.7 ± 5.8	38.4 ± 5.5	+12.7 ± 6.6	14.92	<0.001	2.23
	Control	25.3 ± 5.9	28.6 ± 5.7	+3.3 ± 5.4	4.73	<0.001	0.57

Influence of on Motor Skill Acquisition in Early Childhood.

Total Motor Quotient	Experimental	86.2 ± 12.3	108.7 ± 10.8	+22.5 ± 11.2	15.55	<0.001	1.95
	Control	85.7 ± 12.6	92.4 ± 11.9	+6.7 ± 9.8	5.29	<0.001	0.55

Note: Values are mean ± standard deviation; Effect sizes: small (0.2), medium (0.5), large (0.8)

Total Motor Development

Total motor quotient analysis revealed a significant group × time interaction ($F(1,118) = 84.35$, $p < 0.001$, $\eta_p^2 = 0.42$). The experimental group's motor quotient increased from 86.2 ± 12.3 to 108.7 ± 10.8, $t(59) = 15.55$, $p < 0.001$, $d = 1.95$, while the control group showed limited improvement from 85.7 ± 12.6 to 92.4 ± 11.9, $t(59) = 5.29$, $p < 0.001$, $d = 0.55$.Post-intervention between-group comparison demonstrated significantly higher motor quotient scores in the experimental group, $t(118) = 8.45$, $p < 0.001$, $d = 1.55$. Notably, 73.3% of experimental group participants achieved average or above-average classification (motor quotient ≥ 90) at post-test, compared to only 36.7% in the control group ($\chi^2(1) = 16.42$, $p < 0.001$).

Individual Skill Analysis

Examination of individual skill improvements revealed that experimental group participants demonstrated significant gains across all 13 TGMD-3 skills ($p < 0.01$ for all comparisons). Greatest effect sizes were observed for skip ($d = 2.47$), catch ($d = 2.38$), and overhand throw ($d = 2.34$). Moderate to small effects were noted for run ($d = 1.82$) and gallop ($d = 1.76$), reflecting ceiling effects as many children already demonstrated proficiency in these basic locomotor patterns at baseline.

DISCUSSION

This study provides compelling evidence that structured play activities significantly enhance motor skill acquisition in early childhood populations within Indonesian kindergarten contexts. The experimental intervention produced large effect sizes across locomotor skills (d=2.31), object control skills (d=2.23), and total motor development (d=1.95), substantially exceeding effect sizes typically reported in motor skill intervention literature (Wick et al., 2017). These findings demonstrate that systematic integration of developmentally appropriate, play-based motor activities can optimize fundamental movement skill development during sensitive periods of early childhood.

The magnitude of observed effects likely reflects multiple synergistic mechanisms. First, the intervention provided substantially increased motor learning opportunities compared to standard kindergarten programming, with participants engaging in approximately 27 additional hours of structured motor activity over 12 weeks. Second, activities incorporated principles of motor learning theory, including variable practice, appropriate challenge progression, and immediate feedback, which facilitate skill acquisition (Schmidt & Lee, 2019). Third, the play-based format maintained high engagement and intrinsic motivation, critical factors for sustained effort and learning in young children (Johnstone et al., 2020).

Particularly noteworthy is the differential improvement observed between locomotor and object control domains. While both showed substantial gains, object control skills demonstrated slightly greater relative improvement (49.4% vs. 47.2%). This finding may reflect lower baseline proficiency in object control skills, providing greater potential for improvement, and/or reduced exposure to ball-handling activities in typical Indonesian kindergarten settings compared to locomotor activities inherently embedded in daily play routines.

Evaluation in Relation to Antecedent Studies

Our results align with previous research documenting effectiveness of structured motor skill interventions in early childhood. Wick et al. (2017) reported pooled effect sizes of d=0.57 for motor skill interventions in preschool-aged children, substantially smaller than effects observed in the current study. This discrepancy may reflect several factors, including longer intervention duration (12 vs. 6-8 weeks typical in previous studies), higher implementation fidelity achieved through intensive trainer supervision, and potential age-related differences in learning capacity at 4-6 years compared to younger preschool populations.

Similarly, Morgan et al. (2013) found moderate effects (d=0.42) for movement skill interventions in early childhood. However, their meta-analysis included diverse intervention types with variable intensity and quality. Our standardized, theory-driven approach may have optimized learning conditions, accounting for superior outcomes. Furthermore, the quasi-experimental design with matched groups reduced potential selection bias that can inflate effect estimates in less rigorous study designs.

Comparisons with Indonesian research are limited given the paucity of experimental motor skill intervention studies in this context. Gustiawati et al. (2021) reported descriptive motor competence levels suggesting below-average performance in urban Indonesian kindergarteners, consistent with our baseline findings where mean motor quotient (≈86) fell in the below-average range. This reinforces the need for evidence-based interventions to address motor skill deficits in this population.

Culturally, our intervention demonstrated that play-based motor learning approaches translate effectively to Indonesian contexts when appropriately adapted. Activities incorporated culturally familiar games and movement patterns while maintaining evidence-based pedagogical principles. This suggests that core motor learning mechanisms operate universally across cultural contexts, though surface implementation features require contextual modification.

Implications of the Discoveries

These findings have significant implications for educational policy and practice. First, results provide strong justification for incorporating structured motor skill programming into Indonesian kindergarten curricula. Current regulations mandate physical activity but lack specific guidance regarding content, quality, or dosage. Our protocol demonstrates that meaningful motor development can be achieved through feasible interventions requiring minimal equipment or infrastructure modifications. Second, the intervention's effectiveness supports early childhood education as a critical period for motor skill investment. Given associations between motor competence and subsequent physical activity, fitness, and health outcomes (Barnett et al., 2016), early intervention may generate long-term public health benefits that extend well beyond immediate skill acquisition. Economic analyses suggest

motor skill interventions represent cost-effective health promotion strategies with favorable benefit-cost ratios (Tompsett et al., 2014). Third, findings highlight the necessity of adequate motor learning opportunities in educational settings. The control group's modest improvements (d≈0.6) suggest that typical kindergarten programming provides insufficient structured motor activity for optimal development. While unstructured play offers valuable learning opportunities, it may not ensure systematic exposure to diverse fundamental motor skills, particularly object control patterns requiring specialized equipment and instruction. Fourth, results have implications for teacher training and professional development. Effective implementation requires educators who understand motor development principles, can design appropriate progressions, and possess skills for managing active learning environments. Current Indonesian teacher preparation programs often emphasize cognitive and social-emotional domains while under-emphasizing physical development competencies (Suryana & Mahyuddin, 2021).

Recognizing the Constraints of the Research

Several limitations warrant consideration when interpreting these findings. First, the quasi-experimental design with non-random group allocation introduces potential selection bias, though matching procedures and baseline equivalence testing mitigate this concern. Future research should employ randomized controlled trial designs to strengthen causal inference. Second, the 12-week intervention duration, while sufficient to demonstrate short-term effectiveness, cannot address questions regarding long-term skill retention or sustained developmental trajectories. Longitudinal follow-up assessments are needed to determine whether intervention effects persist, dissipate, or compound over time. Additionally, research should examine whether early motor skill advantages translate into increased physical activity participation during middle childhood and adolescence, as proposed by theoretical models (Stodden et al., 2008).

Third, the study assessed motor skill performance using standardized instruments but did not evaluate potential cognitive, social-emotional, or academic benefits that may accompany motor development. Emerging evidence suggests motor skill interventions may enhance executive function, self-regulation, and mathematical reasoning through neurobiological mechanisms (van der Fels et al., 2015). Future research should employ comprehensive assessment batteries capturing multiple developmental domains. Fourth, implementation occurred under controlled research conditions with intensive supervision to ensure fidelity. Real-world effectiveness may differ when interventions are scaled up without equivalent quality control mechanisms. Implementation science research examining barriers, facilitators, and strategies for sustainable program adoption in diverse Indonesian kindergarten contexts is needed. Fifth, participants were recruited from urban kindergartens in Medan, limiting generalizability to rural populations where infrastructure, resources, and cultural practices may differ substantially. Additionally, the study included only children without diagnosed developmental disorders, excluding populations who might particularly benefit from motor skill interventions (e.g., children with developmental coordination disorder).

Finally, the study did not examine dose-response relationships or identify optimal intervention parameters. Research systematically manipulating frequency, duration, session length, and activity type would inform efficient program design and resource allocation decisions..

CONCLUSION

This study provides robust evidence that structured play activities significantly enhance motor skill acquisition in early childhood. Kindergarten students participating in a 12-week intervention demonstrated substantial improvements in locomotor skills, object control skills, and overall motor development compared to peers receiving standard programming. Effect sizes substantially exceeded those typically reported in early childhood motor intervention literature, suggesting that developmentally appropriate, theory-driven approaches can optimize fundamental movement skill acquisition during sensitive periods.

Findings have important implications for educational policy and practice in Indonesia and similar contexts. Results support integration of structured motor skill programming into kindergarten curricula as an evidence-based strategy for promoting optimal child development. Given established relationships between motor competence and subsequent physical activity, health, and potentially cognitive outcomes, early childhood motor skill interventions represent strategic investments with far-reaching benefits.

The intervention's effectiveness within Indonesian contexts demonstrates that core motor learning principles translate across cultural settings when appropriately adapted. This suggests potential for broader implementation of similar approaches throughout Southeast Asia and other regions facing analogous challenges related to childhood physical activity and motor development.

Future research should address identified limitations through longitudinal investigations examining skill retention and developmental trajectories, comprehensive assessments capturing multiple developmental domains, dose-response studies optimizing intervention parameters, and implementation science research facilitating sustainable program adoption in diverse educational contexts. Additionally, investigations should examine intervention effectiveness for special populations, including children with developmental disorders who may particularly benefit from systematic motor skill instruction.

The evidence presented here offers strong justification for prioritizing motor development within early childhood education. By providing children with optimal opportunities for fundamental movement skill acquisition, educators can establish foundations for lifelong physical activity participation, health, and well-being.

Author Recommendations:

1. Implement structured play activity programs in kindergartens throughout Indonesia, particularly urban settings where children have limited access to diverse movement opportunities.
2. Develop teacher training modules focusing on motor development principles, activity design, and pedagogical strategies for effective physical activity instruction.
3. Establish national standards specifying minimum quantity and quality requirements for physical activity programming in early childhood education settings.

4. Conduct longitudinal research tracking motor skill trajectories and associated outcomes from early childhood through adolescence.
5. Investigate integration of motor skill activities with academic content to maximize learning efficiency and child engagement.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the kindergarten administrators, teachers, and staff in Medan Deli who facilitated this research. We extend sincere appreciation to the children who participated with enthusiasm and their parents who provided consent and support. Special thanks to the research assistants who contributed to data collection and analysis.

CONFLICT OF INTEREST

The authors declare no conflicts of interest related to this research. No financial relationships exist with organizations that might have interest in the submitted work. The funding source had no role in study design, data collection, analysis, interpretation, or manuscript preparation.

REFERENCES

Barnett, L. M., Stodden, D., Cohen, K. E., Smith, J. J., Lubans, D. R., Lenoir, M., Iivonen, S., Miller, A. D., Laukkanen, A., Dudley, D., Lander, N. J., Brown, H., & Morgan, P. J. (2016). Fundamental movement skills: An important focus. Journal of Teaching in Physical Education, 35(3), 219-225. https://doi.org/10.1123/jtpe.2014-0209

Gustiawati, R., Arisman, A., & Prabowo, T. A. (2021). Assessment of fundamental motor skills in Indonesian kindergarten children: A developmental perspective. Journal of Physical Education and Sport, 21(4), 2156-2162. https://doi.org/10.7752/jpes.2021.04290

Hardy, L. L., King, L., Farrell, L., Macniven, R., & Howlett, S. (2010). Fundamental movement skills among Australian preschool children. Journal of Science and Medicine in Sport, 13(5), 503-508. https://doi.org/10.1016/j.jsams.2009.05.010

Hulteen, R. M., Morgan, P. J., Barnett, L. M., Stodden, D. F., & Lubans, D. R. (2018). Development of foundational movement skills: A conceptual model for physical activity across the lifespan. Sports Medicine, 48(7), 1533-1540. https://doi.org/10.1007/s40279-018-0892-6

Johnstone, A., Hughes, A. R., Martin, A., & Reilly, J. J. (2020). Utilising active play interventions to promote physical activity and improve fundamental movement skills in children: A systematic review and meta-analysis. BMC Public Health, 20(1), 1-12. https://doi.org/10.1186/s12889-020-08582-7

Morgan, P. J., Barnett, L. M., Cliff, D. P., Okely, A. D., Scott, H. A., Cohen, K. E., & Lubans, D. R. (2013). Fundamental movement skill interventions in youth: A systematic review and meta-analysis. Pediatrics, 132(5), e1361-e1383. https://doi.org/10.1542/peds.2013-1167

Robinson, L. E., Stodden, D. F., Barnett, L. M., Lopes, V. P., Logan, S. W., Rodrigues, L. P., & D'Hondt, E. (2015). Motor competence and its effect on positive developmental trajectories of health. Sports Medicine, 45(9), 1273-1284. https://doi.org/10.1007/s40279-015-0351-6

Schmidt, R. A., & Lee, T. D. (2019). Motor learning and performance: From principles to application (6th ed.). Human Kinetics.

Stodden, D. F., Goodway, J. D., Langendorfer, S. J., Roberton, M. A., Rudisill, M. E., Garcia, C., & Garcia, L. E. (2008). A developmental perspective on the role of motor skill competence in physical activity: An emergent relationship. Quest, 60(2), 290-306. https://doi.org/10.1080/00336297.2008.10483582

Suryana, D., & Mahyuddin, N. (2021). Early childhood teacher education in Indonesia: Challenges and development. Journal of Education and Learning, 15(1), 78-84. https://doi.org/10.11591/edulearn.v15i1.17289

Tompsett, C., Sanders, R., Taylor, C., & Cobley, S. (2014). Pedagogical approaches to and effects of fundamental movement skill interventions on health outcomes: A systematic review. Sports Medicine, 44(12), 1795-1819. https://doi.org/10.1007/s40279-014-0243-1

van der Fels, I. M., Te Wierike, S. C., Hartman, E., Elferink-Gemser, M. T., Smith, J., & Visscher, C. (2015). The relationship between motor skills and cognitive skills in 4-16 year old typically developing children: A systematic review. Journal of Science and Medicine in Sport, 18(6), 697-703. https://doi.org/10.1016/j.jsams.2014.09.007

Webster, E. K., & Ulrich, D. A. (2017). Evaluation of the psychometric properties of the Test of Gross Motor Development—Third Edition. Journal of Motor Learning and Development, 5(1), 45-58. https://doi.org/10.1123/jmld.2016-0003

Wick, K., Leeger-Aschmann, C. S., Monn, N. D., Radtke, T., Ott, L. V., Rebholz, C. E., Cruz, S., Gerber, N., Schmutz, E. A., Puder, J. J., Munsch, S., Kakebeeke, T. H., Jenni, O. G., Granacher, U., & Kriemler, S. (2017). Interventions to promote fundamental movement skills in childcare and kindergarten: A systematic review and meta-analysis. Sports Medicine, 47(10), 2045-2068. https://doi.org/10.1007/s40279-017-0723-1

Wulandari, D., & Suryana, D. (2020). Outdoor play and gross motor development in Indonesian kindergarten. Indonesian Journal of Early Childhood Education Studies, 9(2), 95-102. https://doi.org/10.15294/ijeces.v9i2.42156